G. S. Whitby.

REPORT

OF THE

BRITISH ACETONES TORONTO, LIMITED

TORONTO, CANADA

May, 1916 — November, 1918

COL. A. E. GOODERHAM

1919

G.S. Whitby I
from J.H. Parker

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COL. A. E. GOODERHAM

UNIVERSITY OF TORONTO PRESS

BRITISH ACETONES TORONTO, LIMITED

SIR FREDERICK NATHAN,
Director of Propellant Supplies,
London, England.

SIR:—

I have the honor to submit herewith a report on the work done by the British Acetones Toronto, under the Weizmann process.

The report is lengthy, going into all details, but is well worth more than a casual glance. It sets forth the difficulties met with in making a commercial success of what had been little more than a Laboratory Experiment, and the means employed to overcome these difficulties. On our success I need not elaborate, as our output and exceedingly low percentage of spoiled grain (viz.: less than one-half of one per cent.) speaks more forcibly than any words of mine could do.

During the first fifteen months of operation, we shipped 2,162,000 lbs. of Acetone, and it should be borne in mind that this production was carried on while very extensive alterations and enlargements were being made to the plant.

This success is due entirely to the untiring efforts of my staff.

My son, Captain A. E. Gooderham (who was medically unfit for Active Service) looked after the correspondence, office, employment of men, and in my absence managed the entire works. He worked indefatigably in the interests of the Company.

Mr. H. B. Speakman, who was sent out from England to work the Fermentation end was most untiring in his efforts and most successful in developing the ferment, and systematizing the work of his Department.

To Mr. D. Alliston Legg great credit is due for his part in the distillation and purification of the Acetone and in the working out from a scientific point, of the Methyl Ethyl Ketone plant.

Mr. W. Charles Collett, our architect, a master of his calling, saved us many a dollar in the close supervision of the construction of the plant.

Mr. E. Metcalfe Shaw, our Chief Engineer, proved himself a genius in inventing heating and cooling apparatus for use in the different parts of the plant—in devising simple, yet most effective methods of sterilisation and generally in devising apparatus which materially reduced the liability of failure to a minimum and also the cost of production.

Mr. J. H. Parkin, his assistant, worked night and day in the interests of the company, and most ably assisted Mr. E. Metcalfe Shaw, his work on the Catalysers being worthy of special mention.

To Mr. D. J. Thomson, belongs the special honor of inventing a method of heating the Catalysers in the M.E.K. process which such companies as the General Electric and Westinghouse did not care to undertake, and positively would not guarantee to work satisfactorily, and that, too, at a cost of one-half the estimate of these Companies. He also had the supervision of all the Electric work about the premises, and it speaks well for his supervision that the Inspectors never once altered any of his work, nor had we any trouble with the electric work after he took charge.

Mr. F. W. Barron, our Mechanical Superintendent, had the entire confidence of the men under him. He supervised all our boilers, steam supplies, pumps, etc., and save us many a ton of coal by his close supervision of the plant.

Mrs. Bowes proved herself an ideal Superintendent of the Girls' Department. She had the happy knack of choosing girls who worked well and harmoniously together.

We are greatly indebted to the University of Toronto for allowing several of their staff to assist us, and for supplying us with Chemicals which it was impossible to purchase.

In conclusion, may I say that had it not been for the splendid team work of the members of the Staff, I feel sure The British Acetones could not have been such a pronounced success.

When the Armistice was signed, I received orders to close down immediately. I called my staff together, in my office and thanked them all for the support they had given the Company, and while thankful that the Great War was over, we all regretted that the very happy relations which had existed between us during the past two and a half years was so soon to be severed. "They all did their bit."

Personally, I am most thankful that I had the opportunity of doing something helpful to those brave fellows at the Front.

I have the Honor to be,
Sir,
Your obedient servant,
ALBERT E. GOODERHAM, COLONEL.
General Manager.

TORONTO, APRIL 3RD, 1919.

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LIST OF ABBREVIATIONS

Abbreviation	Liquid	Composition.
	FROM FERMENTATION.	
Beer	Fermented Mash	0.7% acetone 1.4% butyl alcohol 0.8% ethyl alcohol.
	FROM DISTILLATION OF BEER.	
AB	Acetone-Butyl Mixture	20-24% acetone, 40-45% butyl, 3-4% ethyl and 37% water.
	FROM FIRST ACETONE RECTIFICATION.	
A1 (1st)	Washings from Condenser.	
A3	Pure Acetone for Shipment.	conforms to all Government Specifications with 2-3 hour permanganate test.
A2	Acetone requiring further refining.	99% acetone, less than 50 min. permanganate test.
A1 (2nd)	Intermediate Fraction.	25-30% acetone, butyl, ethyl and water.
B1	Butyl Constant Boiling Mixture.	Butyl, water and 5-6% ethyl.
LR	Last Runnings.	Butyl and higher alcohols and esters.
	FROM SECOND ACETONE RECTIFICATION.	
A2 and A3	As above.	As above.
	FROM NORMAL BUTYL ALCOHOL PURIFICATION.	
B2	Top layer of C.B. Mixture (B.1).	75% butyl, 6% ethyl and traces of other alcohols and ketones.
	(Bottom layer).	(8.10% butyl).
B2 (salted)	Top layer after salting (NaCl) 90-92% dry.	84-85% butyl, 6-7% ethyl, 0.6% ketone, 8% water and 0.2% salt.
FR	First runnings from rectification.	60-65% ethyl, 20-25% butyl, 2-3% other alcohols and 2-3% ketones.
B1	As above.	As above.
B3 or RNB	Rectified Normal Butyl Alcohol	98-99% butyl, 1% higher alcohols, ½% water.
Tails	Residue in Kettle.	Butyl and higher alcohols.
	FROM RECTIFICATION OF FR FRACTION.	
FRAI	First Runnings.	10-15% acetone, ethyl alcohol, water, etc.
FR2	Second Fraction.	75-80% ethyl, 5-10% butyl, 4% other alcohols, and less than 1% ketones.
B1	As above.	As above.

LIST OF ABBREVIATIONS

IN SECOND STAGE M.E.K. PROCESS.

Butylene	Butylene from Catalysis.	80% of gases, over 99½% pure.
BHS	Butyl Hydrogen Sulphate.	B.H.S., unabsorbed butylene, acid, polymerized butylene.

FROM PURIFICATION OF SECONDARY BUTYL ALCOHOL.

Crude SB	Crude Secondary Butyl Alcohol.	60% or more secondary butyl.
Salted SB	Top layer after salting.	
FRSB	First Runnings from rectification.	Dissolved butylene, little M.E.K., sec. but. C.B. mixture (80% sec. but.)
SB1	Secondary Butyl C.B. Mixture	Free from impurities in FRSB and less water.
SB2	Intermediate Fractions.	Between sec. but. C.B. mixture and dry sec. but.
RSB	Rectified Secondary Butyl Alcohol.	Pure.
LRSB	Residue in Kettle.	Sec. But. plus high boiling oils (60% S.B.).

FROM RECTIFICATION OF METHYL EHTYL KETONE.

M.E.K. (crude)	Crude Methyl Ethyl Ketone.	Over 60% M.E.K.
FRMEK	First Runnings.	M.E.K. and water C.B. mixture.
MEK2	Strong M.E.K.	Conforms to specifications regards to S.G., but possibly fails on permanganate, acidity or alkalinity.
MEK	Rectified M.E.K. for Shipment.	Conforms fully to specifications.
MEK (inter.)	Intermediates.	Contains small amounts sec. but.
RSB	As above.	As above.
LRMEK	Residue in Kettle.	Sec. but. and high boiling oils (60% S.B.).

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BRITISH ACETONES, TORONTO, LIMITED.

FERMENTATION DEPARTMENT.

JUNE, 1917.

H. B. SPEAKMAN.

A Report on the progress made and the results obtained during the period from August 1st, 1916, to April 30th, 1917.

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BRITISH ACETONES, TORONTO, LIMITED, FERMENTATION DEPARTMENT.

A Report on the progress made and the results obtained during the period from August 1st, 1916, to April 30th, 1917.

N. W. PIRRIE, ESQ.,
Director of Propellant Supplies,
Imperial Munitions Board,
Ottawa.

DEAR SIR:—

The process in operation at the British Acetones, Limited, Toronto, may be briefly described as one in which maize mash is prepared in a certain manner and fermented in iron vessels by inoculating with a vigorous culture of a micro-organism. The products of this fermentation are afterwards distilled and rectified.

In my report I propose to follow the course of the mash and the inoculant in their various stages, and in the final fermentation, describing and considering them purely from the bacteriological point of view.

LABORATORY CULTURE—To avoid contamination of the culture the usual precautions have been taken, and ordinary bacteriological technique employed. The cooking and sterilisation of flasks and tubes of maize have been done by responsible persons only, owing to the prevalence of resistant spore-forming air organisms. During the twelve months' work here we have not been troubled so far by contamination in the laboratory.

A great source of trouble and anxiety during the first few months was the repeated sluggishness of the fermentation. This phenomenon appears after about six generations in open culture tubes, even when using perfectly pure cultures and growing under anaerobic conditions. Much detritus and very few spores are formed, and these things I regard now as characteristic of a sluggish fermentation. This problem has been solved in the following manner.

Sealed culture tubes in vacuo are only used at intervals, and the effect is beneficial. Different media have been employed at intervals of a few generations—potato, maize and wort. Chiefly, however, we have been able to preserve strongly fermenting cultures by discarding tubes at intervals and starting from an old culture containing spores, usually from three to six weeks' old. This has been done twice per week. In two generations, starting from such a spore culture, a vigorous, rapidly fermenting culture is obtained.

The culture which I brought out from England has been used for the first ten months. Recently I have examined carefully and used in the factory tubes brought out by Colonel Gooderham from England recently. This, I presume, is the culture that has been used at home for the last few months. The culture was perfectly pure, and gave very good results in the factory. Eventually, the rapidity of the fermentation began to diminish, and the culture has now been replaced by one recently isolated and developed in my laboratory.

After many experiments with different solid media I have found one which gives splendid results with a Weizmann culture. This is made according to the following recipe:—

To 1,000 c.c. of wort, S.G. 1.008, add 1% gelatine, 1% calcium carbonate, 2% agar. Heat gently, filter, sterilise and make up into tubes in the usual manner. Use for shake cultures, and in making the dilutions an old culture containing spores must be used. Vegetative forms will not grow in the medium, but spores give rise to large colonies of healthy bacilli in forty-eight hours. Up to the present no successful technique has been found for preparing good plate cultures using this medium.

FLASKS—A 10 c.c. tube of culture is used to inoculate a 500 c.c. flask, containing 300 c.c. maize mash. This is incubated for eighteen to twenty-four hours at 37° C.

PAILS—Satisfactory aluminum pails have not been obtainable in Toronto. It was found impossible to get rid of very serious air leaks, and the aluminum pails were therefore discarded. Copper pails are now being used, and are giving every satisfaction. Experience has shown that the thin black coating formed over the copper must not be removed by vigorous scouring when the pail is empty, thus exposing a new copper surface. Rubber gaskets are a constant source of danger and difficulty.

Contamination has several times been discovered in the pails, and has been traced to air leaks occurring when the pail was cooling. Before a pail is used it is tested under compressed air after all joints have been made, and is rejected if there is the slightest leakage of air under 10 pounds pressure.

The only opening made after this test is completed is the one through which the mash is poured, and it is closed with a cotton plug during the cooking and cooling. The cause of several of our failures here has been traced back to slight contamination occurring in the pails. I therefore attach great importance to this preliminary test.

The mash is made in an open copper vessel, heated by a steam jacket, and taken up to boiling and kept for twenty minutes at this temperature before putting it into the pail. By this method we avoid the necessity of interrupting the sterilisation to stir the mash, and obtain a homogeneous medium.

The pails are sterilised for two-and-a-half hours at twenty-five pounds pressure, and are afterwards cooled slowly in a water bath. They are inoculated with one of the flask cultures, and are incubated for twenty hours at 370° C. A permanent slide is made of the flask after the pail is inoculated, and kept for at least one week.

For the first four months the pails were used to inoculate the seed tanks directly, which were in turn used to inoculate the fermenters. When we began to ferment from four to five fermenters per day, requiring the same number of seed tanks, with every possibility of still further increasing our output, I introduced another generation or stage in the processes, i.e., the inoculators. By this method I hope to obtain better results in the seed tanks, and also to economise on labor.

INOCULATORS—This battery consists of four units: one open copper mashing vessel, heated by means of a jacket, and fitted with a mechanical stirring gear, with three copper fermenting vessels capable of standing a pressure of twenty-five pounds (see diagram). The mash is prepared in the open vessel, and when boiling is run by gravity into the inoculator. After cooking for two hours under 10 pounds pressure the mash is tested to see if any organisms still persist. If the mash is sterile the vessel is cooled after three hours' cooking.

The consideration of the inoculators provides an opportunity of stating several points which I have come to regard as essential, especially in connection with inoculators and seed tanks.

(a) There is no type of plug cock or plug valve obtainable here which for very long remains gas tight. Three way cocks are especially dangerous, and have been a constant source of weakness. Recently, they were discarded wherever possible. Complete immersion in an antiseptic liquid is the only remedy for the danger.

(b) We assume now that all globe and gate valves leak to a slight degree, and that these leaks are sufficient to cause the loss of several fermenters. Acting on this assumption, we protect the tank in one of two ways. All valves leading into the atmosphere are either open with steam passing through when the tank is empty and under steam, or closed and covered very carefully with cottonwool when the mash is cooling and during the fermentation. Valves leading from the mash or inoculating lines into the vessel are covered by the next point.

(c) The mash and inoculating lines when not in use are continually under live steam pressure. This also is to prevent contamination from air or water organisms. The great importance of this has been shown on several occasions, when what would appear to be negligible amounts of air have been allowed to leak in. On one occasion the mash line was broken without authority for a few minutes when at room temperature, and the mash afterwards pumped through the line into four fermenters owing to the person in charge at the time neglecting to cease operations and resterilise the line. Each of these four fermenters was a failure.

It does not seem possible to erect a large perfectly gas tight plant, but speaking from a bacteriological point of view, I feel sure that by working constantly under pressure from live steam, sterile mash, or fermentation gases, pure culture fermentation processes can be successfully carried on in spite of the ever present danger from air contamination which has been the cause of all our trouble here.

(d) Only by constant examination and careful repair work can the plant be kept in suitable condition for our work. Mr. Shaw recently placed at my disposal a competent member of his staff, who tests and examines carefully the inoculators and seed tanks when they are empty, and repairs the small defects. I attribute the recent run of successful fermentations largely to this continued and systematic overhauling of the plant.

One of the copper pail cultures is carried from the laboratory and used as inoculant for the inoculator. A permanent slide is made of the pail, and kept for at least one week, after a careful examination has been made. We are hoping in the near future to discontinue the use of pails, owing to the fact that while the inoculators are being inoculated the culture must come in contact with the atmosphere, and there is a slight possibility of contamination occurring at this point. Instead of the present arrangement, smaller culture vessels will be connected by a line to the inoculators in the factory, and apart from the tubes and flasks the process will be in a continuous plant.

After the fermentation has been going six or eight hours we commence to make observations at intervals of two hours until the inoculator is used. These observations consist of the titration of samples to see the acidity, and of a careful examination of slides. The last slide is converted into a permanent one, and preserved for several days, and a sample of the culture is taken in a sterile flask and incubated. The permanent slides and samples of the culture will be considered later.

SEED TANKS—The seed tanks consist of four, which are part of the original plant, and five new ones which have since been added. The diagrammatic drawing of the plant, which is appended, shows the relative positions of the inoculators and seed tanks.* The mash is supplied to the seed tanks from the four cookers by a two-inch line, which is equipped for sterilisation purposes with a low pressure steam inlet line, a safety valve and a drain. If a seed tank is required to inoculate a fermenter to-morrow at 12 o'clock noon, it is filled with mash from the cooker after the batch in the cooker has been pronounced sterile at 12 o'clock noon to-day. In the seed tanks the mash is heated further under pressure from 12 to 1 p.m., and is again examined for sterility. If the mash is sterile, the tank is cooled down by an outside water curtain and inoculated with twenty gallons of inoculant from one of the inoculators, previously described, at about 3 o'clock p.m. One hour after inoculation the seed tank is connected by a one-inch pipe line to a gas meter, and hourly gas readings are taken by the factory staff. The laboratory staff examine the culture in the manner previously described every two hours, and from the gas produced, the rise and fall of the acid-

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* All drawings, charts and diagrams, etc., are contained in separate portfolios. The large size and great number of these prevents them being incorporated in the report proper.

ity and the examination of microscopical slides an opinion concerning the culture can be formed.

This matter will be considered further in a paragraph dealing with contamination in the factory.

If a seed tank is not in use it is kept under a slight steam pressure to prevent the growth of organisms in the residues from the last fermentation, and the condensed steam effectively washes the bulk of the tank. I have not found it necessary to wash out the seed tanks by hand after each fermentation, and in addition to the economy in labour the nine seed tanks by this system enable us to ferment at least six fermenters per day, and also joints when once made satisfactorily are not broken frequently to remove manhole covers.

MILLING—The meal used in the factory is ground in the Gooderham & Worts' mill. During the process from five to ten per cent. of the whole corn is removed in the form of bran; a large part of the nitrogeneous matter is included in this, with fibre and some starch. The fermentation has not suffered owing to the shortage of protein matter and the bran is a valuable commodity for cattle food. If, on the other hand, we fermented whole cornmeal I doubt very much whether our present methods of cleaning and sterilising the fermenters would be successful in freeing them from the slimy residue, and also our problem in connection with slop disposal from the beer-still would be greatly accentuated.

I hope that in the near future some method of working the mill will be devised to cut down the percentage of starch in the bran sold. At present, especially when the corn is new and has a high moisture content (14-15%), the bran contains about 50% starch. The new corn has also caused our percentage yield to fall slightly. The meal used in our mash is passed through No. 18 gauge wire screens.

MASHING—No attempt is made in mashing to sterilize the corn. Standard mashes are made with 4,500 gallons of water to 3,500 pounds of meal. Allowing for condensation in mashing and cooking, five mashes are equal to 25,000 gallons, with 17,500 pounds of maize. This amount is put into one fermenter, after cooking in the four cookers which hold 1¼ mashes each.

I hope in the near future gradually to raise the concentration of the mash from seven to eight per cent., and ferment 20,000 pounds of maize meal in each fermenter. The mash is raised to boiling point, and kept for thirty minutes. During the whole period of mashing the rakes in the mash tun are revolving rapidly, and a perfectly homogeneous mash is obtained. The mash floor record which is attached to my report is kept by the staff on the mash floor. The flora of the mash at this stage is a very numerous one.

COOKING—The mash is pumped across to the fermenting floor through a four-inch pipe by means of a centrifugal pump. Communication is maintained between the cookers, the pumpmen and the mash floor men by means of electric bell signals. On the way over live steam is injected into the mash through a series of one-inch pipes fitted into the line close together at right angles to it. The steam intake is controlled by one of the girl members of the staff, and as far as possible the mash is maintained at a temperature of 240° F. To assist her in this operation a recording thermometer is fitted in the line. The maize mash beyond the steam injector contains only B. mesenterious, chiefly the spore form. The steam injector, therefore, besides heating and disintegrating the mash, brings about partial sterilisation. All these three things are important and essential features in the proper preparation of the mash. (See thermometer chart in appendix.)

When the cooker is full, the stirring begins at once. At present no mechanical stirring gear is fitted into the cookers. During the first few months cone stirrers, driven by mechanical stirring gear, were used in the cookers, but owing to the danger due to spark formation during their operation they were removed. At present the stirring is effected by means of two low pressure steam jets fitted on to a revolving shaft at the base of the cooker. These are revolved by hand, and steam 22 pounds pressure blown into the cooker. At the base of the draw-off line from the cooker a high pressure steam jet is inserted to prevent the caking of mash in the line and the possibility of any organisms surviving the cooking treatment. A safety valve, which operates above a pressure of 15 pounds, and a vacuum valve are fitted on the cookers.

After one-and-a-half hours a test for sterility is made. Owing to the impracticability of incubating samples or preparing plate cultures, a rapid and reliable test had to be devised. A slide is made of the mash, and the cooker is pronounced sterile when no organisms whatever are indicated under the microscope. I do not regard it as practicable or safe to leave any room for discussion as to whether organisms which may be visible are dead or alive in the mash. Also the mash on different days and in the four cookers is not sterilised in the same time. Unless we could allow three hours at least in the cookers a test of every batch should be made. If the mash is not sterile according to this test the cooking is prolonged. The line from the cookers through the cooler pump to the cooler is under live steam pressure continuously when not in use. At the end of each filling period the line from the mash floor to the cookers is washed out with hot water prepared in one of the mash tuns. The drain connection is shown in the diagram.

Cooling—From the fermentation point of view the cooler must satisfy three conditions:—

(a) The sterility of the mash must be preserved;

(b) The temperature required by the organism must be easily obtained to within 1° F.;

(c) The cooler must respond quickly when slight changes in the temperature of the stream of mash are desired.

The cooling system designed and erected by Mr. Shaw has satisfied these three conditions. When not in use the cooler is sterilised with live steam, and cleaned by condensing live steam in the coils. Experience has shown that the cooler slows down after two fermenters are filled. For this reason and others we then close down for two hours to steam sterilise the mash line and the cooler and the time is recovered by the more rapid cooling which follows.

Fermenters—The General Distillery was equipped when we arrived with nine large open fermenters. To make them suitable for our work a conical top was made for each. At the beginning of this year to increase our capacity seven new fermenters were added of the same size. I hope that these new fermenters will soon be in use. They embody all the improvements which experience here has shown to be desirable. Since operations began here several times changes have been made in the old fermenters, especially in the gas measuring system. (See Mr. Shaw's report.)

Previous to coming to Canada I had been working for two months at the Royal Naval Cordite Factory, Poole, England. My experience there had shown that the success of this process depends almost entirely on the sterility of the conditions under which we work.

A large percentage of the fermentations at home had failed owing to the imperfect sterilisation of the maize mash during cooking. From the first, therefore, it has been our endeavor to sterilise the mash in the cookers, and to prepare a sterile vessel in which to ferment it.

Owing to the construction of the fermenters it has not been possible to sterilise with steam at high pressure. The maximum steam pressure which we are using corresponds to twelve inches of water pressure. When a new fermenter is first used, or after a fermenter has been contaminated, it is sterilised under pressure for twelve hours and then cooled for twelve hours. This steaming and cooling is repeated three times before the fermenter is used at all. Assuming that the fermenter is not thickly coated with maize mash residues, a temperature of 214° to 215° F., for this period of time, with intermediate cooling periods, is sufficient to sterilise the body of the fermenter. The next and perhaps more difficult problem is to cool down the fermenter ready for use and still to preserve its sterility, knowing that the greatest danger of contamination is from the atmosphere.

A short length of four-inch pipe, fitted with a four-inch gate valve and terminating in a large galvanised iron funnel, is fitted into the roof of the fermenter. Also in order to prevent the collapsing of the fermenter due to the formation of a vacuum during the cooling on account of carelessness of the operator, or some accident occurring, another similar funnel is fitted, but instead of the four-inch valve a vacuum valve is fitted in the pipe. This vacuum valve comes into operation when a vacuum of more than three inches of water pressure occurs in the fermenter.

During the sterilising period the condensed water and the residues from the last fermentation are drained periodically through a four-inch sludge valve at the bottom of the fermenter. The condensation of steam on the walls and bottom of the fermenter has a cleansing effect, and under ordinary circumstances the fermenter can be used again after eight to twelve hours' standing.

Before cooling down the fermenter the vacuum valve and air intake valve funnels are thoroughly sponged and cleaned with a solution of carbolic acid. The galvanized iron funnels are deteriorating rapidly with this treatment, and copper ones are being made for the factory. A thick covering of cottonwool in layers, and cheescloth is placed over them and securely tied. The sludge valve is also covered with cottonwool, seeing that this valve also leads into the atmosphere. The four-inch line running from the top of the fermenter through the roof to take away the gases during the fermentation is fitted at the base with a live steam jet, which plays on to the valve during the period of cooling. The mash line is, of course, under pressure continuously, and there is no danger of contamination from this source. (See diagram.)

When these precautions have been taken the steam is turned off, and the air allowed to pass into the fermenter through the cotton-wool over the air intake valve by opening the four-inch valve when the manometer only shows about .2 inches pressure. The temperature of the fermenter at all times is kept on a recording thermometer. The cooling time can be arranged so that the fermenter is ready approximately at the time required. If the cooling proceeds too rapidly a little steam is turned on, and the temperature is thus sustained for the time required. (See thermometer chart in appendix.)

The filling of the fermenter commences when the temperature of the fermenter is as near as possible to 120° F. The arrangement of the mash line leading to the fermenters is shown on the diagram attached to my report. When filling has been in operation for fifteen minutes the temperature of the mash in the fermenter is taken. The temperature reading is repeated at half-hour intervals throughout the filling. The foreman in charge is kept acquainted with this temperature, and arranges the temperature of the mash at the cooler accordingly. After a little experience it is possible to obtain a mean temperature of 98° F. in the fermenter throughout this operation.

Our usual practice is to cool down two fermenters with an interval of one hour between, and to fill them together, putting in the cookers alternately. By this means there is an interval of about one hour between any two cookers going into one fermenter. The effect of this has been to increase the rapidity of the fermentation, owing, I think, to the fact that the inoculant has an opportunity of developing and producing a strong culture in the first cooker of mash before the second is put into the fermenter.

If the temperature of the mash at the end of a quarter-of-an-hour after filling begins is right, the inoculant from one of the seed tanks is run into the fermenter with the remainder of the cooker. This operation is spread over a period of twenty minutes, and an intimate mixture of the inoculant and the mash is obtained. The greatest care is taken to prevent air from being drawn into the seed tank as the inoculant leaves it by thoroughly protecting all the air inlets with cottonwool filters. The inoculating line shown in the diagram is under steam pressure when not in use, and by opening one valve only the mash from the main line backs up the line and prevents a vacuum when steam is turned off. The cock at the base of the seed tank is then turned, and the inoculant is forced by gravity into the stream of mash just as it leaves the cooler.

Four cookers of mash are put into each of the fermenters, and then all valves are closed. Generally fermentation is already proceeding to some extent, and gas is being produced, but in order to prevent the possibility of contamination owing to air being drawn in as the fermenter cools slightly, the fermenter is kept closed for one hour. By means of the manometer it is possible to tell whether gas is being produced, and roughly to what extent. During this period, if the pressure within the fermenter exceeds twelve inches, the safety valves come into operation and the gas is released.

After the filling of two or three fermenters during the day, instead of continuing and filling the remainder of the fermenters we shut down for two hours and empty and re-sterilise the mash line, the cooler pump and the cooler. In this way the cooler maintains throughout the day its normal efficiency, whereas during a very long run (for example, towards the end of the filling of four or five fermenters) the rapidity of the cooling begins to diminish. Sterilisation of the cooler with steam appears to clean the copper coils, and in this way helps to transfer the heat. If for any reason the mash line is contaminated during the filling of one of the first two fermenters, experience has shown that until the line is emptied and re-sterilised all the fermenters will be contaminated and will fail. Using our present system we have reduced the possibility of contamination to two fermenters, and by re-sterilisation of the cooler, thus increasing its efficiency, we recover the time spent in the operation.

Gas Measurements—For some time it was our intention not only to measure the gas, but to collect and store it, and by means of a compression system to extract the volatile acetone carried over from the fermenters. The system involved the use of a gas drum, divided by a diaphragm in the centre, of which there was an aperture 1.5 in. in diameter. This drum was connected to the fermenter and to the gas storage tank by horizontal pipes. The drums were never completely gas tight; also the piping system became foul with mash during the foaming periods, and owing to the existence of dead ends during the sterilisation period this part of the system could not be sterilised satisfactorily.

The whole of this system has been removed, and we have abandoned for the present the idea of recovering the acetone carried away with the gases.

At the end of one hour the four-inch gas valve at the top of the fermenter is opened, and a free passage is made for the gas to escape into the atmosphere. From this time onwards, careful readings of the pressure, temperature and acidity of the culture are made and recorded.

Fitted into the gas pipe there is a movable diaphragm with an aperture of known diameter. (See diagram.) From the pressure in the fermenter and the area of this aperture the amount of gas produced per hour can be calculated approximately. When the pressure exceeds five inches on the manometer, the diaphragm is removed, and a full four-inch pipe is available for the gas to escape. Usually the pressure falls to about .5 inches. The reason for this operation is that violent foaming often follows high pressure in the fermenter. From the fermenting liquor large quantities of slimy head pour out through the safety valves and manometer connection and are often driven four or five feet high on the roof through the gas-pipe while this foaming is going on. Apparently the semi-fermented mash becomes supersaturated with gas. The residues form a head which is gradually formed and then lifted above the body of liquid. We have tried by working at a lower maximum pressure to avoid foaming, but it still occurs, and when once it begins the only remedy is to pump out of the fermenter until the foaming ceases. Efforts made to stop it with live steam blasts blown into the mass of foam in the dome of the fermenter have not succeeded. Unfortunately, the most violent foaming coincides with rapid, vigorous and successful fermentations.

During the first four months the average time of the fermentation in the fermenters was about 36 hours, counting the time from when the fermenter was full. Since Christmas the fermentation period has gradually diminished, and the great majority of fermentations are completed in between 24 and 27 hours.

In the normal working of the plant the fermenters are not cleaned by hand after each fermentation. I propose cleaning out one or two fermenters per week when everything is running smoothly. Normally the cleaning operation depends on the work done by the live steam during sterilisation. At intervals, however, the inside of the fermenter is thoroughly scraped and cleaned. The sides and bottom are not difficult to clean, but the roof and the upper part of the body of the fermenter are usually coated with a thick crust—composed of maize mash, deposited during the periods of foaming, and iron rust. Besides cleaning the interior of the fermenter all the valves and the cocks are removed and repaired. Following this operation the fermenter is sterilised intermittently for two days before being put back into use.

At present there are two points of weakness in connection with the fermenters. The safety valves which were fitted to deal with steam during the sterilisation and gas during the fermentation are a possible source of contamination. During the foaming periods the mash fills the valve, and no doubt remains on the seating, and the disc does not return to its proper position. It is not possible in practice to remove and thoroughly clean the valves at frequent intervals, owing to their construction. If during the cooling of the fermenter a valve is being kept open by small particles of maize mash, unfiltered air must be drawn into the fermenter. These valves are now being removed, and a water seal fitted on to the fermenters, which not only acts as a safety valve, but also measures approximately the output of gas during fermentation. (See Mr. Shaw's report.)

We have, therefore, removed the straight gas-pipe which ran from the top of the fermenter through the roof wherever the opportunity has arisen (without diminishing our output), and as soon as the new device could be made. If the four-inch valve in this line was leaking slightly we had again the possibility of contamination. Using the water seal arrangement, there is one exit only from the fermenter, and this is immersed continually in a bath of antiseptic fluid. As far as I can see, there is no possibility of contamination unless the liquid is all drawn into the fermenter to overcome a vacuum during cooling. If this occurred the fermenter could be re-sterilised and not filled and no maise would be lost.

The line at the bottom of the fermenter along which the beer is pumped to the beer-still is not under steam pressure, and when the beer-still is not in operation this line is filled with air or stagnant beer. At present there is only one four-inch gate valve separating the sterile fermenter from this line which is not sterile. If during the cooling of the fermenter the beer line is full of air or beer containing foreign organisms, and the four-inch valve is not in the best condition, contamination of the fermenter may occur. In the near future we hope to duplicate the four-inch valve on the draw-off line from the fermenter, and insert between the valves a high pressure steam jet. If during the cooling of the fermenter there is a slight leak in the valve, live steam only will pass into the fermenter and sterility will be preserved. There will be no danger also from possible leakage through the sludge valve. (See diagram.)

GENERAL REMARKS.

CONTAMINATION—The whole of our failures since work began here have been due to contamination, and not to weakness in the principles underlying the process.

As I have previously said, in each case unsterile air getting into the vessel concerned has been the cause. Generally speaking, this has been due to faulty valves or connections, and very rarely to carelessness on the part of members of the staff. On a few occasions when slight contamination has been detected the fermenter has given a sufficiently high yield of acetone to justify its being distilled, but in the majority of cases the contamination has proved fatal. We have detected three different organisms which cause the trouble, all of them being short bacilli or bacteria which from the morphology in the vegetative condition cannot be distinguished with ease from the Weizmann bacillus. Owing to this fact it is extremely difficult in the early stages of the fermentation to detect any impurity. One of the foreign organisms does stain a little more deeply with carbol fuchsin, and in a few cases the slide shows this and the organism can be detected. After twelve to fifteen hours the same one, a strepto bacillus, begins to form characteristic spores in chains, and this enables us to detect its presence with certainty. The acidity of the mash also continues to mount steadily, instead of turning and falling in the usual manner. We have succeeded in the laboratory in isolating one of the impurities, and are studying at present its life history and behaviour on different media. By working along these lines we may succeed in finding some method of combating the impurities, even when, unfortunately, they are found in the fermenter.

INSTRUCTIONS—I was faced at the commencement of the operations here with the difficulty of starting this work, which was largely at that time in the experimental stage, with a completely new staff, none of them, apart from my laboratory assistants, possessing any bacteriological training, either theoretical or practical. Our methods of working necessarily changed from time to time, and the plant has been changed very considerably. There was the possibility of confusion arising in the factory on account of these things. Also the most delicate operations, requiring great care, patience and cleanliness, are being conducted in enclosed metal vessels out of the sight of the operators, and they cannot see the results of their work. From the beginning careful written instructions have been handed to the different sections of the staff to guide them in their work. To overcome the lack of any knowledge of the principles involved or the actual process, demonstrations of the various stages, using glass vessels, and short simple talks have been given in the laboratory. For example, I have tried to show what the difference is between unsterile and sterile mash, and what is the result of slight contamination from the atmosphere by means of slides and plate cultures. The staff have benefited largely from these demonstrations, and the time has been very well spent from my point of view.

RECORDS—I have traced the mash from the mash floor through the cooker and cooler into the fermenter; also we have considered the sterilisation, cooling and filling of the fermenter, and the inoculant has been traced from the laboratory through its various stages into the fermenter. Day by day a careful and accurate written record is kept of all these operations on the forms and charts provided. With the record of the various observations the observer puts down his or her initials, with the time the observations are made. Mention has been made of the microscopical slides and incubated samples which are kept. This system has been of great help in improving, checking and making our work of value in the future. A similar record, though not so complete, has been kept from the commencement, and is available at all times for reference or for the obtaining of any data required concerning the various units in the plant.

Several times when the fermenters have failed, owing to contamination, by careful examination of these records we have been able to find out the cause of the failure and also to remedy it. For example, a careful examination of the slides and samples of the culture in the flask, pail, inoculator and seed tank stages will indicate whether the contamination occurred at any of these points. On one occasion the failure of a fermenter was found to be due to carelessness on the part of one individual, and the evidence of this was in the record of the cooling of a fermenter. When so many people take part in the one process in its various stages, with so many possibilities of contamination the most careful record is the only check.

SUMMARY OF FACTORY RESULTS.

NOTE—The first column shows the number of fermenters filled during each week from Monday morning till Saturday night.

Failures represent those fermenters which on account of contamination have not yielded sufficient acetone to justify their being distilled.

The percentage yields of acetone and butyl alcohol are the figures supplied by the chemical department.

Month.	Fermenters per week	per month.	Failures	% Acetone	% Butyl Alcohol.
August	10	10	2		
September,					
1st. week	6		0	7.89	
2nd. “	2		0		
3rd. “	6		0	8.35	
4th. “	12	26	0	7.8	
October,					
1st. week	11		0	8	
2nd. “	11		0		
3rd. “	11		1		
4th. “	11	44	0		
November,					
1st. week	11		0	7.34	
2nd. “	10		1	7.5	
3rd. “	5		0	8.89	
4th. “	14		3	8.56	
5th. “	17	57	0	8.39	
December,					
1st. week	18		0	8.33	
2nd. “	12		3	8.6	
3rd. “	9	39	0		

FERMENTATION DEPARTMENT

Month.	Fermenters per week	per month.	Failures	% Acetone	% Butyl Alcohol.
1917.					
January,					
1st. week	9		2		
2nd. "	15		0	8.26	
3rd. "	21		0	8.48	
4th. "	9	54	0	8.8	
February,					
1st. week	21		0	7.83	16.5
2nd. "	24		0	7.36	17.36
3rd. "	21	66	4	8.07	18.6
March,					
1st. week	25		0	8.08	19.2
2nd. "	25		0	8.5	19.7
3rd. "	18		2	8.27	18.7
4th. "	22	90	4	8.6	18.3
April,					
1st. week	25		2	8.12	18.9
2nd. "	30		0	8.48	18.5
3rd. "	30		0	8.48	18.8
4th. "	29	114	0	8.6	18.3
		500	24		

Fermenters filled to end of April	500
Fermenters rejected	24
Corn mashed	8,272,000 lbs.
Corn rejected	403,000 "
Acetone shipped	250 tons

STAFF—I wish to bring to your notice the faithful and conscientious work of the members of my department. By their keen interest in the work they have become proficient very rapidly, and have endeavoured to overcome the difficulties which we have encountered.

I am, Sir,
Your obedient servant,
H. B. SPEAKMAN.

JULY 2

DISTILLATION AND RECTIFICATION
OF
ACETONE AND BUTYL ALCOHOL.

JULY 21, 1917.

D. A. LEGG, A.I.C.

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DISTILLATION AND RECTIFICATION OF ACETONE AND BUTYL ALCOHOL.

The main units concerned in distillation and rectification include the following:—

Beer Still—A 30-ft. still, 6 ft. in diameter, and containing 19 plates, with 69 boiling caps on each. The "beer" before entering the still passed through a 15-ft. beer heater containing 66 2½-in. tubes, and outside these the vapours from the beer still pass and are to some extent concentrated. There is no rectifying section. The beer is heated by a callandria and by an auxiliary live steam ring.

Tank AB—This is a 13,000 gallon graduated tank, and receives the distillate from the tail box of the beer still.

Rectifier *I.* (*Referred to as R*1)—This is a batch still with a 13,000 gallon kettle and 37-foot column associated with a goose tank dephlegmator. The column has twenty-four 5-ft. plates, with seven six-inch bonnets on each. It can deliver to R2., "Tails", A1, B1 and LR, and receive from AB and A1.

Rectifier *II.* (*Referred to as R*2)—Construction identical with R1. Used for final rectification. It can deliver to A3, via gauge tanks, and A1, and "Oils" and receive from R1 or shipping room. Kettle used directly as storage tank for A2.

Tank A1—A 13,000 gallon graduated copper tank.

Vide, Blue Print: "Diagramatic Arrangement of Distillation and Rectification Plant."

Tank B1—A 13,000 gallon graduated tank, with gauge glasses and overflow at 11,000 gallon mark to Tank B2.

Tank B2—A 13,000 gallon graduated copper tank, which receives the top layer which overflows from B1.

Tank A3—A 13,000 gallon copper tank for storage of pure acetone.

TANK "OILS"—A 13,000 gallon copper tank for "acetone oils" obtained as "tails" in final rectification.

TANK "TAILS"—A 13,000 gallon copper tank to be used in emergencies for any very bad distillate which may be obtained.

TANK LR—A 1,400 gallon tank used for "last running" from butyl alcohol.

GAUGE TANKS—Four one hundred gallon tanks receiving from tail box of R2, and delivering either to A3 or to A1.

TESTING ROOM—This is a small whitewashed room with special "daylight" illumination, situated in the still control floor, and used by still men and girls for control tests.

PRIMARY DISTILLATION IN BEER STILL.

When the gas pressure on a fermenter indicates completion of fermentation the fermenter is stirred and a sample taken and the beer pumped to a 13,000 gallon tank on still control floor, and from thence to beer still by another pump on control floor, which can thus be conveniently controlled by the still men. By this arrangement the still pump has less head to pump against, so that smoother running and greater capacity are obtained. The beer is pumped at the rate of about 6,000 gallons per hour, enters the still from the beer heater at a temperature of about 140 degrees F., and yields a distillate of from 600-700 gallons from each tub. (17,500 lbs. corn.)

The distillate known as AB contains usually 20-22% of acetone, and from 46-49% of butyl alcohol (and other alcohols). No separation of acetone from butyl occurs in this still. The working is controlled by determinations of S.G. at tail box. This varies from 0.876-0.890.

NOTE.—ESTIMATION OF ACETONE IN SAMPLE OF BEER—500 c.c. of the sample are distilled till 100 c.c. of distillate are obtained. This is diluted to 1 litre and 10 c.c. of this used for the estimation, as follows:—100 c.c. of distillate and 50 c.c. of N. soda and 20 c.c. of N/5 iodine solution are allowed to stand for ten minutes. 55 c.c. of N. sulphuric acid are added, and the liberated iodine titrated back with N/10 phiosulphate. The solutions are from time to time standardized under like conditions against pure acetone. A factor for converting c.c. of iodine into c.c. of acetone per gallon is used.

The value of these estimations for determining the yield of acetone is somewhat vitiated by the fact that we have no definite means of controlling or measuring the volume of beer in the fermenters; but they serve as a check, and are sufficiently accurate to indicate in event of contamination occurring whether the beer is worth distilling.

AB—This is contained in tank AB, and on the composition of this liquor the weekly estimate of acetone produced and the yield is based. The tank is provided with sampling cocks, and can be stirred. At the commencement of a week the percentages of acetone and butyl in the liquor and volume of liquor are measured, and when any AB is pumped to R1 the amount is recorded and a sample analyzed for acetone and butyl. At the end of the week the residual contents are again analyzed, and from the figures obtained the amounts of acetone and butyl produced during the week are calculated.

This system had till recently proved satisfactory, but is now somewhat complicated by the occurrence of foaming. Thus supposing on Friday (weekly report day) we are distilling the last of the week's fermenters with the intention of taking samples of AB on completion, it now frequently happens that one or more of the next day's fermenters will start to foam, and will have to be pumped to the still.

(So far the only satisfactory method of dealing with such tubs is to pump them to the still for a time in order to reduce the volume in the tank, and thus save flooding of the floor.)

This means that AB will now include some acetone derived from the next week's tubs, so that before we can make our weekly estimate (and obtain yield) we must wait till the foaming tubs have been completely distilled.

This difficulty can, of course, be overcome by installing a second AB tank, so that the tanks could be used alternately each week. Till then it will be necessary to make the weekly estimate at a time (as near as possible to Friday) at which AB has received distillate from completely distilled tubs.

Note.—Estimation of Acetone and Butyl Alcohol in AB—The acetone in the AB is estimated by the iodometric method, as indicated previously.

The butyl is estimated by salting a certain volume with pot: carb:, noting the volume of oil, taking the S.G., and calculating from curves the residual water content. The water and acetone are deducted and the remainder assumed to be butyl alcohol. This will, of course, include the small proportion of ethyl alcohol and traces of higher alcohols, etc., which are present.

FIRST RECTIFICATION.

This is carried out in R1. The charge is made up of AB and A1, and is about 13,000 gallons in quantity, and contains from 15-25% of acetone (A1 being variable in acetone content).

The first runnings (obtained after 5-6 hours' heating) wash out the condenser and are run back to A1. There appears to be very little head product, the impurity at start being mainly due to previous distillation. The acetone quickly reaches a good quality as regards permanganate test and S.G., and is then run to R2. It is tested periodically, and as soon as the permanganate test fails to hold for fifteen minutes, the acetone is run back to A1. This is continued till a test on the distillate indicates 1% or less of acetone. It is then run to B1, where it separates into two layers, the top layer overflowing into B2, and the bottom layer, containing 8-10% butyl, being periodically pumped to beer still with the beer. (This is allowed for in the weekly estimate.)

NOTES—A charge of, say 6,000 gallons of AB at 21.8% acetone, and 6,900 gallons of A1 at 9% acetone would give about 1,500 gallons of A2, 5,000 gallons of A1 and 5,000 gallons of B1.

If, however, A1 contains, say, 20.25% of acetone, as it sometimes does after receiving from Rectifier 2, the amount of A2 obtained is considerably higher.

The amount of acetone obtained in this distillation which would satisfy the specification is small, the maximum permanganate test being rarely more than 100 m. and the acidity being somewhat high, so that it has been found advisable to redistill the whole of the A2.

A2 as a whole, then, consists of strong acetone, but containing traces of impurities which prevent its satisfying the tests.

A1—The intermediate fraction between A2 and B1. It is larg in quantity and runs from 98% at the start to 1% of acetone at th finish, and contains also butyl alcohol, water and a certain amount of ethyl alcohol.

B1—This consists chiefly of butyl constant boiling mixture, but contains some ethyl alcohol.

A rapid test was devised to enable the stillman to tell when to switch from A1 to B1. This is based on the iodoform reaction, and indicates when the amount of acetone in the distillate is less than 1%.

LAST RUNNINGS LR—At the end of the distillation about 20-30 gallons of greenish oil are obtained. This is run to tank LR where it separates into two layers. The aqueous layer contains butyric acid, and the oily layer has been investigated and so far found to contain amyl alcohols, normal hexyl alcohol, esters of ethyl, butyl, amyl and hexyl alcohols, and about ½% of what I have thought to be a mixture of citronellol and geraniol esters. This I am investigating further, as there might be valuable products.

SECOND RECTIFICATION.

Carried out in R2.

The A2 from R1 runs directly into the kettle of R2. (This saves evaporation and transference losses which were previously found to be considerable).

For this final rectification the most suitable charge has been found to consist of 4,000-5,000 gallons of A2 and 1,000 gallons of water plus 10 lbs. of soda. The column of the still holds another 1,000 gallons of water. The diluted soda is charged on to the 5 bottom plates, and thence into the kettle.

The acetone runs after about 5 hours' heating, and almost at once is of excellent quality, tailing off gradually towards the end. The delivery is at the rate of about 300 gallons an hour. The acetone is run into the series of 4 gauge tanks, so that it can be tested before running to the shipping tank A3, and if of poor quality can be run back to A1. Towards the end a small quantity of yellowish oil is obtained. 4,500 gallons of A2 will usually give a car load (3,600 gallons) of good acetone, the tails being considerable in amount and very bad in quality, and are run back to A1. The average acetone as obtained analyses approximately as follows:—

Permanganate Test, 4-6 hours.
Acidity (carbon dioxide only) 0.0013%-0.0015%.
Alk. to p-nitrophenol, nil.
Sp. Gr. 0.7980 at 15.5° C.
Residual matter, 0.0004%-0.0007%.

It has been found more satisfactory to run the tails back to A1 and mix with fresh AB than to retain the tails separately and redistil. Possibly the organic acids in AB have a beneficial effect in purifying the tails, as it usually happens that when a large amount of tails are obtained from R2 and are run back to A1, that the next distillate of A1 and AB gives exceptionally good quality acetone.

The acetone is sometimes distinguishable from the acetone prepared by other processes by a very faint musty odour. The cause of this has not been determined, but the amount of the impurity must be extremely small. The odour seems to be exaggerated by the distillation with soda, being present before this treatment in modified form. It is not apparently completely removed by distillation with dilute sulphuric acid, but appears to be modified by this treatment. It might possibly be due to minute traces of imid ethers. Any aldehyde which is present in A2 appears to be high boiling and is probably butyric aldehyde.

BUTYL ALCOHOL.

This runs as constant boiling mixture from the tail box of R to tank B1, from whence the top layer overflows to B2. B2 is periodically pumped out to a large iron storage tank (250,000 gallons outside, the amounts pumped being measured.

From this tank, referred to as B2 storage the butyl is withdrawn, and passed through the continuous salting plant, then an 18,000 gallon settling tank, from which the butyl layer overflows to the shipping tank.

The butyl salts up to about 92% dryness, and the following an approximate analysis made on a sample of 92% dryness, which was taken from the whole of the stock which had accumulated to April 8th, 1917.

Butyl-Alcohol	84-85%	by weight
Ethyl alcohol	6-7 %	" "
Water	8 %	" "
Acetone	0.7 %	" "
Salt (sodium chloride)	0.2 %	" "

Included under butyl alcohol will be the small amounts (probably less than 1%) of amyl, hexyl alcohols, etc. The salted butyl alcohol is found to very rapidly rust steel drums, thus causing discoloration.

GENERAL CRITICAL SURVEY.

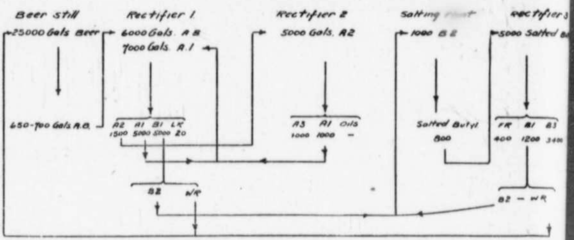
BEER STILL—By instalment of the double pumping arrangement referred to the capacity of this still has been raised from between 4 and 5 thousand gallons per hour up to 6,000 gallons per hour; but it does not seem probable that the column as at present constituted could deal with a much greater amount of beer. We are thus able to deal with from 5-6 fermenters per day, provided everything runs smoothly. As in the near future we hope to be fermenting 6-7 tubs a day, the question of increased beer still capacity is under consideration.

RECTIFICATIONS.

R1—With the present arrangement, which involves the use of kettle R2 as storage tank, this still (R1) is pretty well fully loaded, and when our fermentation capacity is increased to 6-7 fermenters a day it will be overloaded. In view of this fact, and the fact that R2 is not altogether a satisfactory type of still for the final rectification, we are considering the question of installing a small continuous still for the rectification of our A2. This would allow the use of our present stills R1 and R2 for primary rectifications.

R2—The kettle of this still is used as a storage tank for the A2 derived from R1, thus saving evaporation and transference losses. This still has too large a kettle, and is generally speaking too large for the work which it has to do. Thus at 6 tubs a day this still would only require to be run once a week with a charge of, say, 3,000-4,000 gallons of acetone. It appears that the prolonged heating to which some of the acetone is necessarily submitted in a discontinuous still of this type has a detrimental effect upon the acetone, so that comparatively large amounts of poor acetone are obtained as a tail product. Possibly the relatively large copper surface to which the vapours are exposed for a considerable time under pressure may have a detrimental catalytic effect.

Scheme of Distillation.



Beer	Contains	roughly	½% A & 1% B
AB	"	"	22-23% A. & 46-48% crude dry Butyl.
A1	"	"	10-20% A. variable amounts of Ethyl Alcohol, Butyl Alcohol.
A2	"	"	98-100% A. traces of impurities.
A3	"	"	Pure acetone as shipped.
B1	"	"	Butyl constant boiling mixture separates into 2 layers.
B2	"	"	Top layer of B 1.
B3	"	"	Rectified Butyl alc. 98-100% Butyl alcohol.

LR Mixture of amyl alcohols, hexyl alcohol, octyl alcohol, and esters of these.

WR Bottom layer of B1 (8-10% butyl alcohol.)

Salted Butyl 90-92% dryness and contains ethyl alcohol and traces of acetone.

DISTILLATION LOSSES AND YIELD TO WEDNESDA JUNE 15th, 1917.

Up to this time the amount of fermented corn which has passe through the beer still was 11,852,975 lbs. which corresponded approximately to 10,202,841 lbs. of dry corn.

As we have no means of estimating accurately the total aceto in a fermenter, we cannot estimate losses in the Beer Still, but a this is a continuous still and rarely removes the acetone togeth with butyl and water with no rectifying action the losses here would be very small.

The average yield of acetone on dry corn based on estimated of acetone in AB is 8.45%.

The average yield of acetone on dry corn based on acetone shipped is 7.7%.

The percentage loss in the two rectifications and until acetone is shipped is 8.9% of the acetone in AB of which 1.8% is accounted for by acetone which goes away with the butyl (the wet butyl) alcohol containing approximately 0.7% acetone).

Thus acetone loss not accounted for is 8.9 - 1.8=7.1% of the acetone in the original AB.

The installment of the small continuous Barbet still (which is in progress) should reduce rectification losses as these are undoubtedly partly due to the use of large discontinuous rectifiers.

"IDEAL ARRANGEMENT."

(a) Probably the most satisfactory distillation plant which could be installed in view of present arrangements would be as follows:

Retain present beer still and either install a small auxiliary ditto, or convert the present beer still into two stills, as it appears that the whole of the separation takes place in the top half of the still. The A.B. from these stills would then be passed through some form of Barbet continuous still, provided with a good rectifying column, and containing acid and soda chambers, so that these could be used if necessary. Evidence obtained from our discontinuous rectifiers, indicates that head products, more especially after soda treatments, are very small, if any at all, hence we could probably draw off from such a still, a pure acetone with a single distillation. Probably by the use of the continuous still the tail product would be considerably reduced. From the lower plates in the still, one might draw off a mixture of butyl alcohol, water, and ethyl alcohol, rich in the latter, and from the bottom, butyl alcohol —water constant boiling mixture.

(b) As an alternative to the above, the following arrangement could be more easily and rapidly installed, and in view of urgency will probably have to be done:

Retain present beer still, and either install small auxiliary ditto, or cut present still in half and convert into two separate stills. Use R1 and R2 for primary rectification running the A2 from these to the storage and diluting tank, and from thence to a small continuous still to obtain the pure product.

RECTIFICATION OF BUTYL ALCOHOL.

It appears that whilst some manufacturers are satisfied with the crude wet Butyl Alcohol (72-75% dryness) or the salted Butyl Alcohol 90-92% dryness others require pure dry Butyl Alcohol and we have had enquiries for this.

Arrangements are being made to put one of the Gooderham & Worts' rectifying stills permanently in commission for rectifying the Butyl Alcohol, meanwhile two trial distillations have been made and indicate the purification will be a simple process.

The still used is a discontinuous one of similar construction to those used in the rectification of our acetone and consists of a 40 ft. column made up of 9 sections with 25 plates, each containing 3 boiling caps. The kettle is of 7,000 gal. capacity. A goose tank dephlegmator is used.

In the first distillation the kettle was charged with 5,000 gals. of salted Butyl (92% dryness) the column being left dry.

Procedure and results as follows:

Heated up 4 hrs. returning liquor to column via goose tank. At end of this time the liquor had attained a gravity of 0.814 at 21 deg. C. indicating a strong spirit. The gravity gradually rose during 4 hrs. to 0.840, the temperature of the vapours rising from 70 deg. C. to 90 deg. C. At this stage the gravity of the liquor rapidly rose to 0.875 and the liquid became milky, the temperatures of the vapour being 91-93 deg. C. The liquor ran cloudy for 3 to 4 hrs. and consisted of Butyl constant boiling mixture free from Ethyl Alcohol. Towards the end of this fraction the rate of flow diminished to a mere trickle and the temperature at the top of column rose to 109 deg. C. At this stage therefore the reflux liquor from the goose tank was sent directly to the cooler instead of being returned to the column. The liquor at the tail box rapidly attained a gravity of 0.810 at 21 deg. C. and became clear. The temperature of the vapours at top of column at this stage was 116 Deg. C. The cut between the fractions was very sharp:

In the second distillation the column was left charged with dry Butyl Alcihol and a fresh charge of 5,000 gals. salted butyl was introduced.

It is considered advisable to divide the product into 3 fraction.

(1) First Runnings. F.R.

A spirit rich in Ethyl alcohol and containing in addition Butyl alcohol, water, acetone. This is non-saltable but might be redistilled to obtain a strong ethyl alcohol and recover some of the butyl alcohol Specific Gravity at tail box varying from 0.814 to 0.840. Temp. of vapours from 72 deg. C.-91 deg. C. (chiefly at about 80-85 deg. C.).

(2) BI.:

Butyl constant boiling mixture practically free from ethyl alcohol. This is saltable and the top layer will be returned to the salting plant, the bottom layer (aqueous) to the beer still.

(3) B3:

Rectified Butyl Alcohol. This is water white dry butyl alcohol coming over at 116-117 deg. C. with specific gravity of 0.811-0.810 at tail box.

The two trial distillations indicate that the relative proportions of these fractions from a charge of 5,000 gallons of salted butyl will be roughly as follows (it is assumed that the column is charged with dry butyl from previous distillation, 2,000 gals.):

(1) 400 gallons F. R.
(2) 1,200 gallons B. 1.
(3) 3,400 gallons B. 3.

The average rate of distillation will be from 300-400 gals. per hour—about 150 gals. per hour of B. 3 for whole time.

QUALITY OF B. 3 (RECTIFIED BUTYL ALCOHOL).

Sample from 6,480 gals. on hand June 29th.

Specific Gravity at 21 C. 0.8109.

Tests for Water:

(a) Crystals of pot, permanganate, no coloration.
(b) Carbon bisulphide. No turbidity. ,

150 c.c. distilled in 250 c.c. flask with standard thermometer at rate of 1 drop per second.

Bar: Pressure 759 mm.

First runnings at 110° C.

110-114° C.	8 c.c
114-116° C.	15 c.c.
116-117° C.	115 c.c.
117-117.2° C.	8 c.c.
Left in flask still boiling at 117.2	2 c.c.
	148

This indicates in my opinion, that the quality is very satisfactory the amount of water being very small.

BUTYL RECTIFICATION—ARRANGEMENT OF PLANT AND METHODS OF WORKING.

A 2,500 gallon tank (B2 supply) delivers to the salting drum and thence to an 18,000 gallon tank (Butyl settling). The overflow from this tank runs into another 18,000 gallon tank which constitutes a supply for the Butyl alcohol rectifier or a shipping tank for salted Butyl alcohol.

From this tank the liquid is pumped over to two graduated charge tanks of 8,000 gal. capacity contained in the G. & W. section. The kettle of the rectifier is charged by gravity from these tanks.

The rectifier delivers from the tail box through 3 pipes.

(a) F. R. To any one of nine 9,000 gallons graduated copper storage tanks in No. 2 tank house.

(b) B. 1. To two 3,600 gallon tanks.

(c) Rectified Butyl alcohol. To any one of nine 9,000 gallon graduated copper tanks in No. 2 Tank house.

F. R. Can be pumped back to the rectifiers for further rectification if necessary.

B. 1. Can be pumped back to a settling tank near the salting plant, the aqueous layer being then pumped with beer to Beer Still and the top layer delivered by gravity to the salting drum.

B. 3. Can be racked off in No. 2 Tank House.

CHEMICAL LABORATORY.

During the first two or three months, Mr. Speakman and myself equipped the present Bacteriological Laboratory and worked together in this laboratory on general chemical and bacteriological problems connected with the carrying out of the fermentation process on a large scale. On commencing regular work on the large scale it was agreed, on account of limited accommodation, in the bacteriological laboratory and in order to facilitate the control of the working of the two main sections of the process, i.e., fermentation and distillation, that Mr. Speakman take charge of the working control of the fermentation section and myself of the distillation and chemical end. In regard to general principles in either section, these have been decided on after discussion at the bi-weekly meetings of the executive and elsewhere. The chemical laboratory was therefore transferred to the laboratory of the General Distilling Company, situated in the distilling building.

This is a room about 30 ft. by 20 ft., well equipped for the purpose of an ordinary routine work laboratory.

For the investigation and research in connection with the carrying out of our process, considerable rearrangement and additional apparatus has been necessarily required, and I am greatly indebted to the Toronto University Chemical Department, for the loan of apparatus and chemicals which could not be readily obtained.

ROUTINE WORK—This includes: Estimation of Acetone per gallon in "beer" from all fermentations.

Estimation of Acetone and Butyl Alcohol in all charges delivered to rectifiers and in storage tanks at end of week.

Examinations of each batch of pure acetone from R2 and examination of samples from drums.

Control of drum cleaning and shipping room staff.

Control and training of acetone distillation and rectifying staff and supervision of plant.

Control of Butyl Alcohol salting and rectifying plant and staff.

Analysis of coal and flue gases.

Records of distillation and rectification are kept by still men and girls as shown on accompanying sheets.

RESEARCH WORK—Under this heading are included numbers of minor problems which naturally cropped up in connection with the carrying out of a comparatively new process. For example, it was noted that a very large intermediate fraction A1 was obtained and that this ran clear from the tail box after the percentage of acetone was reduced to less than 1. This was found to be due to presence of ethyl alcohol not previously mentioned to my knowledge, in connection with this process.

Laboratory, research and experimental plant work in connection with the Methyl Ethyl Ketone plant has been previously reported on.

There has of course been much time spent in consultation with Mr. Metcalfe Shaw in connection with method for carrying out not only the fermentation process but conversion of butyl alcohol into methyl ethyl ketone. In these discussions we have endeavored to get at the root of matters before proceeding to construction though necessarily some sections of construction work have been experimental.

D. A. LEGG.

JUNE, 19

FLOW OF MATERIAL THROUGH PLANT

JUNE, 1917.

J. W. HAYWARD.

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FLOW OF MATERIAL THROUGH PLANT.

GENERAL—This section of the report deals with the capacity of each section of the plant in relation to the amount of material with which it has to deal. From such a point of view, and considering that an old factory has been adapted to new purposes, we now have a fairly well balanced system for fermenting 87,500 pounds of corn per day, in five batches.

So far it has been necessary to keep Sunday clear for alterations and repairs; thus thirty batches per week is our standard.

The following is a table of weekly quantities:

	Per week	Per 100 lbs. corn as used.	Per 1 lb. finished acetone
Maize, lbs.	525,000	100	15.0
Mash, gals.	750,000	143	21.3
1st distillate, gals.	21,750	4.15	0.62
Acetone in ditto lbs.	37,300	7.1	1.06
Finished acetone, lbs.	35,100	6.7	1.00
Coal, lbs.	900,000	171	25.6

ORIGINAL PLANT—In May, 1916, there was handed over to us the complete plant of the General Distillery Company, designed for making alcohol from molasses, and we were given the use of the boilers, grinding mills and mash tubs in Gooderham & Worts' distillery. The two distilleries, though then quite distinct, are built on opposite sides of a common yard.

The General Distillery plant consisted in the main of six Babcock and Wilcox boilers of 1,200 h.p., total capacity, and working at 110 lbs. pressure; nine open steel fermenting vessels, 18 ft. diameter, 20 ft. high; four smaller vessels 12 ft. diameter, 12 ft. high; four copper yeast tanks, 680 gals. capacity; five ditto 140 gals.; a continuous beer still, 6 ft. diameter; two rectifiers to take a charge of about 13,000 gals. each; various storage tanks; charcoal filters, and a large evaporator.

The Gooderham & Worts plant has twelve tubular boilers of 1,200 h.p. capacity, 60 lbs. working pressure; a mill capable of grinding 8,000 lbs. of corn per hour to pass a 36 mesh sieve; and four mash tubs for cooking mash with live steam, each of which will hold 5,000 gallons.

ALTERATIONS MADE—All that we had to do with the Gooderham & Worts' plant was to put in a centrifugal pump and 500 feet of piping to pump the mash across the yard to the General Distillery.

The conversion of the General Distillery plant into an acetone factory was a more serious matter. Messrs Legg, Speakman and Hayward had had some experience of what was required, and what was to be avoided, from experiments with a single 12,000 gallon fermenter at Poole, in which all the processes of mashing, cooking, cooling, fermenting and distilling were carried out. Mr. Shaw had had experience of evaporation on a large scale in connection with sugar making, and last, but not least, Colonel and Captain Gooderham had a thorough knowledge of corn milling and alcohol distillation.

We agreed from the first that a prompt and large output was of more importance, under present conditions, than low factory costs, and the former consideration has always been given precedence when it clashed with the latter.

The chief alterations made were as follows:

The four 12 ft. vessels were enclosed and strengthened to withstand a working pressure of 15 lbs., and used as cookers. Mechanical stirrers were installed, but have been abandoned, and the stirring is now done by steam jets.

The nine larger vessels were enclosed and used as fermenters; and three similar ones were added. It was the original intention to work these under 1½ lbs. pressure of gas when fermenting, or of steam when sterilizing. Dead weight safety valves were fitted, but as the weights were often moved and sometimes altered by thoughtless workmen, these were replaced by spring loaded valves, which in their turn gave trouble by sticking or leaking. It was also intended at first to collect the gas generated and extract any acetone it might contain, afterwards making use of it to drive gas engines. This was abandoned on account of building and other restrictions in force in Toronto.

Now the idea of working the fermenters under more than a few ounces pressure has been given up. The gas escapes directly to the air, and safety valves are being replaced by a simple water seal like that used successfully at Poole—a most important simplification.

A pump and a cooler, especially designed for the purpose were installed between the cookers and fermenters.

The four larger yeast tanks were adapted for seed tanks, and five more of the same size were added, and also three copper kettles for preparing inoculant, and a small mash tub for filling these. One inoculator serves three seed tanks, and one seed tank one fermenter, though half a tank has been used successfully on occasion.

An extra pump and a service tank were fitted to pass the fermented mash to the beer still at as fast a rate as possible.

No change, except alterations in piping, was made in the still or in the first rectifier, which is used to separate the acetone from the butyl alcohol.

In the second rectifier arrangements were made for flooding certain plates in the column with a solution of soda, and four gauging vessels were added below the tail box, into each of which in turn the finished acetone is run, and tested with permanganate before being sent forward for shipment.

SYSTEM OF WORKING—Mashing is started every week day morning at 7 o'clock, and stopped for two hours in the afternoon to allow of sterilising the cooler and cooled mash pipes. It is finished at four or five a.m., allowing a second interval for cleaning and sterilising. The advantage of working thus on a regular schedule so that each operation is carried out at the same time each day is most marked. It prevents mistakes, and checks needless delays.

Five tubs of mash go to four cookers, and four cookers to one fermenter. This quantity fills a fermenter to within about five feet of the top. If filled fuller the mash foams up through the gas pipe during fermentation. As it is, foaming often occurs and gives considerable trouble. It takes place towards the end of fermentation, and is stopped by pumping some of the mash to the beer still service tank.

The beer still is worked as required, but is usually idle for a few hours each afternoon, and always on Monday night.

One batch (25,000 gals.) yields 725 gals. of first distillate, called AB. an average analysis of which is:

Acetone	**21.4%**
Butyl Alcohol	**47.4%**
Water	**31.2%**

This is redistilled in Rectifier 1, along with the returns from the rectifiers, called A1, and yields acetone, which is sent to Rectifier

2 for final treatment, and butyl alcohol, called B1, and some returns A1. On standing, a little water, with acetone, settles out of B1, and this is returned to the beer still. The remaining butyl is being stored for further drying.

From Rectifier 2 the pure acetone goes through the gauging tanks to the shipping tanks, that which has to be returned is also classed as A1.

The average charge of Rectifier 1 is 12,750 gallons, consisting of 5,680 gallons of first distillate (AB) and 7,070 galllons of returns (A1).

STEAM SUPPLY—Five of the six boilers of the General Distillery are constantly under steam, and one is open for cleaning. Of Gooderham & Worts' boilers seven are always in use, one is open for cleaning, and four are permanently shut down.

Records of the coal burnt per week show that the consumption is roughly 20,000 lbs. per batch, plus 43,000 lbs. per day to cover radiation heating of buildings, etc. The latter item is of necessity large, since for safety a thorough circulation of fresh air has to be maintained in the fermenting and still rooms. In the winter this air comes in dry at a temperature of from 0° F. to 20° F., and goes out moist at 60° F. to 80° F.

A two-inch diameter emergency connection has been put in between the two system of steam pipes, to provide heat in all the buildings in case of a breakdown in either boiler plant. A full size connection properly safeguarded is under consideration.

DETAILS OF WORK.

MILLING—The mills will grind the 87,500 lbs. of corn required for five batches in eleven hours.

Since we grind only to pass a 24 mesh sieve, instead of the 36 mesh for which the plant was designed, the working balance is somewhat upset, the scalpers for separating the bran being harder worked than the rest. An extra scalper has been ordered. When it arrives the hours can be reduced.

MASHING—Three of the four mash tubs are in regular use, the fourth serves to store hot water for washing out the others. Each tub is in actual use 15 hours per day.

COOKING—Including filling, at least two hours' cooking, and emptying, each cooker is occupied 18½ hours.

At present this total is controlled by the rate at which the mash can be cooled.

COOLING—The cooler is in use also 18½ hours per day.

FERMENTING—During the week ending April 29th, which is fairly representative, each fermenter has been occupied on the average as follows:

	Hours per week 7 days.	Hours per batch gross.	Hours per batch net.
Filling and fermenting	77.4	30.9	30.9
Waiting for still	4.9	1.9	1.9
Emptying	8.6	3.5	3.5
Cleaning	0.7	0.2	.....
Sterilizing	33.7	13.5	12.0
Spare time	42.7	17.1	.....
	168.0	67.1	48.3

One fermenter only is cleaned per week; therefore the above average allowance for cleaning is one-twelfth of the time actually occupied.

Ordinarily, 12 hours is allowed between batches for steam washing and sterilizing, but after opening a fermenter to clean it, or when contamination is found, an extra period of 60 hours is occupied in alternate heating and cooling.

From the above table it appears that the time allowance for each batch must be at least 48.3 hours, or 50 hours including allowance for cleaning and other delays.

PREPARING INOCULANT—The seed tanks are filled directly from the cookers, and cooled by running water down the outside. There are sufficient of them to allow of one being laid off for repairs at any time.

The contents of any seed tank that is not used for inoculation is sent to the beer still, when completely fermented.

DISTILLATION—The first distillation is carried out in the beer still. The fermented mash is pumped first into a service tank of

7,000 gallons capacity, and thence to the still by a second, gear-driven pump, the speed of which can be accurately controlled. Thi arrangement allows of a constant rate of distillation, though th first pump has to be slowed down when a fermenter is nearl empty, to avoid drawing air. The fastest regular rate of working obtained so far is one batch in 3 hours 50 minutes, or 30 batche in 115 hours.

It is more economical to run slower when time allows.

First Rectification—In rectifier 1 it takes 36 2-3 hours t distil an average charge of 5,689 gallons of first distillate (AB) mixed with 7,070 gallons of returns (A1); to empty, clean an refill takes at least 3 hours.

These figures imply that at standard output rectifier 1 is occ pied 154 hours per week, leaving a balance of only 14 hours. Hen rectifier 1 is at present the hardest worked section of the plant.

Second Rectification—Rectifier 2 is at present worked wit an average charge of 4,900 gallons run direct from rectifier 1, an about 160 gallons of returns from the shipping room.

The average run takes 24 hours; emptying and cleaning tak 2 hours; no separate time can be stated for filling, as this depen on the working of rectifier 1. An intermediate tank could be use and then filling would take one hour. On this basis rectifier 2 ma be considered as usefully occupied for 40½ hours per week.

Future Extensons—Four new fermenters are complete an ready for use. An additional cooler is erected, and has been trie but requires some alterations. Designs are being prepared for small continuous still to do the final rectification of the acetone an so leave both existing rectifiers free to deal with the first distilla The beer still in Gooderham & Worts' distillery is available wh needed.

With these additions, we estimate that the output of the pla will be at least 39 batches per week, *i.e.*, 6 and 7 a day alternate

Further, we intend to increase both the amount and streng of each batch. We are making experiments in this directi already.

Assuming that we can increase the maize fermented per ba 10%, with a 5% increase in the amount of water used, our wee output will be as follows:

FLOW OF MATERIALS.

	Quantities Per Week.	
	Present.	Future.
Maize, lbs.	525,000	750,750
Mash, gals.	750,000	1,023,750
1st distillate, gals.	21,750	31,100
Acetone in do. lbs.	37,300	53,300
Finished acetone, lbs.	35,100	50,300
Coal, lbs.	900,000	1,080,000

Assuming that the work will be divided evenly between the new cooler and the old one, and that the first rectification will be carried out in both rectifiers, and making allowances for increased quantities per batch, the weekly time-sheet will be:

PROCESS	Units in Use	Working hours per unit per batch	Ditto per week	Cleaning etc. per week	Idle hours per unit per week
Mashing	3	3.2	125	3	40
Cooking	4	3.7	144	12	12
Cooling	2	2.4	94	24	50
Fermenting	16	3.0 a	117	5	46
Distilling	1	4.0	156	4	8 b
First rectification	2	2.9	116	....	52

(a) An allowance of twelve hours for sterilizing is included in this figure.

(b) It is intended to use Gooderham & Worts' still when needed to make up time after delays.

It appears that in future the cookers will be the hardest worked part of the plant. It will, however, most likely be possible to reduce the time of cooking slightly. Ten minutes on each cooker would increase the idle hours to 25.

J. W. HAYWARD.

EDWA

July 14, 19

BRITISH ACETONES, TORONTO, LIMITED

GENERAL REPORT

by

EDWARD METCALFE SHAW, WH.SC., ASSOC. M. INST. C.E.

July 14, 1917. **Toronto, Canada.**

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SECTION 1.—GENERAL INTRODUCTION.

GENERAL—In the spring of 1916, the Imperial Munitions Board entered into certain arrangements with the General Distilleries, Limited, and Messrs. Gooderham & Worts, both of Toronto, Canada, under which the British Acetones, Toronto, Ltd., was formed for the purpose of converting the General Distilleries into a factory for the manufacture of Acetone; certain parts of the Gooderham and Worts Distillery being also placed at the disposal of the Company. Operations were begun in May, 1916, Colonel Gooderham accepting the position as manager of the new Acetone Factory with Capt. Gooderham as Assistant Manager. Mr. E. Metcalfe Shaw accepted a position as expert in connection with the various methods and processes. Mr. J. W. Hayward, Construction Engineer, Mr. Allison Legg and Mr. H. B. Speakmann, Research and Bacteriological Chemists, were sent out by the Imperial authorities to take charge of the respective departments.

PROCESS—The process to be adopted was that in use at the time at the Royal Naval Cordite Factory at Poole, involving the use of Dr. Weizmann's culture, but the information available regarding the process was admittedly very incomplete. Accompanying this (see Appendix to this section) is a copy of a memorandum by Mr. Arthur E. Hadley, the only information available before the arrival of the experts from England, and the only written matter received on the subject.

The process is simple provided certain fundamental conditions are not violated and the culture under favourable conditions, works rapidly, but is unable to combat even small numbers of foreign germs. Thoroughly sterile liquor or starch solution produced from either crushed maize or malted barley wort is inoculated with the culture and the resulting fermentation continues for from 18 to 48 hours, with a reasonable certainty of completion between 24 and 30 hours, depending on various conditions after which the beer is distilled and fractionated or rectified in the usual way. The yield based on previous work elsewhere was stated to be about 8% of acetone and 19% of butyl alcohol (both on a dry corn basis).

OUTPUT—Originally the plant at Toronto was expected to have a maximum output of 250 tons of Acetone per year. This maximum has, however, through hard work, careful management, good engineering, chemical and bacteriological practice and painstaking attention to details, been steadily increased to a rate at present of 1,000 tons per year. This rate, however, is being constantly increased through improved methods and apparatus, and increased skill in operation, and it is expected the final rate will considerably exceed the present output.

In view of the difficulty experienced here and elsewhere in getting steady good results by this process the successful working of this plant makes it desirable that this report should be as exhaustive as possible, not only as regards the arrangements which are working well, but as to many details which have been eliminated as faulty or dangerous.

WORT *vs.* MASH—The first point considered was whether wort produced by malting on the one hand, or mash on the other was to be used for fermentation. The decision in favor of the latter was influenced mainly by the greater yield from mash, the increased cost of malting and largely by the experience of Colonel Gooderham in dealing with problems involved in operating with large quantities of mash and beer, containing high percentages of undissolved matter. It was evident that the mash system would reduce cost whilst the difficulties involved in handling the mash and beer, in the beer still could be safely dealt with under Colonel Gooderham's guidance.

There were many points to be considered before arriving at a decision in the matter. The most important factors favoring the use of the clear wort are the percentage of solids retained as cattle food and an easier liquid to handle, especially when cooling, while against these are the greater cost of barley and the cost of malting. In connection with the mash, the disadvantages to be overcome are the difficulty of cooling and maintaining sterility, the complete destruction of the solids from a cattle food point of view, and the difficulty of disposing of the enormous quantities of slop. On the other hand, the use of mash possesses the advantages of giving excellent results and better yield than the wort.

The record at present made, during a continuous run of 3 months still proceeding of 460 fermenters of 25,000 gals. capacity equal to a total of 11,500,000 gals. without the loss of any maize and a high yield of from 8.5 to 8.8% shows that though difficult the system can be safely and regularly worked.

Having decided on the mash as against the wort system an inspection of the plant, placed at the disposal of the Imperial Munitions Board showed that ample facilities existed for corn and coal storage, steam production, corn grinding and mashing. It remained to re-arrange, re-construct and add to the appliances available or deemed necessary for carrying on the whole of the process from the mash stage to the shipped product.

CONDITIONS—In doing this the following conditions had to be fulfilled:

(1) Complete sterilization of mash.

(2) As complete solution of starch as reasonably possible.

(3) Absolute sterility of all pipes, valves and vessels in use.

The methods adopted at the outset to secure the fulfilment of these conditions have been found satisfactory in principle. From time to time improved means of carrying the methods into effect have been devised until it would appear that for a partially continuous plant such as this developed into, the existing arrangements as now being perfected are capable of only such improvements as would be possible in putting up an entirely new installation.

PRINCIPLES UNDERLYING METHODS ADOPTED.

In the beginning practically the only information available on which to base the construction and operation of an acetone factory working on this system, was that gathered from the operation of the comparatively small acetone plant at the Royal Naval Cordite Factory at Poole, England. This information was first received in the memorandum from Mr. Arthur E. Hadley and later directly from the Research and Bacteriological Chemists and Construction Engineer sent out by the Imperial authorities, and who had the benefit of having actually worked at Poole.

In the Toronto plant, however, there were principles underlying the methods adopted to carry out the various processes which differed from those used at Poole, these constitute one of the factors to which the Toronto Plant largely owes its success.

MASH PREPARATION—The first change in principle from the methods adopted at Poole, was the abandonment of the, in some respects preferable and more easily handled system of using malted barley or oats to produce wort for that of using a mash of crushed maize. As will be observed from the section of the report dealing with the original plant, there were in the Gooderham & Worts Distillry, a completely equipped mill and mashing arrangement including 4 wooden mashing tubs, formerly employed in the production of the whiskey from malt, rye, oats and corn. This equipment was used for the grinding of the maize to meal of a fineness which has been successively varied from that which would pass through a 36 screen down to that passing through an 18 mesh, and the subsequent mashing or mixing of the meal with water, in the mash tubs at the temperature of 120° F.

This necessitated combining the preparation of the mash in the whiskey plant of the Gooderham & Worts Co. with the subsequent fermentation in the plant of the General Distilling Co. originally producing industrial alcohol from molasses.

DIGESTERS—A convenient and valuable device adopted was an arrangement for heating and partial-cooking the above mash on its way to the cookers proper by means of steam jets, near the delivery and of the mash pipe which thus formed a "Digester"—see special section describing this. This proved efficient and a satisfactory innovation taking care of a part of the cooking and delivering the mash at the working temperature into the cooker, thus materially reducing the load on the cooker, and rendering the mash immediately sterile.

SEPARATE COOKERS—Another departure in principle of an important character was the cooking of the mash in steel tanks entirely separate from the tanks in which the fermenting part of the process is being carried on. The mash passes from the digesters into the cookers, of which there are four. These are cylindrical steel 8,000 gal. tanks, in which the cooking is done under a pressure of 15 lbs. of steam for an outside period of 2 hrs. thoroughly preparing the mash for bug food and rendering it absolutely sterile.

COOLING—Continuous cooling is an important element in the process as carried on at Toronto. The cooling is done as the mash is pumped from the cookers to the fermenters in specially built coolers of the coil type, which are fully described in a separate section of the report. There are two coolers both designed on the same principle in so far as the mash circuit is concerned, but of different construction as regards the water circuit. These coolers have done well and are efficient, as regards space occupied, rapidity of cooling and self-cleaning properties, and working together deal with about 10,000 galls. of mash per hour, with cooling water entering at 40° F.

Positive System—A principle to which much of the success of the Toronto plant is due is that of securing continued sterility in the plant by maintaining so far as possible, a positive steam pressure at all times throughout the entire system (except in the fermenters, which under rigid precautions are compelled to have at definite times an internal pressure slightly below that of the atmosphere), and also in addition the frequent steaming of the units and lines under high pressure. The general system is thus a positive one by means of which the pressure is always from the inside outward effectually preventing the entrance of foreign germs. In the case of the fermenters this positive pressure cannot be continuously maintained because of the cooling which causes a partial vacuum. A system of sterilised air supply under pressure to overcome this objectionable lowering of pressure was considered but abandoned because of serious objections to its use. The inflow of air occurs now through sterile cotton wool.

This positive system will be found illustrated and described in various sections of the report.

Fermenter Protection—The problem of safeguarding the large fermenting tanks made of thin steel sheeting which are fully described in the section of the report dealing with the existing plant was a difficult one. It was finally solved by discarding commercial types of vacuum, and safety valves, and installing a specially designed and constructed style of vacuum valve (see section on the Existing Plant which was sensitive and safe as regards sterility; together with a new and efficient safety device. (See section on the Existing Plant and also the section on the Gas Discharge). This latter consists of a water seal arrangement using antiseptic water thus ensuring absolute sterility. The device acts as a safety valve, a gas discharge measuring device and when gas is discharging at a maximum rate affords a free outlet to the atmosphere. It has proved eminently satisfactory, as with its introduction the long run of successful fermentations began.

The abandonment of gauge glasses on the fermenters was another radical but necessary step because of the nature of the medium in the tanks. The glasses proved quite unreliable due to choking and were therefore abolished. At the present time the trycocks only are used to determine the approximate contents of the fermenter (within 200 to 300 gals.) The contents are primarily dependent on the quantity in each mash tub. Five of the latter are divided equally among four cookers and four cookers are used to fill a fermenter. A tank is known to be empty when the pump emptying it commences racing.

EDWARD METCALFE SHAW.

Appendix—Communication from Arthur E. Hadley.

ACETONE—WEIZMANN PROCESS.

As this process is new and has not been tried on a large scale for any length of time, I am unable to send exact details of what alterations will be required at the Distillery. You will realize that lacking detailed drawings of the fermenting vats, etc., and not knowing whether the Distillery produces its Alcohol from grain or molasses, it is rather difficult to say exactly what should be done to make it suitable for producing Acetone. Perhaps the best way will be to give a general account of the Weizmann process as it is at present at work in the Royal Naval Cordite Factory at Poole, and you will then be able to judge the local alterations that are necessary to the General Distillery Company's plant at Toronto.

The process is simple provided absolute sterility is obtained before the liquor is inoculated. The culture works rapidly under favorable conditions, but fails if foreign germs are present even in small quantities.

The liquor to be inoculated may be produced from crushed maize or from malted barley wort. If crushed maize is used, the spent grain or draff must be left in the liquor until fermentation is completed; clear wort is preferable as the spent grain after fermentation gives rise to difficulties in handling it and cleaning the fermenting tanks.

If wort is used, the clear liquor should be run off as a mixture composed of about 1 part grain to 15 parts water by weight, the grain being about 86-90% crushed maize to 14-15% malted barley. It has been suggested that a mixture of malted barley and malted oats would be better on account of cost, but this has not been tried. The wort prepared in this way has to be run into the fermenting vat and well sterilised. The sterilisation is complete after the liquor has been brought to a temperature of 90° C. for two hours. After sterilising, the liquor must be cooled to about 37° C. and then inoculated. The inoculant is about 3% of the liquor to be inoculated in the fermenting tank. If crushed maize only is used, the fermenting vat can be filled about two-thirds full with water and the crushed maize added. The liquor has then to be raised to boiling point and boiled for about 6 hours to fully extract all starch. Of course, the liquor will also be sterilised at the same time; it has then to be cooled to about 37° C. and the inoculant added as before. It is important that no contamination should take place, and it is, therefore, necessary to admit only sterilised air into the tank after the liquor has been sterilised. Air must, of course, be admitted when the liquor is cooled, and the steam occupying the upper portion of the tank begins to condense.

You will see that to enable the liquor to be sterilised and cooled in the fermenter, it is necessary to have each fermenter fitted with heating and cooling coils through which steam or cold water can be passed. At Poole a tank of 16,000 gallon capacity (containing a charge of 12,000 gallons) had an iron coil fitted inside the pipe being 4 inches internal diameter and 382 ft. long. A larger portion of heating and cooling surface would have been better as it was found that too much time was taken up in heating and cooling the liquor.

After the liquor has been inoculated and fermentation has commenced, the liquor must be kept at about 37° C. and if all goes well the fermentation keeps at about this temperature without any artificial assistance.

After fermentation is complete, which takes from 24-48 hours, depending on the virility of the germs and the temperature at which the tank is kept, the liquor contained ½% Acetone, 1% Butyl Alcohol and 98½% water.

The gases given off during fermentation are hydrogen and carbon dioxide. To prevent the entrance of unsterilised air at manhole joints, etc., it is advisable to allow the gases to escape through a relief valve which may be set at say 1 lb. per square inch above atmosphere.

Dr. Weizmann finds by experiment that 1 kilogramme of sugar or starch gives off 150 litres of hydrogen and 150 litres of CO2.

The best distillation has not yet been evolved, but the latest trials at Poole are encouraging, and it seems established that practically all the Acetone and Butyl Alcohol are given off by evaporating 10% of the fermented liquor. As the boiling points of Acetone and Butyl Alcohol are far apart, the fractionation should not be difficult. The Acetone, however, contains traces of aldehydes, and it may be advisable to mix a small quantity of sulphuric acid or bisulphuric acid with the liquor before distillation.

The fermenting tanks we have at Poole and for experimental purposes are made of iron which has no injurious effect on the liquor and no undue corrosion has occurred on the iron.

Yours faithfully,

ARTHUR E. HADLEY.

SECTION 2—PRODUCTION OF ACETONE.

THE PRODUCTION OF ACETONE BY THE USE OF THE WEIZMANN CULTURE.

GENERAL—Dr. Weizmann's culture is one which operates in connection with enzymes on starch, producing chiefly butyl alcohol and acetone. During this process hydrogen carbonic acid and slight traces of other gases are liberated. The bacilli seem to work best at temperatures of about 100 degrees Fahrenheit. They are extremely delicate organisms, and are destroyed by the ordinary bacilli present in water and air to such an extent that it is absolutely imperative that even in the smallest numbers such bacilli should be kept away.

In the early days of the work at the Toronto plant, and even to a small extent now, irregularities occurred, resulting in the time of the fermentation varying between rather wide limits 28 to 48 hours, with occasional complete spoiling of a 25,000 gall. charge of mash through contamination.

The bacteriological and chemistry experts have had great difficulty in deciding as to how far this irregularity was due to some inherent property of the culture, contaminatory influences acting during the period when the inoculent was being produced, or to other unknown causes, which might ultimately be found to depend on mechanical defects in the plant. The experience gained through a year's operation of this plant has led to a better understanding of the subject and one by one various defects, causing failures and irregularities have been discovered. These defects, such as leaking seed tank flanges, leaking valves with resultant contamination in the pipe lines when rectified have resulted in much more uniform and regular working.

STAGES OF PROCESS—There are four stages in the process.:

The first is that of producing sterile thoroughly cooked mash;

The second the production of the seed;

The third of obtaining the fermentation;

The fourth, of separating the acetone and butyl alcohol from beer.

These operations are dealt with more or less fully in other sections of this report; the one great principle adopted was that of obtaining as far as possible a positive continuous system.

INOCULENT AND SEED—It is of importance that the growth of the inoculent during the early stages should be in a series of small vessels of increasing size, thus reducing the time during which the big vessel would be occupied, and the loss should the original culture be contaminated. Present practice is to inoculate a 5 gallon steam jacketted pail charging this when properly developed into a 100 gal. inoculating vessel, then dividing this latter between three charges of 500 galls. of mash in 600 gallon seed tanks, from which the final quantity considered necessary is introduced into the large 31,000 gal. fermentors. At present a battery of six 5 gal. and six 100 gall. culture vessels is being installed. Thus there will now be two stages in the laboratory followed by the four in the plant proper.

It is obvious that a risk, however small, is incurred every time the growing volume of inoculant is moved from one vessel to another, and this must be true in the laboratory, where the inoculant is poured from one vessel to another, as well as in the factory, where the first portion is poured from the 5 gallon can, into the 100 gal. inoculator or from the flask into the 5 gal. culture vessel and subsequently passes through pipe systems with many cocks and valves and joints. Even under the present system of working there are an objectionable number of places throughout the whole plant where leakages are possible, although the number has been greatly reduced, and it is the constant endeavor of the whole staff to eliminate those remaining as soon as discovered, or possible without interfering with the normal operation of the plant.

CONTINUITY—Dealing with the question of continuity, the applications of this method, which have been possible up to the present are in digesting, cooking and cooling the mash. These are fully described under separate headings. The combined effect of these is that a safe rapid and easily operated continuous system is at work from the mash tubs to the fermenters.

Positive System—With regard to the question of the positive system, this takes the form of maintaining throughout the system from the inlet to the cookers to the discharge from the fermenters (with the exception of certain intervals in the fermenters themselves) a pressure in excess of that of the atmosphere, so that whatever leakage of liquid or gas occurs is outwards sterilised gas or liquid flowing from the system, whilst no ingress of unsterilised gas, air or liquid can occur. One danger only remains which is the possibility of bugs growing back into the system through a leak filled with mash, which is overcome by the application of the same positive principle in the form of the "steam lock." See section of report on pipe lines.

The failures through contamination have occurred from various causes.

Successful Results—Every effort has been and is still being made by applying the positive system, to obtain absolute security. The results of the last three months working shows that a remarkable degree of safety has been obtained, the plant now has been running to July 20th, during which time 516 fermenters have been distilled continuously from April 4th without one failure.

Edward Metcalfe Shaw.

SECTION 3—ENGINEERING DIFFICULTIES.

ENGINEERING DIFFICULTIES.

The difficulties of an engineering nature that have been encountered in the work at Toronto, have arisen from three fundamental causes, the first being the inherent difficulties of the process, the second the natural difficulties attending the manufacturing of an explosive product, and the third due to the adapting of an existing plant to new requirements and methods.

Difficulties of Process—Amongst the difficulties to be dealt with, due to the nature of the process itself, were the maintenance of sterility, handling of the large quantities of thick mash, rapid cooling of this mash, and exact control of the quantities of mash put into or taken out of the tanks.

The sterility was largely maintained by using the so-called positive system. The applications of this principle up to the present has not been thorough due to the difficulties encountered through the adoption of a lot of the plant and piping not quite suitable for the purpose. These latter, referred to later, were mainly due to leaking valves and fittings, awkward piping arrangements and structurally weak tanks.

The handling of the thick mash in such large quantities has been satisfactorily taken care of under the guidance of Col. A. E. Gooderham whose extensive experience in dealing with such problems proved invaluable.

The rapid cooling of the thick mash by some 150 degrees Fahrenheit was a difficulty solved by the invention of a new type of coil cooler of great efficiency and small bulk, with absolutely sealed joints which prevented by its construction, any possible choking of the tubes with the mash.

Because of the nature of the mash, the problem of indicating the level in the different tanks is a difficult one. Gauge glasses proved useless as ordinarily employed, but might prove more successful if provision were made for blowing them out with either steam or water, as is now done on some of the smaller vessels here. At present, trycocks are largely depended on to show the level.

Difficulties Due to Explosive Nature of Product—The fact that the product is explosive, and that hydrogen gas is generated in large quantities during the fermentation necessitated extreme care as to its safe discharge from the building. The question of the disposition of this gas occupied a considerable amount of attention, attempts to utilize its heating or power value, were finally disposed of by discharging the gas directly to the outer air.

Difficulties Due to Using an Existing Plant—Coming to the consideration of the difficulties due to the adopting of an existing plant to the requirements of a new, although somewhat similar, process.

In the first place the tanks were of large size, and built to withstand practically no pressure beyond that due to being filled with liquid so that when strengthened as much as possible the allowable working pressures were extremely low. A higher allowable working pressure would have greatly speeded up the cooking, reduced the time occupied in sterilising both cookers and fermenters and greatly assisted in emptying. The fact that the tank bottoms were all flat, while not only rendering the tank weak from the standpoint of withstanding internal or external pressure, was a great hindrance in emptying the tanks rapidly. This time of emptying is now greatly in excess of what it would be in vessels of similar size with conical or hemispherical bottoms. Those difficulties have been partially overcome in the new tanks by sloping the bottoms as much as possible without interfering with existing piping arrangements and by rivetting the bottom to I beams.

Another prolific cause of trouble was in the valves and fittings. The valves which were in the plant, were in bad shape and required overhauling and both the old ones and the new ones, either gate or globe, were extremely difficult to maintain tight when dealing with mash. In such a process it is not only a question of tightness in the ordinary way, but tightness from a bacteriological point of view. The positive system has been the saving element here, whether the steam is applied to a whole line, to a short section between two valves or to a valve alone. In the former a whole line or header is kept under steam pressure, high or low; in the second an opening is "double valved", that is two valves placed a few feet apart in the same line with a steam connection between them forming a "steam lock", and in the third a steam jet is played on the valve disc. All of these have proved excellent in preventing contaminations but depend to a large extent on the exercising of the utmost care by the staff in working the plant.

The use in the old plant of cast iron fittings was another serious difficulty due to danger of fracture and the bad threads. This is being overcome as rapidly as possible by the substitution of malleable fittings. For extra special work, genuine wrought iron pipe is used because of the better threads.

The labor problem was a serious one from the beginning. An attempt was made to utilize the existing workmen of the two distilleries as far as possible, but proved rather unsatisfactory, because of the new methods employed. Pipe fitters were a cause of much worry because of their failure to understand the importance of tight joints and valves. The operating staff required to be trained on the job to secure good results.

It will be understood that it has been difficult to get the requisite engineering staff, both with regard to superintendents, draughtsmen and workmen. Recently the staff has been greatly strengthened by the appointment of a mechanical superintendent, nd as a result the work in hand is being much more rapidly and efficiently carried out.

EDWARD METCALFE SHAW.

SECTION 4—ECONOMIC CONSIDERATIONS.

ECONOMICS.

Accompanying this are 4 sheets of curves and graphs, a sheet giving the capacities in order of every separate part of the plant nd another giving a summary of the monthly expenditures and manufactured acetone and Butyl alcohol passed into stock or shipped.

The curves and graphs show at a glance not only the capacities f the separate parts of the plant, but the rate at which money has een spent and earned.

No account is taken of the value of the plant and premises laced at the disposal of the British Acetones Toronto but from n examination of the Municipal assessment figures and the proprty itself but it may be safely taken that this represents a sum of 1,750,000. The salaries of the four experts are not included.

Outside these items every expense has been taken into account. t is satisfactory to note that the expenditure and earning curves re rapidly approaching and allowing for the increased inclination f the expenditure curve after this date when the corn paid for is st used up and the new corn will have to be paid for it appears at in the course of the next (1 to 2) months the curves will meet nd all capital expenditures to date would be paid off.

With the expenditure now being incurred for additions to plant nd with the increased rate of production the curves will jump up, t though this will delay the date at which the lines will intersect dicating the paying off of all capital expenditure the cost per lb. product will be reduced considerably below the present figure.

The enlargement of the plant will not entail any appreciable crease in the cost of labour and with the economies now being fected there will be a considerable decrease in the cost of coal per of product.

It will be noticed that the consumption and production curves jump considerably owing to the corn and coal purchases being added at the date of payment. In future reports which will be forwarded monthly the curves will be of a more regular form, the purchases of corn and coal going on to a stock curve and the manufacturing being debited as the stock is used up.

The coal to corn curves show a large relative saving in coal during the last few months. This is partly due to the warmer weather but more on account of the efforts made to save steam.

With the completion in about 10 weeks of the additions now being made to the plant, bringing it up to a maximum output of 12 fermenters daily the reasonable limit of expansion on these premises will have been reached. At the same time the arrangements for steam and coal economy will be practically perfected.

When this plant has reached this stage it will be a well balanced, and economical installation producing Butyl Alcohol and Acetone with certainty at a cost which could not be appreciably reduced except through reduction in the cost of raw material.

EDWARD METCALFE SHAW.

QUANTITY PER HOUR

Size.	Required for 12 Fermenters per day.	Available.	No. of Fermentations per day possible.	Remarks.
1. Grain Storage, 1,000,000 bu.				
2. Coal Storage, 6,000 tons.				
3. Boilers, Gen. Dist., 1,200 H.P. G. & W., 1,200 H.P.	2,400 H.P.	2,400 H.P.	12	
4. Milling, 4,000 bu. day	2,000 lbs.	10,000 lbs.	13	
5. Sifting, 4,000 bu. day	2,000 lbs.	6,000 to 10,000 lbs.	8-13	Depends on dryness of corn.
6. Mashing, 4 tubs	2,000 lbs.	12,000 lbs.	16	At 1¼ hrs. ea.
7. Pumping, new 14 x 10¼ x 10	12,500 gals.	25,000 gals.	24	Estimated.
old 4 ins. cent.	12,500 gals.	20,000 gals.	15	Test
8. Digesting	12,500 gals.	12,500 gals.	12	Designed from data.
9. Cooking, 4 tanks	12,500 gals.	8,000 gals.	8	Depends on pump.
continuous	12,500 gals.	12,500 gals.	12	Or more.
10. Pumping, 8 x 6 x 12	12,500 gals.	12,500 gals.	12	Estimated.
11. Cooling, No. 1 x No. 2	12,500 gals.	12,500 gals.	12	Clean and winter (30)
No. 1 x No. 2	12,500 gals.	7,200 gals.	7	scaled & summer (50).
No. 2 x No. 3	12,500 gals.	14,600 gals.	14	Estimated summer conditions.
12. Culture Vessels, 3-5 gal.			7	Trial
6-5 gal.			12	Estimated.
13. Inoculating Vessels, 3-100 gal.			7	Trial
6-100 gal.			12	Estimated.

Size.	QUANTITY PER HOUR Required for 12 Fermenters per day.	Available.	No. of Fermentations per day possible.	Remarks.
14. Seed Tanks, 9-600 gal.			7	Trial.
16-600 gal.			12	Estimated.
15. Fermenting, 16-30,000 gal.	12,500 gals.		10	38 hr. period.
22-30,000 gal.	12,500 gals.		14	38 hr. period.
16. Beer Pumping, 7 x 5 x 12	12,500 gals.	7,200 gals.	7	Existing Pump.
7 x 5 x 12 and 10 x 4 x 12	12,500 gals.	20,000 gals.	20	Plus new pump.
two 10 x 4 x 12	12,500 gals.	25,000 gals.	24	Two new pumps.
17. Foaming Tanks, 3-50,000 gal.			12	
18. Beer Pumping, 10 x 5 x 12	12,500 gals.	12,500 gals.	12	
19. Beer Stills, 2,500 gals.	12,500 gals.	12,000 gals.	12	Maximum.
20. 1st Rectification, 2-13,000 gal.	375 gals.	425 gals.	14	Estimated.
21. 2nd Rectification, 14,000 lb. Barbet			12	Designed by Badger.
22. Butyl Salting	230 gals.	600 gals.	30	Actual trial.
23. Butyl, Rectifying, 2-7,000 gal. G. & W.	165 gals.	200 gals.	14	Trial.
24. Acetone Storage, 2-1,000 gal.		Ample		New tanks.
25. Butyl Storage, Crude, 1,250,000 gals.				
Salted, 2-18,000 gal				
Rectified, 16-2,100 gal.		Ample		Salting plant tanks.
				G. & W. Spirit tanks.
26. Acetone Shipping, 5 drums 1 hr.			42	Trial.
27. Butyl Shipping, 5 drum 1 hr.			19	Estimated.

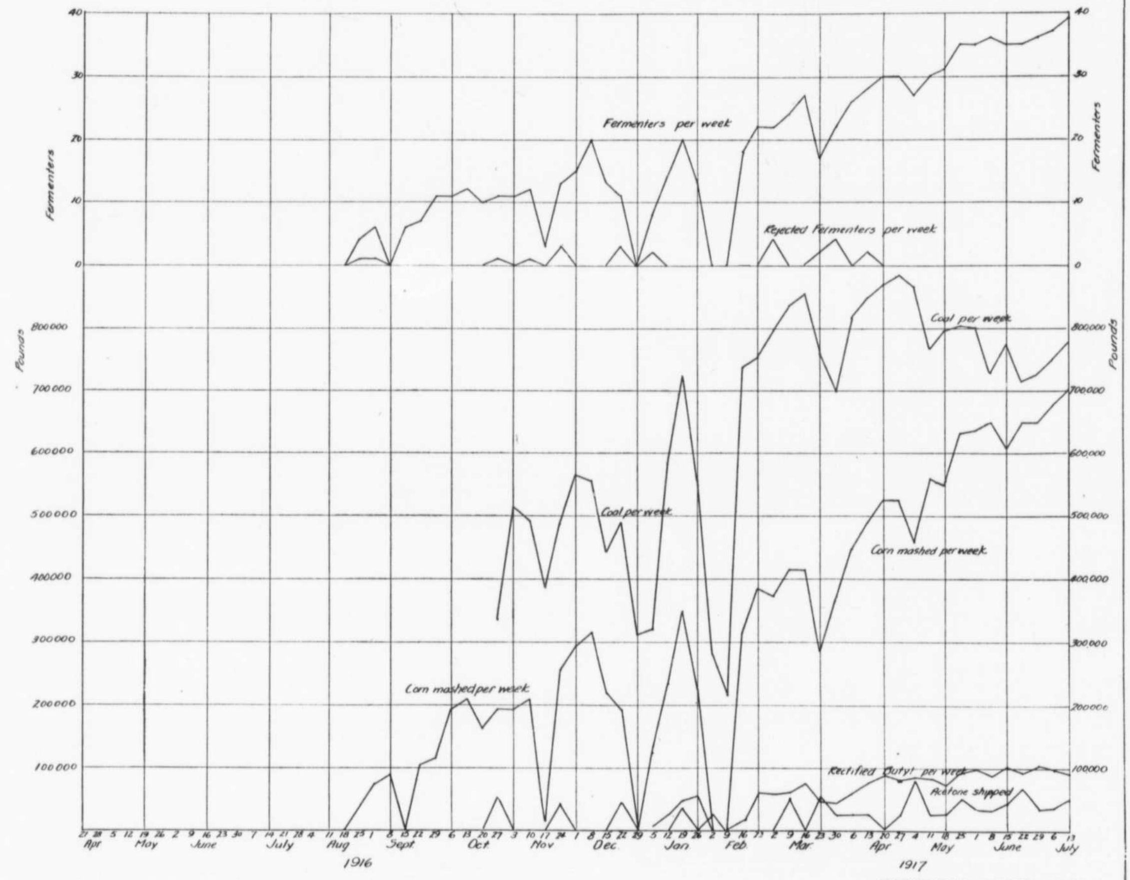
NOTE—(a) The above is based on a 24 hr. day.

(b) Cooking and fermenting capacities depend largely on pumping rates, filling and emptying. The fermenting, in the above modified methods of working are assumed and no time allowed for cleaning tanks.

BRITISH ACETONES TORONTO, LIMITED
PRODUCTION DATA

	WET CORN (lbs.)					ACETONE					BUTYL.					FERMENTERS	
Week Ending	Mashed	Distilled	Rejected	% Moisture	Coal	% AB.	Wt. in process	Yield	Rectified	Shipped	% AB.	Wt. in storage	Yield	Rectified	Shipped	Per week	Rejected
Aug. 25..	75,760	...	14,000	...	... ...	...	...	...	...	...	...	...	...	...	...	H.	1
Sep. 1..	89,240	...	17,500	...	...	...	...	7.2	...	...	...	...	22.3	...	...	6	1
" 8..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
" 15..	105,000	...	...	...	...	...	...	7.89	...	...	...	...	...	...	...	6	...
" 22..	115,500	...	...	...	...	...	...	8.35	...	...	...	...	...	...	...	7	...
" 29..	192,500	...	...	...	...	...	...	7.8	...	...	...	...	...	...	...	11	...
Oct. 6..	192,500	...	...	...	...	...	...	7.8	...	...	...	...	...	...	...	11	...
13..	210,000	...	...	...	...	...	...	8.0	...	...	...	...	...	...	...	12	...
" 20..	161,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...	10	...
" 27..	192,500	...	17,500	...	3,372,110	...	17,986	7.51	5,280	55,440	...	‡10,258	16.61	...	...	11	1
Nov. 3..	192,500	17,500	...	...	514,420	...	29,152	7.34	5,280	...	...	‡13,132	14.68	...	...	11	...
" 10..	210,000	227,500	17,500	...	492,860	...	43,952	7.5	5,280	...	...	‡29,093	15.00	...	...	12	...
" 17..	17,500	52,500	17,500	...	389,900	...	47,616	8.9	5,280	...	...	†256,432	17.8	...	...	3	...
" 24..	258,000	258,000	46,500	...	488,340	...	14,032	8.58	240	42,900	...	284,088	17.16	...	...	13	...
Dec. 1..	297,500	316,500	...	...	574,340	...	37,136	8.39	240	...	...	331,456	16.78	...	...	15	...
" 8..	315,000	262,500	...	...	567,220	...	50,800	8.33	240	...	...	371,840	16.66	...	...	20	...
" 15..	220,500	238,000	17,500	13%	440,110	20.	68,616	8.6	240	...	...	384,000	17.2	...	...	13	3
" 22..	192,500	210,000	35,000	13%	489,920	18	34,280	7.27		44,880	36%	428,800	14.54	...	...	11	...
" 29..	...	35,000	...	...	311,340	17.64	37,208	9.03	....	...	37.6	**406,703	19.5	...	...	...	...
Jan. 5..	122,500	52,500	35,000	13%	320,820	17.2	41,056	8.4	...	...	37.3	415,191	18.58	...	...	8	2
" 12..	245,000	175,000	...	13%	581,112	21.1	37,800	8.26	15,840	...	46.7	442,573	17.6	...	...	14	...
" 19..	350,000	315,000	...	13%	721,400	22.6	36,392	8.48	...	36,300	47.4	492.150	18.1	...	...	20	...
" 26..	227,500	367,500	...	13%	556,070	21.5	31,696	8.85	33,000	...	42.4	548,859	17.7	...	...	13	...
eb. 2..	...	...	...	13%	280,000	...	31,696	...	5,280	27,720	...	548,859	...	...	...	...	...
" 9..	...	...	...	13%	216,190	...	31,696	...	5,280	...	...	548,859	...	...	...	...	...
" 16..	315,000	140,000	...	13%	637,260	20.2	41,146	7.83	5,280	...	41.8	568,745	16.5	...	...	18	...
" 23	385,000	402,500	...	13%	751,500	22.2	31,906	7.36	41,280	...	51.5	629,500	17.36	...	...	22	...
ar. 2..	371,750	375,250	66,500	13%	798,510	22.0	60,346	8.07	*39,580	...	48.5	688,650	18.6	...	...	22	4
" 9..	416,500	364,000	...	13%	835,620	20.5	47,572	8.08	19,772	51,800	47.9	749,578	19.2	...	...	24	...
" 16..	416,500	448,000	...	13%	854,100	21.3	37,447	8.5	60,060	...	48.6	826,269	19.7	...	...	27	...
" 23..	288,750	306,250	35,000	13%	759,880	21.4	31,115	8.27	33,000	55,400	47.8	876,059	18.7	...	...	17	2
" 30..	371,875	284,375	70,000	13%	697,260	21.6	52,449	8.6	4,930	28,070	45.7	921,403	18.3	...	...	22	4
pril 6..	448,000	367,500	17,500	13%	818,340	20.5	40,375	8.12	15,310	27,720	...	982,000	18.9	...	...	26	...
13	490,000	486,500	14,000	14%	848,080	21.8	49,369	8.48	13,860	27,912	47.0	1,059,000	18.5	...	...	28	2
20..	525,000	560,000	...	14%	869,260	21.7	69,397	8.48	34,320	320	47.8	1,149,000	18.8	...	...	30	...
27..	525,000	525,000	...	14%	881,980	21.7	55,445	8.6	59,400	27,720	45.7	1,231,000	18.3	...	...	30	...
y 4..	459,000	527,000	...	14%	866,360	20.0	64,884	8.4	7,500	80,520	44.8	1,317,053	19.1	...	673	27	...
11..	558,000	540,000	...	14%	768,520	20.4	71,268	8.5	11,900	28,920	44.2	1,401,000	18.2	...	653	30	...
18..	549,000	495,000	...	16%	796,110	22.2	70,680	8.6	18,900	29,400	45.2	1,474,500	17.7	...	...	31	...
25..	630,000	576,000	...	16%	892,790	22.1	80,272	8.78	...	51,800	46.6	1,565,600	18.8	...	...	35	...
e 1..	633,600	633,600	...	16%	800,150	21.2	89,728	8.35	...	35,000	47.2	1,665,000	18.7	...	...	35	...
8..	648,000	630,000	...	16.5%	727,560	21.1	101,780	8.8	...	34,300	47.0	1,753,000	19.7	14,530	1,470	36	...
15..	607,500	643,500	...	16.5%	771,030	21.6	73,448	8.9	...	44,100	45.0	1,854,170	19.4	...	...	35	...
22..	648,000	607,500	...	16.5%	714,840	22.6	43,363	9.0	...	68,600	46.1	1,947,900	18.5	...	...	35	...
29..	648,000	666,000	...	16.0%	726,060	22.2	52,494	8.7	...	35,640	47.2	2,052,500	18.7	...	...	36	...
6..	684,000	648,000	...	16.1%	750,290	21.6	57,979	8.9	...	38,940	46.1	2,150,470	19.2	...	...	37	...
13..	701,525	719,525	...	16 3%	776,080	22.1	55,534	8.6	...	50,160	47.1	2,241,243	18.4	14,297	...	39	...

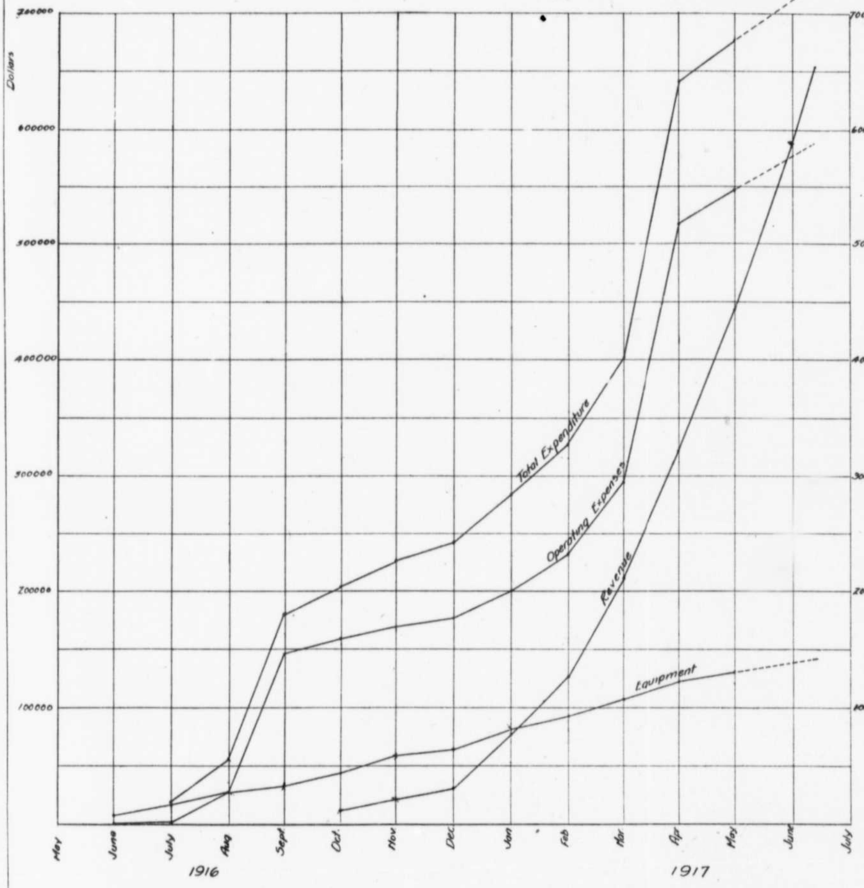
*Reduction due to use for drum washing, afterwards re-rect. ‡ In process. † Wet Butyl in storage. **Estimated rectified butyl. Yields are in % Dry corn.



BRITISH ACETONES
TORONTO

PRODUCTION AND CONSUMPTION
CURVES

July 21 1917 SHEET No 1



Equipment includes: Factory
Laboratory
Office
Operating Expenses includes
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Wages
Corn
Coal
Water
Revenue from
Acetone @ 21½¢/lb
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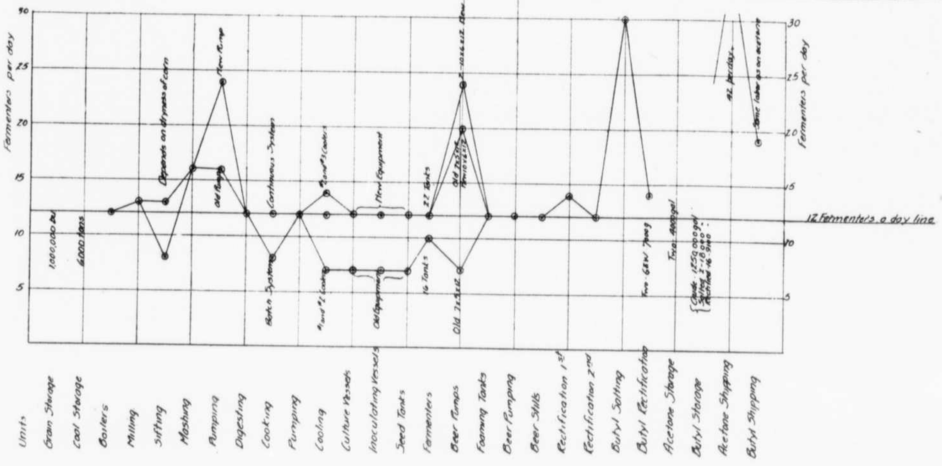
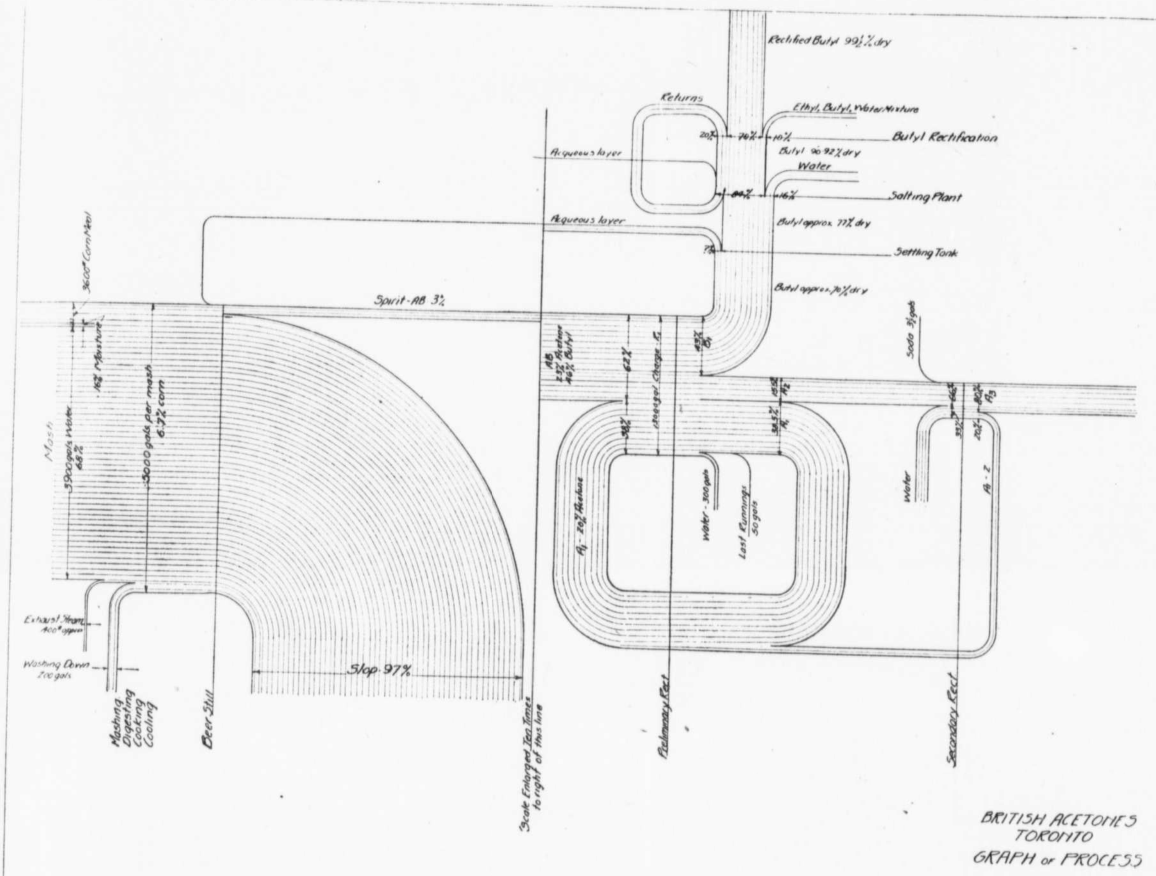
BRITISH ACETONES
TORONTO
EXPENDITURE AND REVENUE CURVES

July 21 1917 SHEET No. 2.



BRITISH ACETONES
TORONTO
PLANT CAPACITY GRAPH

July 21 1917 SHEET No 3



BRITISH ACETONES
TORONTO
GRAPH OF PROCESS

July 21 1917 SHEET No 4

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SECTION 3—ORIGINAL PLANT.

ORIGINAL PLANT.

General Description of the Portion of the Plant of the Gooderham & Worts Company and of the Plant of the General Distillery Company used by the British Acetones, Toronto, Limited, as they existed prior to May, 1916.

The firm of Gooderham & Worts, Limited, Toronto, established in 1832, carry on a general whiskey distilling business, manufacturing various grades of Canadian whiskey from grain. The plant is in operation from October 15th, to June 15th, of each year, manufacturing in the eight months 2,000,000 gallons of spirit, from corn, rye, malt and oats. The numerous buildings making up this plant were built at various times, dating from the original windmill plant of 1832 to the present.

The more recently incorporated General Distillery Company manufactures industrial, non-potable alcohol by distillation from molasses. This plant was erected in 1902, and is of modern construction throughout. The plant deals with about 100 tons of molasses a day, from which 10,000 proof gallons of industrial alcohol result per day. The plant operates during the summer, the length of time varying from six weeks upward, depending on the amount of molasses on hand. In 1912, during which the plant was in operation for ten weeks, 8,500 tons of molasses were used, giving an output of 840,000 proof gallons of spirit. This was the greatest period of operation of any year.

The plants of both distilleries are situated at the foot of Trinity Street, on the north shore of Toronto Bay, at a point where the Don River at present empties into it.

As will be seen from the accompanying plan (see drawing 62), the plant covers a considerable area, extending from the bay on the south to the Canadian Pacific Railway tracks on the north, and from Cherry Street on the east to Parliament Street on the west. The property is cut by the main line of the Grand Trunk Railway from Montreal and by Mill Street running east and west, and by Trinity Street running north and south.

There are numerous buildings of various types of construction, making up the complete plant of both companies, of which the majority belong to the Gooderham & Worts Company.

GOODERHAM & WORTS BUILDINGS—There are four of the Gooderham & Worts buildings made use of by the British Acetones, viz.: the granary, coal shed, the main building and boiler house. Of these, the two former are located at the water's edge south of the Grand Trunk Railway, and the latter two and other buildings of both distilleries lie north of the railway. There are ample siding facilities on the Grand Trunk Railway, and the raw materials are brought in by rail, as there are no docks or marine unloading equipment.

Since the above was written the following additional buildings have been wholly or in part taken over and used: Rectifying House containing three rectifiers, No. 2 Tank House with 16-9,100 gal. tanks, Malt House, Fermenting Cellar and Barrel Store House.

COAL SHED—The coal shed is of corrugated iron and timber construction, and is situated on the bay shore at the west side of Trinity Street. The coal comes in by rail, is shovelled from the cars on the siding into horse-drawn carts, and hauled up a ramp into the shed and dumped from elevated runways in the shed on piles on the ground below. The coal piles are ventilated with the usual gas pipes. From these piles the coal is loaded into carts again by hand, and carted to the various boiler rooms as required.

The storage capacity of the shed is about 6,000 tons, and in addition coal may be stored in outside piles between the shed and the tracks.

Normally the coal used is slack, but the recent coal shortage in Toronto has necessitated the use at present, of a mixture of slack and lump. There is at this time (May 1st, 1917) about 3,700 tons of the latter in storage.

GRANARY—The granary or grain elevator is also of corrugated iron and timber construction, and is situated on the bay front, west of the coal shed. The railroad cars may be run on to a siding under the building, and the grain is then elevated to a horizontal conveyer, running the length of the building. The conveyer discharges the grain into the various bins, from which it is drawn off at the bottom into specially constructed one horse grain carts, and hauled to the mill. The grain is unloaded directly at the mill unless the storage bins there are full, in which case the surplus is taken in at the elevator. There is at the granary a storage capacity of from eight hundred thousand to one million bushels, and at this time (May 1st, 1917) there are about five thousand bushels in store there.

MAIN BUILDING—MILL—The mill is located in the south-east corner of the substantially constructed masonry and timber main building, built in 1859, on the west side of Trinity Street, just north of the tracks. It contains a power house, mill, mashing equipment, distilling apparatus, various tanks, and the slop drying presses and ovens. The siding from the Grand Trunk railway runs along the south wall.

GRINDING—The grain may be received at the mill either directly from cars on the railroad siding or from carts bringing the grain from the granary, and elevated, passing through a hopper weigh scale to the storage bins in the mill, having a capacity of 18,000 bushels. This is sufficient to maintain a continuous running of the mill night and day for a week.

From the bins the grain passes to the stones, of which there are eight run, five generally in use, with three under repair, as operated now. The meal from the stones is sifted in four gyrating sieves and scalpers, the fine meal goes directly to the meal storage hopper, and the coarse is passed through chilled steel rolls, of which there are ten sets, with only two or three in use.

A single sifter handles the meal from the rolls, separating the bran, which is sacked and sold, and the meal, which passes into the meal hopper. The sifters are equipped with No. 36 mesh wire screens. (A No. 24 mesh wire screen is used in the sifters for acetone work).

The capacity of the mill is from 150 to 170 bushels of corn per hour, depending on the condition of the corn. At present (May, 1917) it is damp, and only 150 bushels per hour is being ground. This capacity is limited by the sifters, which cannot handle as much as the stones are capable of dealing with.

From the meal storage hopper the meal drops into a hopper weigh scale, mounted on a car on rails, in which the charge for the mash tubs is weighed out (3,600 pounds per mash), and the car is run along and emptied into either of four mash tubs.

MASHING—The mash tubs are located in the main building, west of the milling section on the second floor. They are of wooden construction, fifteen feet in diameter by six feet deep, and are fitted with paddles, steam injecting pipes and a series of copper cooling coils. The paddles are driven from below through bevel gears and horizontal shafting, located on the "stone floor" or machinery floor. For mashing for acetone cold city water (3,900 gallons or 39 inches depth) is run into the tubs, and the whole heated by the steam jets blown directly into the mixture through perforated pipes. The bulk is increased to 4,750 gallons during the mashing.

After mashing for whiskey distillation the mash is run from the mash tubs through 6" copper pipes to the fermenting room, where it passes into open wooden troughs, leading to the various wooden fermenters. For acetone work 5" wrought iron pipe was coupled on to the original copper mash pipes close to the tubs, and carried the mash to a steam engine driven reciprocating pump (gear drive). The latter was found unsatisfactory, and was in turn replaced by a steam engine belt driven four-inch single stage centrifugal pump, discharging through a four-inch wrought iron pipe leading to the General Distilleries Building.

Both the engine and pump were supplied and installed by the British Acetones.

The changes mentioned here constitute the only alterations made in the plant of the Gooderham & Worts distillery.

The centrifugal pump requires about thirty-five minutes to empty a mash tub, 200 gallons of water being allowed for washing down the tub.

On the machinery floor in the main building are also other pumps, which are not in use by the British Acetones, and a steam air compressor and receiver, supplying air for the construction work, rivetters, etc., and also where required for the plant operation. The remainder of the main building, excepting the power plant, is occupied by the beer still, tanks, scales, with a slop filter and drying apparatus necessary in the distillation of whiskey, and the preparation of the waste solids for cattle food.

POWER PLANT—In the north-east corner of the main building is the power plant, fitted with four 100 h.p. John Abell return tubular boilers, with Jones automatic stokers, which ordinarily supply steam for the various operations in the manufacture of whiskey, and a 500 h.p. 28 in. by 60 in. single cylinder horizontal steam engine, with Brown valve gear, which drives through an intricate system of gearing, spur and bevel, both the mill and the mash tubs. This engine is located between the mill and the mash tubs, on the same floor as the latter. The boilers are not now in use.

BOILER HOUSE—Steam is at present supplied through a ten-inch main from another Gooderham & Worts boiler room, located east of Trinity Street, on the south side of Mill Street. There are here, eight 100 h.p. return tubular boilers, working under 60 lbs. pressure, and fitted with Jones underfeed stokers. These boilers, of which five are normally in use, also supply the steam to the shop engine and the Gooderham & Worts bottling department.

GENERAL DISTILLERY COMPANY PLANT—This plant is of comparatively recent construction, and is located as shown on the plan, comprising briefly the distillery building proper, filter room, boiler room, store house, and three large outside storage tanks.

The buildings lie between Mill Street and the Grand Trunk railway tracks, and extend from the west limit of the Gooderham & Worts property to Parliament Street.

The buildings, with the exception of the store house, are of rather light steel frame brick construction. The distillery proper is five storeys (72 ft.) high, the fermenting portion two storeys (30 and 36 ft.) and the filter and boiler rooms one storey (20 ft.) high only. These buildings are all adjacent to each other, forming one continuous building. The store house is a separate one storey structure of brick and timber construction, with concrete floor.

MOLASSES—Both beet and cane sugar molasses is used, and is received in railroad tank cars, which are run on the siding at the south side of the store room, (75 ft. by 80 ft.), and emptied by means of a 8 x 10 x 12 in. steam pump in the south-west corner of the store room. The pump is so connected that molasses may be pumped through four-inch pipe into either of the outside storage tanks, from one outside storage tank to another, or into the two mixing tanks. The pump may also be used to return molasses to tank cars on the siding from any of the tanks. These outside tanks are of steel, roofed, and of the following sizes:

The north tank is 48 ft. in diameter 35 feet high, capacity 400,000 gallons.

The west tank is 40 feet in diameter, 30 feet high, capacity 225,000 gallons.

The east tank is 95 feet in diameter, 30 feet high, capacity 1,250,000 gallons.

The west tank is also used for slop storage, and the two varieties of molasses are kept in separate tanks.

The second molasses pump (8 x 10 x 12 in.) in the north-west corner of the store room draws the molasses from the largest outside tank through a five-inch line, and discharges it into either of two inside molasses boiling or mixing tanks of steel, 16 ft. in diameter, 15 ft. high, and 18,000 gallons capacity, located at the west end of the store room. A third brass pump (6 x 5 x 8 in.), between the latter tanks, takes the hot mixture of molasses and acid from the mixing tanks, and pumps it through a battery of three vertical molasses coolers, located outside the north wall of this building, over to a second molasses mixing tank in the south-west corner of the distillery proper. In the latter tank the molasses mixture is diluted and run by gravity into molasses pits or sunken tanks in the distillery. The molasses piping is mostly four-inch wrought iron.

DISTILLERY BUILDING—The main building of the General Distilleries is 146 ft. 7 in. by 123 ft. 8 in., and is divided into two principal parts, there being no dividing wall between the parts on the ground floor. The north part of this building, known as the fermenting room, is 146 ft. 7 in. by 77 ft. 2 in.. two storeys high and has a wooden operating platform throughout, about 20 feet above the ground, except at the west end. Along the north wall stands a row of six and at the east end a parallel row of three steel fermenters, 18 ft. diameter by 20 ft. high, capacity 31,788 gallons. These are mounted on brick piers, and extend through the platform. In the centre of the west end of the platform a row of four steel yeast tanks, 12 ft. by 12 ft., 7,500 gallons capacity, standing on timber frames, extend through the platform. These are arranged parallel to the fermenters. South of these yeast tanks, on the platform, are four 635 gallon copper second yeast tubs, and five 128 gallon copper first yeast tubs in a row. Along the west wall at the north are two sunken steel molasses storage tanks or "pits," 15 ft. by 10 ft. by 7 ft., with a capacity of about 7,000 gallons, and a 6 x 4 x 6 steam pump for elevating the molasses into the nine fermenters. The building is fully equipped with the necessary steam, slop, beer, air and water (bay and city) pipe system.

The south 30 feet of the north portion of the building is occupied by three copper high wines tanks, 14 ft. diameter by 14 ft. high, with 13,400 gallons capacity; located south of the yeast tanks an elevated 1,400 gallon steel fusel oil tank; and at the east a battery of two elevated spirit receivers and a weigh tank, in a screened-off Government weigh room. Each of these tanks has a 9,600 gallons capacity, and is 14 ft. in diameter by 10 ft. high. There is a 6 x 8 x 12 in. steam wine pump for handling the spirit from these tanks. At the west and south of the previously mentioned molasses pits stand two wooden slop neutralization tubs 14 ft. diameter and 14 ft. high, 13,400 gallon capacity, with a 6 x 8 x 12 in. steam slop pump between them. These tubs receive slop from the still and the pump elevates it to the evaporator supply tank.

On the west wall behind these tubs is the tail box for the rectifying battery. East of the Government weigh room is the superintendent's office.

On the ground floor of the south five storey section of the distillery, which is 83 ft. 10 in. by 46 ft. 6 in. (see drawing 59), at the east wall, are two 13,400 gallon copper spirit tanks, with a 6 x 8 x 12 in. steam spirit pump between, and in the north-east corner a second 6 x 8 x 12 in. pump for the scale tanks. At the south wall about the middle and opposite the doorway stand two 14 ft. diameter by 14 ft. high rectifiers, taking a 13,000 gallon charge. North of the rectifiers is the gear driven (steam engine) 6 in. by 12 in. duplex pump, supplying the still, a 10 x 12 x 12 in. air compressor, and two 12 x 14 x 18 in. 1,000 gallon per minute duplex steam pumps, drawing water from the bay through 12 in. intakes, and discharging into a reservoir on the roof through two 8 in. mains.

Standing on special steel columns in the south-west corner is a "double-effet" evaporator for dealing with the slop from the beer still, working on exhaust steam, supplied through a 10 in. inlet, provision also being made for live steam supply if necessary through a 2½ in. line.

Under the evaporators at the south wall is placed a 12 x 10 x 20 in. steam slop pump, which handles the slop from the evaporators discharging it through a five-inch main to the west outside tank. At the west wall is a 16 x 20 x 36 in. dry vacuum pump for the evaporators, and in the corner is the seal well for the evaporator condenser above. Beneath the north evaporator is a small drip receiver (cast iron), and an 8 x 8 x 10 steam drip pump, also for the evaporators. The steam and exhaust piping from the boiler room comes through the west wall at about the north limit of this section.

The 6 ft. diameter by 42 ft. long beer still, capable of handling 4,000 gallons of beer per hour in alcohol distillation, fitted with calandria, stands in the north-east corner of the building, and extends from the second floor through to about three feet above the fifth floor. Its 30 in. diameter by 13 ft. long beer heater (687 gallons) stands just south of it on the fifth floor, extending through the roof, and south of the heater is the 60 in. by 24 ft. long condenser (3,000 gallons), extending from the third floor to the fifth floor. The tail box for this condenser is located on the third floor, which is the operating floor. North of the two rectifiers and connected to them through a 16 in. and a 6 in. pipe, and in about the centre of the building, are two 60 in. spirit columns (1,438 gallons), 37 ft. long, running from the second to just below the fifth floor, which connect through 14 in. headers with two goose tanks (11 ft. 6 in. x 11 ft. x 9 ft. 7,200 gallons, steel), on the fifth floor at the middle of the south wall. Between the goose tanks and spirit columns, and connected to the former through a 12 in. pipe, are two cooling columns, 42 in. diameter by 24 ft. long, (4,400 gallons) which extend from the fifth floor down to the third, where the tail boxes are located. A four-inch copper pipe from the fusel oil traps under the fifth floor leads to the fusel oil cooler, 22 in. diameter by 14 ft. long, with its tail box also on the third. The cooler extends from the third to midway between the fourth and fifth floors.

On the second floor of the north wall is a 100 cubic foot steel compressed air receiver, and west of the latter a 881 gallon open steel evaporator supply tank. In the south-west corner of the third floor is the evaporator condenser, connected to the latter through an 18 in. pipe. At the south wall on the operating floor is an open steel yeast tank, 1,000 gallon capacity, and in the south-east corner is a second 12 ft. diameter by 10 ft. high, 7,100 gallon copper weighing tank in a Government weigh room. The operating floor communicates over the roof of the intervening portion with the north or fermenting part of the distillery.

A large light and ventilation well extends from the evaporators through to the roof at the west side of the building. Over this well at roof level is a 14 ft. diameter by 5½ ft., 5,300 gallon steel water reservoir, covered by a pent house on the roof, and supplied with bay water by the previously mentioned duplex pumps below. This supplies water for cooling purposes in condensers, cooling columns, and, if necessary, for fire protection.

At the east side of the rectifying section and south of the fermenting room (Government weigh room) is small two-storey 46 ft. 6 in. by 32 ft. 6 in. building, forming part of the distillery proper, containing drafting office, vaults, laboratory and storerooms.

Boiler House—The boiler house of the General Distilleries, Limited, is 117 ft. 1 in. by 77 ft. 2 in., and contains a battery of two 250 h.p. and four 175 h.p. Babcock and Wilcox boilers, equipped with Jones automatic stokers, and capable of supplying steam at 110 pounds pressure, through a 10 in. main to the distillery proper. The exhaust returns are brought to a steel hot water drum of about 1,000 gallons capacity at the east end of the boiler room, where the feed water, either city or bay water, controlled by float, is heated. The boiler feed pumps south of the drum are two Northey duplex outside packed pumps 9 in. by 5 in. by 10 in. For draft purposes there are two high speed steam engine driven pressure fans located at the west end of the room. The flue gases are carried off in a 4 ft. diameter by 125 ft. steel stack at the west of the boiler house.

At the rear of the boilers, at the north side, is a large potash riping pit, and in front of the boilers is ample storage space for coal, which is delivered in horse-drawn coal carts through three large doors to the piles, and shovelled from the piles into the stoker hoppers by hand.

In the north-east corner of the boiler room is a bricked-off yeast storage room, and an 800 gallon steel yeast boiler. At the east wall between the latter and the hot water drum is an elevated 8 ft. x 8 ft. 2,500 gallon steel slop tank, designed to be used to supply a special slop burner or potash furnace in the two large end boilers from which the potash goes to the potash riping pits at the rear of the boilers.

Filter Room—The filter room 123 ft. 8 in. by 29 ft. 7 in., occupies the space between the distillery proper and the boiler house, and is a one-storey structure. At the north wall are two 14 ft. diameter by 14 ft. high 13,400 gallon light copper spirit diluting tanks. Just south of these is a battery of three high pressure steam rectifying pumps, 5½ in. by 2¼ in. by 7 in., and next these a 495 gallon steel wash water tank for filter washing purposes. The body of the filter room is occupied by a rectifying battery of 32 heavy cast-iron charcoal filters. A light hand-power travelling crane run north and south over the filters. At the south of the filter room and separated from it by a brick wall is a second molasses mixing tank (previously mentioned), of steel, rectangular, 19½ ft. by 15 ft. by 10 ft., 18,000 gallons, arranged with baffles, where the molasses from the store room is diluted and then run by gravity into the molasses "pits."

WATER SUPPLY—There are two sources of water supply: the municipal system, which supplies pure water at about 80 pounds pressure per square inch, and the company's private supply, which draws impure water directly from the bay. The General Distilleries boiler house is arranged so that the supply may be taken either from the city or from the bay.

The two 12 x 14 x 18 in. duplex steam pumps on the ground floor of the distillery, which supply the tank on the roof, draw their supply from the bay, and are capable of handling 1,000 gallons per minute at a pressure of 100 pounds per square inch. These are ordinarily used to supply cooling water for different purposes, but are also connected to the fire protection system.

The Gooderham & Worts Company have a special fire protection pump house, situated at the west side of Trinity Street, just north of the tracks. This pump house is equipped with two 85 h.p. hand fired Babcock and Wilcox boilers, and two duplex Northey 1,000 gallon per minute pumps, capable of maintaining a pressure of 100 pounds per square inch.

Steam is always up in one of these boilers, and the other has the fire all ready laid, is cleaned, and full of water, and the flue gases from the one under steam pass around the drum of the one not in use, keeping the water warm.

LIGHTING—The lighting is electric, by incandescent lights, operating on 110 v. or 220 v. alternating current at 25 cycles, supplied by the Toronto Electric Light Company. The wiring is partly open, partly in conduit. There is besides 550 v. current available for power purposes where required.

MISCELLANEOUS—SHOPS—The Gooderham & Worts Company maintain well-equipped steamfitters', carpenter and coppersmiths' shops, which are used jointly by the Gooderham & Worts and General Distilleries Companies.

LABORATORIES—There are two well-equipped laboratories on the premises. One is the bacteriological laboratory, located over the Gooderham & Worts offices, and the other is a chemical laboratory, located in the General Distilleries building.

These are more fully described in the reports of Mr. Speakman and Mr. Legg respectively.

OFFICES—The office work of the General Distilleries is handled in the offiices of Gooderham & Worts. There is a small drafting room in the same building with the laboratory, the remaining rooms being used as store rooms only.

STAFF—The Gooderham & Worts Company and the General Distilleries Company maintain jointly a staff of about ten steamfitters and helpers, about six carpenters and helpers, and a coppersmith. The operating staff of the Gooderham & Worts mill numbered about nine men, and there were four men required to look after the mashing, with two still men, two rectifying men, a foreman and a relief man. The General Distilleries Company use two operating engineers in charge of the engines, pumps and boilers, together with about ten firemen and six men as attendants in the fermenting room and rectifying department.

TRANSPORTATION—The transportation of raw material about the plant and throughout the city for both the Gooderham & Worts Company and the General Distilling Company is taken care of by the transport department of the Gooderham & Worts Co. The department is under the direction of a foreman who has charge of 8 carters, 8 horses, 8 coal carts, 6 grain trucks, 3 single lorries, 2 double lorries, 2 barrel waggons, an ice waggon, a watering cart, a lumber waggon and a 3 ton motor truck. The latter is used almost entirely for outside work. The transport department is at the disposal of the British Acetones as required.

The coal carts are the usual single horse back dumping two wheel carts with a capacity of rather more than a ton. The grain carts or trucks are also single horse two wheel with a special low ng body carrying a maximum of 50 bushels of grain.

EDWARD METCALFE SHAW.

SECTION 6.

EXISTING PLANT.

APP. 1—INOCULATING ARRANGEMENTS.
" 2—DISTILLATION AND RECTIFICATION.
"" 3—BRAN DISPOSAL.

PRESENT PLANT.

Description of the Plant of the British Acetones Toronto, Limited as reconstructed from that of the General Distilling Company, with a note on the few alterations made in the Plant of the Gooderham & Worts Company, Limited.

It should be understood that the plant, even after one year's construction work, is still in a state of evolution. Knowledge of the operation and requirements in such a new process and plant is being constantly acquired and results in the plant being constantly in a floating state: *i.e.*, improvements, additions and excisions are being continually made as soon as possible and convenient without interfering with the operation of the plant and the manufacture of as large an output as possible of acetone.

Major alterations on vital parts of the plant and equipment are generally carried out on Sundays when the mashing and cooking processes are out of operation, while minor changes and additions on parts not affecting vital parts are done throughout the week. This description, then, will describe the conditions of the plant from a mechanical point of view as it exists at the time of writing this report—May 15th, 1917.

GOODERHAM & WORTS BUILDINGS.

RAW MATERIALS, HANDLING, MILLING AND MASHING SECTIONS.

BRITISH ACETONES, TORONTO, LTD.

COAL SHED AND GRANARY—No structural changes have been made in either of these buildings, and they are operated just as they were in the old days by the Gooderham and Worts Company. The granary is used only to a very limited extent.

Main Building—Milling—The mill has undergone no structural alterations nor changes in equipment, with the exception of the replacing of the No. 36 wire screens in the sieves by No. 24 wire screens for the acetone meal. The mill is operated in practically the same manner, but at a slower rate due to the dampness of the maize being dealt with at this time.

Mashing—The mash tubs have received only such minor repairs as were required to keep them in good operating condition. For instance, the valve controlling the water was in rather bad condition and has been repaired. The steam jets are used for mashing (supplied at present with 60 lb. steam from the Gooderham and Worts boiler house) and the copper cooling coils are not required or used. The original 6 in. copper mash pipes formerly used have been flange jointed to 5 in. wrought iron pipe (with cast iron fittings), leading through a by-pass system of piping either to a 6 x 12 reciprocating pump, driven through spur gearing from an 8 x 22 steam engine (Brown valve gear), or a 4 in. single stage centrifugal pump, belt driven at 680 r.p.m., by a Leonard 8 x 10 high speed steam engine (220 r.p.m.) The latter is now used exclusively, and is provided with a 3 in. relief bypass.

The pump handles about 170 gals. a minute at present, and operates under 24 lbs. discharge pressure. It is so situated that there is always a static head of about 10 ft. on the suction.

Mash Lines (Mash Tubs to Cookers)—The mash is discharged from the centrifugal pump through a 4 in. swing check valve, into a 4 in. mash line leading to the distillery. This line is exceedingly crooked, due to structural difficulties, and its relocation and construction is now under consideration. The line is approximately 400 ft. long, and in that distance there are ten right angled bends and ten 45 degree elbows. It is asbestos lagged, and is mostly under cover in the different buildings, but about 100 ft. of it is in the open air. The line is heated up before pumping through the mash with steam from the digester nozzles and afterwards is washed out by pumping about 200 gallons of wash water through.

GENERAL DISTILLERIES BUILDING.

Fermentation Section—British Acetones, Toronto, Limited.

Mash Line (Mash Tubs to Cookers)—Digestors—About 50 ft. from the first cooker in the mash line from the tubs, and just inside the south distillery wall there are inserted eighteen ½ in. steam jets, placed 18 in. apart on the average, along one side of the pipe and coupled up by a 2 in. pipe with steam supply at the centre, each half being under gate valve control. The nipples forming the nozzles are bevelled off at 60 degrees against the mash flow, permitting of better steam injection. The 2 in. pipe connecting up the jets of this "digester" is supplied from a 3 in. steam main, in which the steam is controlled by a 3 in. gate valve located on the operating platform some fifty feet away from the nozzles and operated by an attendant, whose duty it is to keep the temperature constant by regulating the steam injected through the nozzles.

It is proposed to place the control valve as close to the digester as possible in the new line, (which is all prepared and awaits only a favorable opportunity to be installed) as the present construction is subject to serious defects from a temperature control viewpoint.

Just past the nozzles on a 4 x 4 x 3 tee is placed a 3 in. pop safety valve set to blow at 40 lbs., and inserted in the tee immediately before reaching the first cooker is the bulb of a recording thermometer, the dial of which is opposite the digester steam control valve. Between the safety valve and the thermometer connection is a pressure gauge connection (fitted with a drain) leading to a pressure gauge placed above the thermometer dial. The mash line runs along the south side of the row of cookers, and 4 in. branches lead from tees in it through 4 in. swing check valves and 4 in. gate valves, controlled from the upper platform, into the cookers, about 3 ft. from their bottoms. The flanges for these connections were already on the cookers.

Between cookers 2 and 3 a 4 in. slip expansion joint is placed and at the end in the branch leading to No. 4 cooker is a 3 in. drain line with a 3 in. gate valve in it, leading to the floor gutter.

COOKERS—The cookers consist of four 12 x 12 steel yeast tanks standing on 10 ft. timber stands. These tanks are of 5-16 in. steel plate with single riveted lap joints, and originally carried only a light flat cover. When taken over new domed 5-16 in. plate covers (19 in. dome) were riveted on them, fitted with 14 x 21 in. manholes and special central gland; a special 3 in. cast iron flange for the safety valve; a standard 2 in. flange for relief valves; and tapped for the pressure gauge.

The bottoms, which are flat, were strengthened by being riveted to six beams built up of two 12 in. channels at 20½ lbs., which were placed on the timber stands, and fitted with vertical plates and angles at the ends riveted to the tank sides. The tanks were subjected to a static test of 22½ lbs. by the government inspector. A special electric cast steel bowl outlet casting (see drawing 3) is riveted in the centre of the bottom, having an upper diameter of 10¾ in. and a lower diameter of 4 in. and carrying a journal for a vertical pin. This casting is fitted with ½ in. steam jet, to guard against contamination by playing on the gate of a 4 in. gate valve, flange-jointed to the casting below. The jet is on a 22 lbs. steam system, controlled by a Locke regulator.

The manhole gaskets are of asbestos 1¼ x ½ standard stock. The central gland (see drawing No. 1) on the tank roof is designed to take a 3 in. rotating pipe, and is bolted by studs on a lead levelling gasket to an electric cast steel stud ring, riveted to the roof. The 3 in. pipe, machined on the outside to 3 7-16 diameter, passes through this gland and is fitted with 3 x 3 x 2 x 2 in. cast iron cross below, in the bottom opening of which is screwed a bronze plug with a 1¼ in. pin which rotates in the journal of the bowl casting at the bottom (see drawing 4). Fitted in the two openings of the cross are two 4 ft. lengths of 1 in. pipe, which are used as steam jet stirrers, the steam discharging directly from the end and thoroughly mixing the mash.

There is also another cone type stirrer bolted on each central pipe, but it does not act to any extent under the present system of operation. These stirrers are described in another section of the report.

The steam is supplied to the 3½ in. central pipe from the 1½ in. steam line on the 22 lb. steam system through a special gland connection; (see drawing 5). The central pipe carries a 16 in. cast iron worm wheel, originally used for motor driving purposes, mounted on it between the tank gland and the upper gland. This wheel now has a long handle fastened to it, which is used to rotate the central pipe and steam jets through 180 degrees at intervals by hand.

Each cooker is fitted with a 3 in. spring loaded safety valve, set at 15 lbs., the vertical exhaust pipe from which is fitted with a drain to prevent liquid from settling back on the valve.

From the 2 in. flange a bent nipple leads to a cast iron tee, on opposite branches of which are mounted a 2 in. brass swing check valve, acting as a vacuum valve; and a 2 in. gate valve, with vertical pipe leading to the atmosphere, which is also fitted with a drain. There is also a 30 lbs. 6 in. dial pressure gauge mounted on the tank roof. The cookers are fitted with ¾ x 18 in. gauge glasses, one at the top, which is above the platform, and the other at the bottom. The latter is tapped into the bottom of the tank, and comes away from a ¾ in. cross, the downward opening of which acts as a blow-off, controlled by a ¾ in. gate valve. This gauge has proved useless owing to choking with the thick mash at the tank bottom. There are three ½ in. try cocks; one 2 ft. and one 3 ft. from the top, and the other at the bottom, which are used to check the water gauge readings.

The tanks are asbestos lagged, the roof lagging being protected by sheet metal cover.

MASH LINE (COOKER TO COOLER—HOT)—This mash line (see drawings 63 and 71) is of a 4 in. wrought iron pipe and leads from the bottom of the cookers (bowl casting) to the cooler pump. The line from each tank runs from the outlet casting through a 4 in. flange gate valve and two flange elbows (to act as an offset), and then north through a length of pipe a 4 x 4 x 2½ tee, and a 4 in. globe valve located just beyond the edge of the tank, into the main mash line. These two valves are controlled by extension handles from a runway between the fermenters and the cookers. In one of the two elbows a ½ in. high pressure steam pipe is tapped, which keeps the pipe between the two valves always under high pressure steam, affording an efficient steam lock against contamination.

From each of the tees just mentioned a connection runs into a 2½ in. line for filling the culture vessels (seed tanks). This small line at the dead end beyond cooker No. 4 is fitted with a 2 in. diameter drain and a 2 in. blow-off valve to blow at 20 lbs. and at the west end turns south and then vertical leading to the seed tanks where the sterilising steam supply is located.

The mash line to the cooler has at the east end beyond No. 4 cooker a 1 in. high pressure steam sterilising inlet. At the west end just beyond the connection from No. 1 cooker the line turns and passes south under No. 1 cooker, then drops vertically to a 4" Y, and through the side outlet of the latter to the cooler pump. The through outlet of the Y (vertically downward) leads into a short length of pipe, capped and fitted with a 2" drain gate valve forming a pocket which is expected to catch any nails, pieces of wire, etc., which may come through with the mash. From the side outlet the 4″ line passes to a gate valve and thence into the side outlet of a second Y at the suction of the cooler pump. The through opening of the latter Y is connected through a 4″ gate valve and pipe line to what was originally the fusel oil tank (1,400 gal. steel) now placed at the west wall south of fermenter No. 14.

STERILE WATER RESERVOIR—The tank acts as a sterile water reservoir (90-100° C) and is used to supply water to flush out the cooler pump, cooler coils and fermenter mash line after pumping through the mash. It is supplied with sterile water from two traps in the 2" beer still calandria exhausts. The traps discharge into a 3" line leading to the feed water drum in the boiler room. From a 3 x 3 x 4 tee in the latter line the condensate runs under gravity through a 4″ line to the above tank.

To insure sterility there is a ½" steam pipe tapped into the tank through which live steam from the main steam line is being continually discharged into the tank. In addition there is a 1½" exhaust line from the main exhaust header running to the tank supplying it with exhaust steam.

The cooler pump is a new 8 x 6 x 12 Fairbanks duplex steam pump and is located on the ground floor south of No. 1 cooker. The piping between it and the coolers is arranged with valves and cross connections as shown in drawing 84 to enable the mash to be discharged into either No. 1 or No. 2 cooler or both simultaneously. Both the new No. 2 cooler and the old No. 1 are now used acting in parallel. The mash piping is laid out to give the least resistance by using long radius elbows, Y's and offsets wherever possible, as shown.

COOLERS—The coolers are described in detail under a separate heading, and will not be touched on here (see drawings 6, 7, 12, 30, 30A, 35 and 41).

(COOLER WATER CIRCUITS)—The cooling water lines, see drawing 84, are supplied from the municipal system and are arranged so that either cooler or both together may be supplied. In No. 1 cooler there is a single water circuit while in No. 2 cooler there are two water circuits, one acting in units 1 and 2, and the other in 3 and 4. The water discharged from all three circuits is brought together in a single header from which it may be directed to various destinations. From the west end of the header a 4" line passes from a 4″ T, under fermenter 15 and along the west wall to a 8 x 8 x 10 simplex pump (formerly evaporator drip pump) located south of fermenter 14 and under the north evaporator. This pump draws the water from the coolers thereby reducing the back pressure on them and delivers the hot water at about 110° F. and 10 lbs. pressure through a 4″ line to the mash tub reservoir in the main building. Water from this reservoir besides supplying the mash tubs is used for all other possible purposes in the building. The other branch of the previously mention T leads through a 4″ by-pass around the latter pump into the mash tub supply line and from this by-pass a 2" pipe leads to the feed water tank in the boiler room. All boiler feed in the General Distilleries boiler house is supplied from this line. The boiler feed is thus primarily heated in the coolers and afterwards in the feed water heater in the boiler room.

From a 4″ T in the east end of the water header a 4″ line passes to an 8 x 10 x 12 simplex pump (formerly molasses pump) which discharges the warm water through a long 4″ line across Trinity St. to the Gooderham and Worts boiler house supplying all the water required there for boiler feed purposes. The surplus water in excess of that required for all these various purposes escapes through the other outlet of the above T and a 4″ line to the sewer. Thus all the water used throughout the plant with the exception of some for minor purposes, passes first through the coolers.

The water and mash lines as shown in drawing 84 are all provided with suitable thermometer pockets and guage connections for getting accurate information on the cooler operations. There are also steam sterilising connections and drains for keeping the different sections of the system sterile. The cooler piping both mash and water is, as is evident from the drawing No. 84, rather confused and complicated. The reason for this lies in the fact that the plant has been constantly developing, necessitating additions to equipment and alterations in piping. In addition the process is a new one and the coolers themselves new so that their behaviour was unknown and provision had to be made for all possible eventualities, such as choking of coils, scaling, etc. Further the endeavour has been to make the system a thoroughly interchangeable one. The very necessary provisions for sterilising added considerably to the complexity.

MASH LINE (COOLER TO FERMENTERS—COOLED)—The mash outlets from both coolers, see drawing 84, come together in a 4″ over the east end of No. 2 cooler and pass thence south through

4 x 4 x 2 T (inoculant entrance), through a long radius elbow and vertically downward into the top opening of a 4″ cross set vertically in the main mash line. The lower opening of this cross carries a 3″ gate valve for emergency drain purposes, but which is ordinarily plugged as an additional safeguard. On either side of the cross are gate valves in the mash line for directing the mash either east or west in the mash line as required. A ½" high pressure steam inlet is tapped into the side of the cross for sterilising or steam locking.

The 2″ inoculating line from the seed tanks passes through a 2″ cross set vertically, with a 2″ gate valve placed immediately next it, directly into the top of the 4 x 4 x 2" T in the mash line from the coolers. The upper opening of the 2″ cross carries a 2″ blow off valve set for 15 lbs., and the lower opening acts as a drain fitted with a 2″ gate valve. The inoculating line is sterilised from a steam connection at the seed tank end of it.

The mash line (see drawings 65, 71 and 77) proper forms a rectangular closed circuit from which the fermenters are supplied through 4″ branches, with two dead end branches to supply fermenters 14 and 16. The branches enter the fermenters 5' from their bottoms, the flanges for these connections existing on the original tanks. The flow of mash into each fermenter is controlled by a 4″ gate valve placed next the tank and operated through a long spindle from the upper platform.

There are three types of branches from the mash line to the fermenters. The first is of the type shown in drawing 84 in the connection to fermenter No. 13. It is employed on the most recently installed fermenters, 10, 11, 12 and 13 and consists of a copper expansion U bend extending from a T in the mash line to the valve at the fermenter. Brazed into this bend is a ½″ steam nozzle so placed and shaped that a high pressure jet of steam is directed on the valve disc when closed to ensure sterility. The second type is that shown in the drawing for fermenter No. 15, and is applied to fermenters 1, 2, 3, 14, 15 and 16, it differs only in the curvature of the bend which is much less than in the first type. The third is employed on fermenters 4 to 9 and is the same as the last except that the connections are taken off in pairs from ″ crosses placed in the mash line.

The mash line itself is provided with two copper expansion bends, one between fermenters 2 and 3 and the other between 4 and 5. Th line is also divided into three sections by gate valves placed one between fermenters 3 and 4 and the other between fermenters 7 and 10. On either side of the former valve is a 1″ steam sterilising inlet which enables either half of the mash line to be sterilised or used independently of the other. In the mash line beyond fermenters 6 and 7 is connected the sterile air inlet shown in drawing 77. This device carries a 1¼″ steam inlet B, a 1¼″ drain T, a compound pressure-vacuum gauge and a 4″ air inlet "C" which is provided with a gate valve and wire screen, covered with a sterile cotton wool filter. It provides an inlet for sterile air should a vacuum ever occur in the mash line due to condensation of the steam.

At the two previously mentioned dead ends at fermenters 14 and 16 the steam seal arrangement shown on drawing 77 is used. This arrangement is as follows: In the mash line beyond the connection to the fermenter is placed a 4″ T carrying a 2″ blow off valve set for 10 lbs., next this is a pair of 4″ gate valves with a T between them in which is a ½″ steam connection and a 1¼″ gate valved drain. This provides a steam lock and beyond this final 4″ valve is a 4" line to the sewer.

SEED TANKS (CULTURE VESSELS)—There is a battery of nine culture vessels in a row on the operating platform south of the four cookers. These tanks are of copper 4 ft. 6 in. in diameter by 6 ft. 6 in. over all high, with dished bottom and a slightly domed flanged cover, having a 635 gal. capacity. Of these tanks four originally existed as second stage yeast tubs, and five new ones, o a slightly improved type have been added by the British Acetones replacing five original smaller yeast tubs. Very few alteration were found necessary, however, in the existing tubs, which are o the usual type of culture vessel. The most important change mad being the strengthening of the cover flange joints. The gener arrangement of the tanks and the various fittings on the ne tanks are shown in drawing No. 66. The actual tanks differ in few minor details from this drawing.

The vessels are of copper and are provided with various fitting The cover carries an 11 x 16 double arched manhole at the righ hand side, a 1¼ in. spring safety valve, at the left a ¾ in. gas co nection at the right in front of the manhole from which the pre sure gauge connection comes off (in the old tanks a 30-lb. pressu gauge is used, in the new a 15-lb. pressure—vacuum gauge), at t back a 2½ in. air valve (globe) with filter flange (this is on t five new tanks only), and at the left back and front two $1\frac{1}{4}$ in. spring vacuum valves. In the four old tanks there are no automatic vacuum valves. Their place is taken by a vertical $1\frac{1}{2}$ in. branch from the inoculating line entering the front just below the top, which is fitted with a globe valve and acts as both vacuum valve and air valve. This latter construction made it necessary to use the air line as the inoculating line, as otherwise the inoculant escaped through the air valve. In the centre of the cover is a gland through which a $1\frac{1}{2}$ in. stirring shaft passes.

On the side of the tank at the left are two 30 to 240 degree F. thermometers, placed 6 in. and 48 in. from the bottom; while at the right are three $\frac{1}{2}$ in. sampling taps at 12, 30 and 48 in. above the bottom.

The inoculating line (green) from the small inoculating vessels passes from the east to the west in front of the tanks, and branches run from it through $1\frac{1}{2}$ in. gate valves into the front of the tanks 9 in. from the top. This line at the west end is fitted with a drain and safety valve. A 2 in. filling line from the cookers (refer back) comes up through the platform beside the west vessel and leads east in front of the tanks, branches running through gate valves into the tanks 24 in. from the bottom.

From the centre of the bottom of each vessel a 2 in. fermenter inoculating line, fitted with $1\frac{1}{4}$ in. side drain, runs into the three way cock in the main 2 in. inoculating line, which passes along the front of the tanks just above the floor and down through the platform at the west tank where it is fitted with a gate valve, drain and safety valve into the fermenter mash line at the previously mentioned cross.

There are $1\frac{1}{4}$" steam sterilising connections (22 lbs. system) at the east end of both inoculating and filling lines. (The connection in the former sterilises the mash line to the fermenters also.)

There are two 1 in. steam inlets into jets in the bottoms of the new tanks, and a single inlet in the side of the old ones, supplied from the Locke regulator 22 lb. system, through an overhead $1\frac{1}{2}$ in. header. Each vessel is equipped just beneath the cover flange with a copper water cooling ring, supplied through a $\frac{3}{4}$ in. pipe, and all tanks are set on timber blocks in a large sheet metal tray which catches the drips, cooling water, etc., and carries them through a galvanised drain to the sewer.

The $\frac{3}{4}$ in. gas outlets are arranged with globe valves, and stop cocks, so that the gas may be discharged either through an ordinary gas meter (of which there are three, one for each battery of three tanks) or into the atmosphere through the wall. The lines to the meters pass through water cooled pipes to cool the gas and there is a steam connection on the air lines also.

The stirrers are of the propeller type in the new tanks, and of a special cone type in the old ones, and are mounted on 1½ in. shafts, carrying 9 in. pulleys, driven through a quarter turn belt from 9 in. pulleys on the countershaft mounted on the wall. These latter pulleys are driven through a lever controlled jaw clutch, and the shaft rotates at about 75 r.p.m., driven from a 7½ h.p. motor through a system of countershafting.

The stirrers of the old tanks are driven one-half as fast as those in the new.

There is in process of installation a set of galvanized iron ventilating caps over each air valve.

INOCULATING VESSELS—A small laboratory has been erected over fermenters 8 and 9, and is fitted with a battery of three 100 gallon inoculating vessels, and a small 100 gal. mashing kettle (see drawing 66). These vessels are hung on cast iron frames, and are equipped with stirrers (propeller type) driven from the main countershafting. The covers are fitted with a gland for 1 in. shaft, 1½ in. air valve, a 60 to 260 degree F. thermometer, a pressure vacuum gauge, and 4 in. filling or charging hole with screw cover. The vessels have a steam jacket around the hemispherical bottoms, supplied with steam (22 lb. system) through a ¾ in. pipe. The jacket may also be supplied through 1 in. bottom connection with water for cooling purposes. This latter connection is further arranged to drain either to the sewer or through a check valve to a steam trap. The jacket has a ½ in. air outlet cock at the top over the steam inlet and at the top opposite the steam inlet pipe a ¾" water overflow line. The vessels are equipped with a gauge glass, and sampling tap, and empty through a 2 in. inoculating line running to the large seed tanks, each branch being fitted with a gate valve, 1 in. drain and connection for the gauge glass (see drawing 38). This latter inoculating line has a ½" steam sterilising connection at the east end.

MASHING KETTLE—The mashing kettle is open at the top, 40 in. in diameter and 30 in. deep, with a hemispherical bottom. It is also equipped with a steam jacket (1½ in. 22 lb. steam and ¾ in. drain to trap line) and two sets of special mixing paddles, running in opposite directions, and scrapers driven through bevel gearing from the counter shafting. There is a ¾" water inlet at the top. The mash passes from the bottom through a 2 in. line to a header branching into the three inoculating vessels at the sides through gate valves and fitted at the east end with a steam sterilising connection. At the east end of this inoculation laboratory is a small office and testing room.

FERMENTERS—The fermenters, 16 in number, are of three types, viz.: those constructed from the original fermenters Nos. 2-9; new fermenters installed in the fall of 1916, Nos. 14-16, together with a rebuilt No. 1; and new fermenters built in the spring of 1917, Nos. 10-13. These are more fully described under a separate heading.

ORIGINAL TYPE—The original fermenters were of 5-16 in. plate, 18 ft. in diameter by 20 ft. high, with a slightly dished bottom (about 6 in.) and no cover. The tanks had single riveted lap joints, and simply rested on brick piers giving great difficulty under slight vacuums due to the drawing up of the bottoms. In the centre of the bottom was a 4 in. outlet, originally controlled by a plug valve with a long handle reaching to the top of the tank, but now leading to the front of the fermenter through a nipple and elbow where the valves are located.

A new conical roof of ¼ and 5-16 in. plate, with an 18 in. rise, is now on the tanks. This roof is fitted with a 6 in. flange at the apex; a 12 x 16 manhole; two special 3 in. flanges side by side for the safety valves; a flange for the 4 in. air valves; and a 6 in. flange for a vacuum valve. The cover is also tapped for a 1 in. thermometer gland, and a 1¼ in. steam supply.

On the side, 4 ft. 6 in. from the bottom at the front, there already was riveted a 4 in. flange, which was used for the mash line entrance. There are three holes tapped for ½ in. pipe arranged down the side for the sampling cocks, one two feet from the top, one midway between top and bottom, and the third 1 ft. from bottom, and a second 1¼ in. steam inlet tapped in 1 ft. from the bottom. At the front, just below the top is tapped in a ½ in. manometer connection. These improved old tanks were subjected to a static test of 1½ lbs. per sq. inch.

FERMENTERS 14, 15, 16 AND REBUILT NO. 1—The new fermenters No. 14, 15 and 16 and reconstructed No. 1 differ from the old ones in that they are built of ¼ in. plate and are 17 ft. in diameter, and 22 ft. 4 in. high at the back, 22 ft. 8 in. at the front, while No. 1 as reconstructed has a diameter of 18 ft. and a height of 20 ft. 2 in. and 20 ft. 8 in. at the back and front respectively. The seams are single riveted lap joints with ½ in. cold driven rivets. The roof is strengthened with ten 3½ x 3½ x 5-16 in. angle rafters, and the bottoms are flat with a 4 in. slope toward the front. The tank bottoms are riveted to six 12 in. I beams at 31½ lbs., running with the slope, which are in turn set on concrete pedestals. The fittings are the same as just described for the old fermenters, and the locations are shown on drawings Nos. 18-36 appended. The water gauge holes shown on these have since been plugged. The 4 in. beer outlet flange at the bottom instead of being at the centre is at the front of the bottom, 8 in. from the side. Also the upper central flange at the top of the cone is 4 in. instead of 6 in., on tanks 14, 15 and 16. These tanks were tested at 3 lbs. static pressure.

FERMENTERS 10-13—Tanks Nos. 10-13 are of the same size and type as the new ones just described. There are, however, two points of difference, the first the beer outlet at the bottom, which is in the form of a special cone elbow casting, with a 16 in. diameter where riveted to the tank, and a 4 in. flange outlet at right angles to the floor; and the second in the placing of a second 12 x 16 in. manhole in the side 1 ft. from the bottom. A static test pressure of 3 lbs. was imposed on these.

MANHOLES—The manholes used are of the usual type with two arches; a special ½ in. square rubber core gasket was used to overcome the unavoidable inequalities in the faces of the cover and ring; 1½ x ¼ plain asbestos gaskets having proved unsatisfactory.

VACUUM VALVES—The vacuum valves are of special design and construction, which will be evident from drawing No. 67, and are set to draw at about 4 in. of water. They are of brass with an inner diameter of 4½ inches, fitted with an air filter funnel (with detachable screen), and screwed into a 6 in. flange riveted to the tank roof near the side. The valves are sensitive, readily accessible for cleaning, proof against contamination and have been foun extremely satisfactory, both from a mechanical and from a bacteriological point of view, eliminating all danger of damaging the tanks or of contamination through drawing in outside air. Commercial vacuum valves proved decidedly unsatisfactory, working on such narrow limits and also due to the difficulty of making the valve bacteriologically tight.

AIR VALVES—The air valves are standard 4 in. gate valves, connected through a 4 in. close nipple with the tank flange, and are fitted above with an air wool filter funnel of galvanised iron.

SAFETY VALVES—The safety valve flanges are not now in use, as the two 3 in. pop safety valves previously employed have been replaced by the device described in the following paragraph.

FERMENTER SAFETY DEVICE—In the central 6 in. or 4 in. flange at the top of the cone is screwed or attached through a nipple and flange a special cast iron cross, having hinged flanges at top and back for cleaning purposes and a front flange set at an angle giving the 4 in. pipe bolted to it an upward slope of 1 ft. in 10 ft. The upper flange permits of the thorough cleaning of the tank flange, and the cross itself; and the back one allows a swab to be run through the 4 in. pipe for cleaning it.

The 4 in. pipe is screwed into the 4 in. brass flange on the special fermenter safety device. This device is now being installed on all the fermenters, and has proved decidedly satisfactory to date, there being no failures on record for any tank on which it has been used. (The one on tank No. 7 has now been in continuous use for two months.)

The device is constructed of No. 20 gauge galvanized iron, and as will be seen from drawing No. 60, is simply an adjustable water seal using antiseptic water. The device relieves at 10 in. water pressure. By adjusting the gate and the outer can the device measures the gas generated by its flow through a $1\frac{1}{2}$ in. circular orifice, and by again adjusting the gate the flow of the gas is obtained through the equivalent of a 4 in. pipe. (For detailed description of the device see section on "Gas System.")

When foaming the outer can is removed completely and the foam discharges directly into the large funnel below. The device is cheap, safe, easily manipulated, readily understood by unskilled operators, and eminently satisfactory from a bacteriological or mechanical point of view. It is the result of a long series of experiments on this subject, and has eliminated an enormous amount of trouble and waste of mash.

THERMOMETERS—There are two methods of registering the temperature of the tanks. The first by means of a continuous recording thermometer, sample charts of which accompany this report. These thermometers are manufactured by the Taylor Instrument Company, read from 60 to 220 degrees Fahrenheit, and are of the well known type by means of which a mercury pressure is obtained through a long pipe of very small bore, with a wire in the mercury space. This long capillary tube passes through a special gland (1 in. pipe thread), tapped into the tank roof at a radius of 4 ft. 3 in. from the centre, and suspends the thermometer bulb at a depth of ten feet from the top. This arrangement gives a fairly accurate average record of the temperature changes in the fermenter.

These records are useful but at the same time temperature records may be taken by means of the bib cocks situated near the top level of the fermenting liquor, half way down the tank, and at the bottom, the liquid withdrawn being tested by ordinary thermometers. Temperatures are taken at intervals of samples drawn from the lowest tap and show a variation of from 2 to 3 degrees higher or lower than the recording thermometer. This results from the fact that the samples are taken from near the side of the tank where radiation, proximity of other hot fermenters, etc., seriously affect the temperature of the sample. The temperature variation from top to bottom of tank as shown by samples taken at the different taps, is extremely small.

MANOMETER—The manometer connection is arranged as follows:

A short ½ in. nipple is tapped into the tank and carries a brass lever handled stop cock into which a second nipple is screwed carrying a ½ in. cast iron cross set vertically. The lower outlet of the cross carries another nipple and a second lever handled stop cock. The opening opposite that leading to the tank is plugged and the fourth opening, that at the top, has a length of ½ in. pipe about 12 in. long screwed into it, carrying a tee (or elbow), of which the upper opening is plugged, and the side outlet has screwed into it a plug into which a short ¼ in. copper tube is threaded. The rubber tubing is slipped over this copper tubing, and connects to the manometer which is quite close to the end of the copper tube.

This arrangement was found advisable because of the difficulty encountered through the connections choking with mash. The construction as described allows the connections to be readily swabbed or blown out when possible, without contamination.

The manometer is simply a ¼ in. glass U tube, with legs about 15 in. long and 3 in. apart, filled with coloured water, with a scale marked on cross section paper, reading to one-tenths of an inch. Both the thermometer and the manometer are mounted on a 12 x 1½ in. pine board, set vertically next the tank at the front on the operating platform, the boards of all the tanks being arranged in parallel rows. The thermometer is placed above the manometer about 5 ft. above the floor, and above the thermometer is the slide or holder for the operating tickets of each tank, while below the manometer is the hook on which is hung the file carrying the operating record of the fermenter.

STEAM CONNECTIONS—The two 1¼ in. steam inlets (high pressure), previously mentioned are for different purposes, the upper one in the tank roof at the side passing through and into a tee in which each branch has a nipple screwed into it and a 45 degree elbow set to throw horizontal jets of steam across the tank top to break up the foam. The action has not been found very satisfactory in this respect. The lower inlet passes to the centre of the tank, and into the back of a side outlet cross (a five way fitting), the other four outlets carrying 1 in. pipes reaching nearly to the walls of the tank and drilled with 1-32 in. holes 1 in. apart. The holes are inclined at an angle of 45 degrees to the horizontal, and giving a swirling action tending to move the heavy sludge collecting at the bottom when emptying the tank toward the centre. This action has been found effective. The lower steam inlet is also used for steaming when sterilising a fermenter. Both lines are controlled from the operating floor.

SAMPLING TAPS—The try cocks or sampling taps are simply in. lever handle plug taps, screwed directly into the side of the tanks, and are used for taking test samples of the mash.

Originally the tanks were fitted with continuous ½ in. gauge glasses reaching from the bottom to the top. The bottom connection was tapped into the tank bottom and for this reason and because of difficulty of effectively washing out, the glasses rapidly chocked and were unreliable and they were therefore abandoned and the try cocks used when necessary.

COOLING RING—For cooling purposes in preventing incipient foaming there are now available two cooling rings of 1 in. copper pipe drilled with 1/8 in. holes 2½ in. apart, and supplied through 1½ in. hose from the water mains. This ring is placed around the centre flange of the roof and directs streams of water over the roof and sides of the tanks. These are to be permanently installed on all the fermenters as they have been found fairly effective in preventing foaming if applied in time.

PROTECTIVE COATING—The tanks are painted on the outside with red lead, and the question of a protective coating for the interior has received considerable attention, but no definite conclusions in this regard have been arrived at up to the present.

BEER LINE (FERMENTER TO PUMP)—The beer line from the fermenter bottom, either the centre or the front, is fitted with a 4 in. gate valve which is just outside the edge of the fermenter. Beyond the valve is a close nipple and cast iron Y, with the branch pointing in the direction of flow to the beer pump. The through opening of the Y is fitted with a close nipple, and a second 4 in. gate valve, which is used for running off sour beer when a fermenter goes "bad," The branch of the Y carries a length of 4 in. pipe in which is placed a third 4 in. gate valve, this branch being sufficiently long so that the main beer line into which it connects through another Y clears the run off valve with a fair margin.

Into the Y next the fermenter is tapped a ½ in. steam pipe leading from a header supplied from the Locke regulator steam system (14 lbs.) which keeps the pipe in between the three valves always under steam and effectively seals a fermenter against contamination working in from the beer line or the outside air. This arrangement which has been placed on all the new fermenters and is in course of application to the older ones is shown on drawing No. 63, as well as a previous arrangement which it has replaced.

The 4 in. beer line runs by way of several branch lines shown diagrammatically on drawing No. 81 from the different fermenter groups to the suction of a 6 x 4 x 10 inch steam duplex beer pump located just south of cooker No. 4. These groups are as follows:-

Group 1—Fermenters 14, 15, 16, 1, 2 and 3 (with 16 on a dead end); Group 2—Fermenters 4, 5 and 6; Group 3—Fermenters

8, 9, 10, 11, and group 4—fermenters 12 and 13. At present No. 7, 8 and 9 are in the 4, 5 and 6 group 2, but are being altered at the present time to the above grouping. Each group passes through a 4 in. gate valve into the two suctions of the beer pump the two groups 1 and 2 into the north suction and groups 3 and 4 into the south. In the latter just before the pump is reached there is a 4" drain. The lines are about 12 in. above the concrete floor, and use is made of Y's and long radius fittings wherever possible to assist the flow of beer. The ends of groups 3 and 4, at the east wall, and group 1 at fermenter 14 are provided with 2" city water connections for washing out and there is a 2" drain at the dead end at fermenter 16 and at the end of No. 13. No provision is made for steaming the beer line as a whole.

PIPE LINES—The pipes in this and other buildings of the distillery, except those carrying spirit, were all wrought iron, and cast iron fittings were exclusively used in the old distillery days, even on the steam lines, and the practice was continued to the present time with the British Acetones; the reason given for the use of cast iron fittings formerly being the fact that they are more readily taken down than wrought iron (a few taps with a 2 lb. hammer generally sufficing to remove the most obstinate cast iron fitting). At present malleable fittings are being substituted on all steam lines, and to a large extent the other lines, as rapidly as possible.

The pipe lines are all painted distinctive colours, and the steam lines and water lines are asbestos lagged. The slop and beer lines are painted red, water lines white, steam, both live and exhaust, black, inoculant green, air and gas yellow and spirit, either iron or copper, blue. The majority of the lines are 4 in. in diameter.

RUNWAY—The fermenter section of the building has been fitted with a timber runway midway between the floor and the operating platform, extending the length of the building between the north row of fermenters and the cookers, and also north of the new fermenters Nos. 10-13 and a small one between Nos. 14 and 15. This is used in manipulating the valves of the cookers, getting samples from the fermenters, etc. The upper platform has also been extended around all the new fermenters and several new flights of stairs built to render the plant more convenient of operation.

FLOORS—The fermenting section of the building had a concrete floor arranged with a system of gutters in the concrete leading to drains to the sewers. These gutters are roughly situated below the beer lines, as they now exist, and afford a convenient means of getting rid of sour beer, drippings from pipe drains, etc. The floor is frequently washed down with hose. Small movable plank platforms or walks are now being put down for the convenience and comfort of the operators and the question has been considered of placing a runway over all the beer lines.

Signals and Communication—There is a complete system of gong and light signals between the mash floor and mash pump in the main building and the operating floor of the fermenting section by means of which the pumping of the mash is controlled. The fermenting floor is also provided with a telephone for communication with the laboratory (bacteriological) or the city system, and there are speaking tube communications where required.

DISTILLATION AND RECTIFICATION SECTION OF THE BRITISH ACETONES, TORONTO, LIMITED.

See Drawing 59A.

Beer Line (Pump to Beer Still)—The beer line from the 6 x 4 x 10 duplex beer pump south of No. 4 cooker passes upward at an angle through the operating platform and south over No. 12 fermenter through the north wall of the distillery five-storey portion of the building, passing just west of the beer still, and then runs vertically upward through the third and fourth floors and discharges over the side of the 7,100 gallon copper beer still service tank (formerly a scale tank) located on the third floor. This line has as easy a run as possible, right angle bends being replaced by 45 degree elbows wherever possible, and at the bottom it is fitted with a 2 in. bypass to the suction. The line just before discharging into the tank is fitted with a 1½ in. riser extending to just below the roof.

From the service tank a 6 x 12 duplex pump, gear driven from a 6 x 10 single cylinder steam engine, draws the beer through a 4 in. suction line, discharging it at a rate subject to close regulation by means of this type of drive, through a 3 in. line to the bottom of the beer heater just below the fifth floor. The pump is fitted with a 2 in. blow-off bypass, and the line to the heater with a 2 in. drain. The suction line to the still pump has besides a 4 in. gate valve a 4 x 4 x 2 tee into which runs a 2 in. city water main for washing down.

This arrangement of two pumps has improved the operation and increased the rate of working considerably over the results obtained by the old arrangement, which used the single gear driven pump on the ground floor. The arrangement has proved advantageous also when foaming occurs through being able to pump some of the beer out of the fermenter into the service tank.

BEER HEATER—The beer heater is of copper 36 in. in diameter by 15 feet long on the cylindrical part, fitted with sixty-six 2½ in. tubes 14 ft. long, the upper tube header being about 9 in. from the top, and the lower 3 in. from the bottom flange. The top is slightly domed, and is fitted with two 2 in. swing check valves on a tee, acting as vacuum valves.

The bottom of the heater is conical, about 30 in. deep, and the beer passes into the bottom of the cone up through the tubes, and the heated beer flows out at the north side, 6 in. from the top flange, through a 5 in. copper pipe into the beer still, entering the latter just below the top flange at the east side.

The vapour coming from the still through a 9 in. copper pipe enters the heater 9 in. below the hot beer outlet, and leaves the heater from the opposite or south side through a 9 in. pipe, 24 in. above the bottom flange, and passes directly into the condenser. There is a 3 in. copper syphon return for the condensed vapours from the heater back into the first plate of the still.

BEER STILL—The beer still is 6 ft. in diameter, and 41 ft. long, with a capacity of 6,000 gallons per hour on acetone work. The still contains 19 plates, the first located 5 ft. 9 in. from the upper flange, and spaced about 18 in. apart, the lowest one being 8 ft. from the bottom. It is built of 6 flange jointed 54" sections each containing 3 plates, and a 7' 4" top and bottom section. Each plate carries 69 boiling caps or mushrooms of 1½" diameter and one 8½" downpipe or overflow.

In the upper part of the still is a heating coil of 5 in. pipe, through which the beer from the heater passes, surrounded by the hot vapour. This 5 in. line leaves the still about 3 ft. below its entrance, and re-enters at the second plate down. There is a 4" vacuum valve on the top and between the second and third plates from the top on the side. The lower 6 ft. of the still is occupied by a calandria containing 404-2 x 42 in. tubes, the steam surrounding them entering through a 3 in. pipe (controlled by a globe valve from the operating floor) which divides into 4-1½ in. branches and enters the calandria at the top at four points of the circumference. There are two 2 in. exhaust outlets at the bottom, running to two steam traps. In addition, there are two auxiliary steam inlets, one a 5 ft. coil of perforated 1½ in. pipe at the bottom below the calandria, and the other a straight piece of 1½ in. pipe above the calandria. Both of these are now used in operating the still.

The calandria is equipped with two 2 in. blow-off valves, set for 12 lbs., a 1 x 18 in. water gauge, and a pressure gauge located on the third floor. The 6 in. slop outlet is arranged with a syphon so that the calandria is always covered, and a float controlled valve which maintains the level at the proper point. From the syphon the slop is carried by a 5 in. W. I. pipe line direct to the sewer.

The still proper has a 3 in. drain, and is fitted with 12 x 20 manholes between each plate, at the top and at the bottom. The pressure on the still itself at the operating floor (between the second and third plate above the calandria) is registered on a water column device on this floor, which proves very sensitive and accurate, more so than a dial gauge. There is generally 2 lbs. pressure at this point on the still.

BEER CONDENSER—The beer condenser is of copper 60 in. in diameter by 24 ft. long, standing on wooden base on the third floor. The vapours come from the beer still and heater through a 9 in. copper pipe, and enter the tube header (containing a spray plate), which is 42 in. in diameter and is fitted with 148-1½ in. x 20 ft. 0in. long tubes, spaced 3" centre to centre. The condenser is cooled with bay water through a 3 in. pipe from the reservoir (there is also a 2 in. auxiliary cooling line and 2 in. drain at the bottom) and overflows through a 4 in. W.I. pipe. It is provided with a 4 in. vacuum valve on the upper tube header.

The spirit leaves the condenser through a 3 in. copper pipe passing to the tail box, from which it passes through a three way cock, the side outlet of which is plugged into a 3 in. copper line, which is flange jointed to a 2 in. W.I. pipe line below the floor, and leads to the top of a 14,300 gallon copper tank AB, formerly one of the three wine tanks. From tank AB the spirit is drawn through a short 4 in. copper pipe into a 6 x 8 x 12 simplex steam spirit pump, and is discharged through a 4 in. copper line to the kettle of rectifier No. 1. This pump is arranged with a suction from a second spirit tank A1, also, which is immediately south of AB. There is, however, only one discharge, as the charge for rectifier No. 1 is made up of spirit drawn from both tanks. The discharge line passes through a 4 in. gate valve into a 6 in. returns line from the spirit column to the kettle just above the latter.

RECTIFYING KETTLE—The rectifying kettle, taking a 13,000 gallon charge, is of copper, 14 ft. in diameter by 14 ft. high. It is equipped with a steam heating coil of 2 in. copper tube, having 4 coils around the side just above the bottom and the remainder consisting of a spiral (17 coils), lying on the bottom of the kettle. This coil is supplied through a 2½ in. steam pipe at its outer circumference, the exhaust coming from the inner coil through a 2 in. pipe and passing to a trap or drain.

The steam valve located where the line passes into the kettle is controlled from the operating floor through a long handle, and the pressure on the boiler side of the valve, usually 90-95 lbs. is indicated on a gauge at the third floor between the two coolers.

The vapours from the kettle pass through a 16 in. copper pipe from a 4 ft. dome on top of the kettle to the spirit column entering the latter 27 in. from its base, and turning down to within a few inches of the bottom inside.

The rectifier is equipped with a 3 in. weighted safety valve, set at 5 lbs., a 4 in. spring loaded vacuum valve, drawing at a very slight vacuum, and a ½ in. gauge glass extending the full depth of the kettle. The 6 in. returns leaving the spirit column below the vapour line entering, runs into the kettle at the top near the side, and passes down inside to within 6 in. of the bottom. The kettles have a slightly dished bottom, leading to a 4 in. copper drain, and are mounted on brick piers about 24 in. above the floor. There is a 12 x 16 manhole in the side near the bottom.

RECTIFIER SPIRIT COLUMN—This is of copper, 60 in. in diam- er by 37 feet high, and stands on the second floor, reaching to st below the fifth. It contains 24 plates, 15 in. apart, each fitted ith three 6 in. overflows or down pipes and seven 7 in. capped pour pipes or bonnets. The first plate is about 3 ft. from the ttom, and the top one 2 ft. from the top. Under the first plate a 12 x 16 manhole. There are 1 in. copper draining bypasses around each plate, and a ½ in. sampling tap for each. The column is composed of ten 31½ in. sections flanged together, with a 5 ft. bottom section and a 4 ft. 6 in. top.

The pressure gauge on the operating floor indicates the pressure in the 16 in. header between the kettle and the column, and usually indicates 3 lbs. There is a 3 in. copper line running from what was formerly the fusel oil trap in the 6 in. copper returns line from the goose to the spirit column, which enters the column through 3 in. iron body gate valves between the ninth and tenth and between the nineteenth and twentieth plates from the bottom. This was expected to speed up the action of the rectifier, but proved disappointing in practice and is not now used. It was applied to No. 1 column only.

From the slightly domed top a 14 in. copper vapour pipe passes through the fifth floor and south near the roof to the goose. The 6 in. copper returns line from the bottom of the goose, containing the fusel oil trap, enters the top of the column near the side. There is a 4 in. vacuum valve also on the domed top of the column.

GOOSE TANKS—The rectangular goose tanks are of steel plate, 12 ft. 6 in. by 11 ft. by 8 ft. 6 in., 7,283 gals. capacity, placed with their bottoms 12 in. below the fifth floor, and are re-inforced with angles and tie rods. The vapour from the spirit column enters the middle of the top of a 14 in. header, 5 ft. 3 in. long, from which seven 6 in. outlets open downward, connecting to seven parallel sets of 4¾ in. pipe loops, consisting of 6 complete loops, each 6 ft. long, vertically, and ending in a 14 in. by 9 ft. 9 in. header at the east end. The seven loops enter the south half of this header at the bottom, and from the north half six similar sets lead parallel to the former sets to a third short 12 in. by 4 ft. 6 in. header, with its axis in line with the first.

The vapour passes out from the north end of the latter header down through a 12 in. copper pipe into the spirit cooler. Each set of loops drains into a header at the bottom, which in turn leads into a connecting header, passing out through a flange in the tank side, a 6 in. copper returns line and what were formerly fusel oil traps into the spirit column.

A 2 in. city water line for washing down or filling up the column runs into this returns line just outside the tank (see note re this later).

The goose tanks are filled with bay water for cooling which enters from the water reservoir through a 4 in. pipe in which is a gate valve controlled through a long spindle from the operating floor. The water is distributed in the tanks from the inlet pipe through five long 2 in. perforated pipes between the different loops. There is a 6 in. overflow 6 in. from the top, and a 3 in. drain in the bottom. A ¾ in. W.I. water sampling pipe from the goose tank taken from a 2 in. flange in the side near the bottom, passes down the south wall of the building to a tap at the third floor, which discharges into a sampling pail fitted with an overflow. The pail is used to obtain the temperature of the water in the goose tank.

Formerly the 2 in. flange connection from which the sampling line is taken connected through a 2 in. plug cock directly into the 6 in. returns line, into which the city water is now supplied. Bay water from the goose tank was then used to wash and fill the column.

Spirit Coolers—The spirit coolers stand on wooden bases on the operating floor, and are of copper 42 in. in diameter and 24 ft. long. They are made up of 60 in. sections. The 12 in. inlet pipe from the goose enters a 29 in. diameter tube header (situated about 2 ft. below the open top), from which 151-1 1-8 tubes 20' 0" long lead to the lower header. The upper header is fitted with a spray plate and 4 in. vacuum valve. The spirit leaves through a 3 in. copper pipe leading to the tail box.

Bay water is the cooling agent, and is supplied through a 2 in. pipe, 6 in. from the base (from which a 2 in. drain also leads), and overflows through a 4 in. W.I. pipe, 6 in. from the top. There is a 12 x 16 manhole in the side at the bottom.

From the tail box the spirit is directed into a 4 in. header, from which three 2 in. outlets lead through stop cocks to the different pipes and tanks.

The first runnings pass through the north outlet into a 2 in. copper pipe leading to the 14,300 gal. spirit tank A1, located beside the tank AB. The second runnings flow through the south outlet into a three way cock, and out of the side opening of the latter into a second 2 in. three way cock, passing out through the outlet of the latter into a 2 in. W.I. pipe leading to the returns line o the kettle of rectifier No. 2.

The next runnings are directed into A1, and are followed by unnings (butyl) which pass out through the outlet of the first hree way cock through a 2 in. W.I. line to the reservoir B1, formerly a 13,400 gal. wine tank.

The "last runnings" come out through the south outlet and the side outlet of the second three way cock into a 2 in. iron line known as LR. and flow to a small 881 gal. tank on the second floor, formerly the evaporator supply tank. The middle outlet from the header leads through a 1½ in. "tails" line (copper) to the two spirit diluting tanks, 13,400 gallon capacity, in the filter room, the tails being directed to the west tank. A branch of this line also runs to the top of BI, but is not used. The tails line is used for emergencies, bad stuff, etc.

Rectifier No. 2—The second rectifier, spirit column, goose and cooler are identical with the first, but the charge is made up of the spirit R2 from rectifier No. 1, soda and water, and the runnings from the tail box of rectifier No. 2 pass into the header as in No. 1, from which in turn it passes through the three plugged stop cocks and 1½ in. pipe to three possible destinations.

The first runnings pass through the north outlet and a 1½ in. copper pipe into the previously mentioned line to tank AI. The second runnings (acetone) pass out of the south outlet through a short 1½ in. W.I. pipe to a battery of gauging vessels on the third floor. After the acetone there is another run of AI, and the last runnings, the "oils", pass through the 1½ in. copper pipe previously mentioned to the east tank of the two in the filter room.

Soda Tank—The former 1,000 gallon yeast tank on the third floor is now used as a soda mixing tank, and is supplied with city water through a ¾ in. line and tap. The soda from this tank passes through a 1 in. W.I. pipe line to the tops of the kettles of the two rectifiers, and also through ½ in. pipes to plates 2, 4 and 6 (from the base) of spirit column No. 2, entering through the sampling tap holes.

Spirit Tanks—The location of the three former wine tanks has been altered. Two of them viz.: AB and AI, are now side by side between fermenters 13 and 14, and just east of the main stairs leading to the platform. The third, BI, stands practically due north of rectifier No. 2, between two brick pier carrying the north wall of the building, and south of and midway between fermenters 12 and 13.

The two 13,400 gallon spirit tanks formerly located at the east wall (now B2 and A3) east of the rectifiers have not been moved, except that the south one, A3, used now as an acetone storage tank, has been raised some 3 feet to provide sufficient head to cause flow to the shipping room.

From a point 2 ft. from the top of B1 a 2 in. W.I. line leads into B2 about 30 in. from the bottom, and from B2 a 4 in. W.I. line leads to the 12 x 10 x 20 steam pump under the evaporators (formerly slop pump) from which a 4 in. overhead pipe carries the butyl to the north 400,000 gal. outside storage tank.

Another connection may be substituted for the one just described on B2, the drain from the tank passing to a 6 x 8 x 12 spirit pump between the two east tanks, which discharges through a 2 in. W.I. line back to rectifier No. 1 through the safety valve opening.

The bottom layer of B1 is drawn off through a 4 in. W.I. pipe by the one-time scale tank spirit pump (6 x 8 x 12) beneath the beer still, and discharged through a 3 in. copper line up to the beer still service tank.

GAUGING VESSELS—These vessels, four in number, located on the operating floor, are of galvanized iron, 100 gals. in capacity, 4 ft. in diameter with a 15 in. cylindrical part, a 6 in. conical bottom, terminating in a 1½ in. pipe flange. The lids are fitted with a 9 in. diameter sampling opening with a hinged cover. They are shown in drawing No. 22, attached herewith, together with their connections.

These vessels are used to hold the runnings from rectifier No. 2, while the sample is being tested, after which it may be directed back to A1 for re-rectification or to the acetone storage, as determined by the test. The inter-connections are 1½ in. genuine W.I. pipe. The supply from the tail box of No. 2 rectifier enters the tops of the vessels through globe valves and leaves at the bottom; the left-hand branch of the drain controlled by globe valve being the return line to A1, and the right-hand controlled by lever handled plug stop cock the acetone line which passes down the south wall of the building. The vessels are placed so that the handles of the lower valves are just above the floor, all the underpiping being below the floor level. The vessels are numbered 1-4 from south to north and the samples are taken from them by means of a copper dipper.

ACETONE LINE—The acetone line from the gauging vessels coming down the south wall of the building branches just below the second floor, one branch running horizontally and fitted with a valve, controlled from the operating floor, into the raised tank A3 in the south-east corner of the building. The other branch passes down through a globe valve about 6 ft. above the ground floor, and into a tee in a line from the bottom of the raised tank, there being a valve in the latter line at the tank. A single line passes from the tee through the wall and along the south side of the building on the ground for about 75 ft. to a small concrete drip box, where it turns down and run southwest for 25 ft. underground through a 3 in. protecting pipe to about 3 ft. from the north-east corner of the store room building (now used as a shipping room), and under the south-east corner of a new elevated acetone storage house. The protecting pipe has a slope back to the concrete box and serves to indicate any leaks in the acetone line.

ACETONE STORAGE HOUSE—Just outside the wall of the shipping room is a tee in the acetone line, one branch running west and then vertically upwards through the concrete floor to the acetone storage house near the roof, where it again divides, one branch with gate valve control going over the edge and through a 3 in. flange into each of two 3,000 gallon 9 ft. diameter by 7 ft. 4 in. average height, No. 12 gauge galvanized iron tanks.

The tanks are covered, the covers having a 12 x 16 in. manhole, and a flat sloping bottom (4 in. slope) draining to the front, where a 2 in. drain flange is riveted. The tanks are placed in a small steel and galvanized iron elevated structure, shown in drawing No. 20. The tanks now used are larger than those indicated on the drawing, which were recently replaced by the larger ones in order to secure storage for a carload of acetone with a sufficient margin for eventualities.

The structure has a sloping, reinforced concrete floor, and was erected by the British Acetones. The 2 in. drain lines provided with 2 in. gate valves pass through the concrete floor and come together below, a single line passing into the shipping room.

SHIPPING EQUIPMENT—The store room of the General Distilleries is used as a shipping room for the British Acetones. The 1½ in. line from A3 and 2 in. line from the elevated storage tanks run along the east wall to the centre, where they turn outward at right angles and terminate in downward directed pipes fitted with plug cocks over the platform of a 1,200 lb. platform scale, on which the drum is rolled for filling. A short length of pipe is inserted in the bunghole of the drum, and is then screwed on the end of the plug cock nipples for filling. Midway between the north wall and the scales is placed a drum washing tank, which is shown on drawing No. 21, from which the dimensions may be obtained. There are two rotateable wash nozzles which may be supplied with either steam or water.

The drum is rolled up a skid on the north end over the trough, and a nozzle inserted in the bunghole. After washing it is rolled down the skid at the south end rinsed out with acetone and up another directly to the 42 in. by 42 in. platform of the scale, where it is filled. From the 2 in. acetone line previously mentioned, a branch runs to a flange in the side of the trough, by which means any acetone of poor quality may be run into the trough and drawn by a small pump (2½ x 2 x 4) in the north-east corner through a 1½ in. pipe from the drain of the trough, and discharged through a ¾ in. pipe enlarging to 1¼ in. back to rectifier No. 2. The drum washings are redistilled in this rectifier. The 1½ in. acetone supply line also has a branch for the same purpose, which instead of entering the flange provided on the trough comes into the pump suction direct through a tee. Besides the drain line from the trough to the pump there is a second 1½ in. drain running directly to the sewer.

North of the scales on the wall are the stencil racks and the scale testing weights, while south of them is the desk, sample cupboards and storage shelves. A 9 ft. by 9 ft. door in the middle of the south wall opens directly on the railroad siding, and in this door was erected a 5 x 10 ft. timber loading platform, at a slightly greater height than the floor of the railroad cars.

The filled drums are hoisted to this platform by means of a fixed radius (9 ft.) steel jib crane, equipped with a 1 ton Morris electric hoisting block, installed by the British Acetones; and the drums are then rolled on a skid to the car.

Empty drums received from the cars are simply rolled down a skid from the hoisting platform to the floor of the shipping room, which is about 3 ft. below the yard level.

The remainder of this building, with the exception of that occupied by the original molasses mixing tanks and pumps, and the butyl salting plant in the north-west corner, is used for drum storage purposes, there being kept here generally about 100 empty cleaned and uncleaned drums. There may in addition occasionally be 15 to 20 filled drums here left over from a previous shipment.

The acetone is shipped in carloads, with 42 drums to a carload generally. The drums are standard pressed steel 28 x 42 in. acetone drum, with a 2 in. pipe tap plug. The drums have a tare weight of about 170 lbs., and are now shipped with 700 lbs. of acetone in them. The plugs are screwed home with a heavy 24 in. T plug wrench.

The rate of filling with this equipment is six drums an hour, and a car can be loaded in about one hour with a gang of nine men.

OUTSIDE STORAGE TANKS—Of the three original outside storage (molasses) tanks, the west 250,000 gal. one has been broken up and sold and the north 400,000 gal. tank, now holding butyl has been sold and is about to be broken up. The south 1,250,000 gal. tank will be retained. It is at the present time unused but will likely be used for butyl storage or slop settling in the future.

POWER PLANT AND STEAM SUPPLY—The boiler house of the General Distilling Company supplies the steam required for all the operations with the exception of the milling and mashing.

The equipment consists of a battery of six Babcock and Wilcox boilers arranged in pairs, the two end ones being 250 h.p. and the four middle ones 175 h.p. The boilers are equipped with Jones Underfeed stockers, hoppers hand filled, 3½ in. spring loaded safety valves, set for 125 lbs., and carry normally 120 lbs. of steam. The higher power boilers have two drums, the others one only. The steam comes off through a 6 in. valve and pipe into the top of a steam header which increases from 6 in. diameter over the west boiler to 10 in. where it passes through to the distillery. At the west end a 4 in. valve controls a line leading to the shipping room and butyl plant, with a 2 in. branch parallelling the main header running to the east end and supply the boiler feed pumps. A 2 in. line from the safety valve connection on the second boiler from the west end is connected into the latter line also. At the east end just past the last boiler is a 10 in. gate valve from which the 10 in. steam main leads through the east wall, through the shop (formerly filter room) and into the distillery proper.

The boiler feed pumps, are two 9 x 5 x 10 outside packed duplex pumps, which draw the feed through 4 in. pipes from a 6 x 6 h water drum, (there is a 2 in. city water connection into the we pump section) and discharge it through a 4 in. pipe either through a 1,200 h.p. Alberger exhaust steam feed water heater, or directly to either of two 4 in. feed water lines, equipped with swing check valves, to the boilers. The discharge lines from the heater are provided with a large air chamber. Up to the present there has been only one feed line passing in front of the boilers supplying them from the 2 in. branch. This was extremely bad, as with a break down in the line at the east end all the boilers west of the break were put out of commission. There is now, however, a practically completely installed second 4 in. line parallelling the first, and linked up with it at the west end. The first will be broken between each pair of boilers, and 4 in. valves inserted, effectively safeguarding the boilers against feed line breakages.

The hot water drum is so connected that the water may be supplied to it through a 2 in. float valve from either a special separate city supply, the ordinary distillery city supply, the bay water system or a hot water line from the mash coolers, all through 2 in. pipe. A 3 in. and four 2 in. exhaust steam lines from various traps, that formerly entered the drum direct, causing difficulties when the traps were out of order through steam surging in, are now connected with tees and branches collecting in an overhead 4 in. header, leading the steam either into the main 8 in. exhaust header to the heater, or if sufficient exhaust is already available directly to the air.

The exhausts from the different pumps and engines in the distillery have recently been collected into a single 8 in. exhaust header, and returned to the Alberger heater from which the condensate passes through a 2 in. pipe to the hot well.

The flue gasses from the boilers pass off through a 6 ft. 6 in. square iron breeching to the 4 x 125 ft. steel stack, set on a concrete base, outside the west end of the boiler room. A continuous flue gas recorder and a flue gas thermometer have been inserted in the smoke flue just beyond the last boiler.

There are two pressure fans for forced draft, one motor driven (30 h.p.) by a belt at 750 r.p.m., with a 5 ft. x 24 in. impeller which is generally used, although not continuously, merely to keep the pressure up under heavy loads. This also drives the stoker feed mechanism. The other fan has a 4 ft. x 21 in. impeller, and is belt driven from a high speed steam engine.

STEAM PIPING SYSTEM—The main steam header enters the distillery through the west wall, where a recording and indicating pressure gauge is tapped in just as it passes through the wall, and beyond it is a tee from which a 6 in. branch passes vertically through a valve and again divides, another 6 in. branch going south to supply the evaporators and pumps in the south-west corner, and a 4 in. branch going north to supply the fermenting section. ward and divides into two 6 in. valve controlled branches, one supplying the rectifying kettles and beer still, and the other the two

From the first tee, the second or through 8 in. line runs east-main water pumps, various small pumps, besides the Locke regulator controlling a 2 in. 15 lb. heating line for the girls' mess room and offices. The 4 in. fermenting section steam supply divides into two 4 in. lines, one of the latter further dividing into a 3 in. under control of an attendant supplying the mash line digester nozzles, and another 3 in. feeding the cooler pump, beer pump and fermenter mash line valve jets. The other 4 in. branch itself divides into a 3" branch and two smaller branches as follows: a 2 in. Locke regulator 22 lb. line for the cookers, inoculating vessels and sterilisation of lines and a 2 in. line for fermenters 10-13. The 3 inch branch supplies a 2" fermenter header over the remainder of the fermenters which loops up with the 2 in. over fermenters 10-13 at the east end and also supplies a 1½ in. high pressure sterilising line under the runway. The latter supplies the steam for the jets on the valves in the mash line to the fermenters. There is a 2 in. cross-connection to supply the fermenting section with steam from the line feeding the office Locke regulator, and also from a 2 in. line from the Gooderham & Worts boiler house. The latter line is further connected up to supply the Locke regulator on the office heating system.

At present five of the six boilers in the General Distilling boiler house are always in use, but the boilers have been found to be in bad shape, and are now being thoroughly cleaned. It is expected that three boilers will in future do the work now being done by the five, so that five will be able, in addition, to supply all the steam necessary for milling and mashing, thus eliminating the Gooderham & Worts boiler house now used.

In the latter there are eight 100 h.p. return tubular boilers, of which six are now in use, supplying steam for mashing and milling, the Gooderham & Worts fitters' and carpenter shops and bottling department.

WATER SUPPLY SYSTEM—There are four main sources of water supply for the British Acetones.

The first is a 4 in. line from the municipal system entering the building at the north wall between fermenters 1 and 16, which divides into a 4 in. branch which runs around fermenter 16 and branches, a 4 in. branch running east under the runway to supply the coolers the floor hosing system and the beer line washing connection and a 3 in. branch running east and vertically to supply the fermenting floor and from which a 2 in. header runs east above the cookers and fermenters besides a branch over the seed tanks both of which supply the cooling rings of the different tanks. A 3 in. branch from the original supply passes under the platform and through the west wall into the filter room, where lines run to the spirit diluting tanks, the wash water tank, the molasses mixing tank south of the filter room, the shipping room and from which two 2 in. branches pass into the boiler room, one to the yeast kettle and the other to the feed water drum.

The second source is also the municipal system, and is a 2 in. line for boiler feed purposes only, coming in through the boiler house wall and a separate meter to the feed mater system direct.

The third is a bay water supply which is drawn by two 12 x 14 18 in. duplex steam pumps in the distillery through 12 in. suction pipes from a well at the bay front, and discharged through two 8 in. lines to the reservoir on the roof. The pumps handle 1,000 gals. r minute at 100 lbs. per square inch. From the 5,300 gal. bay ater reservoir on the roof, which is fitted with a 10 in. overflow, series of lines are taken. The first is a 4 in. line which reduces 3 in., and supplies the beer still condenser; the second a 6 in. hich divides into a 5 in. to the goose tanks and a 3 in. to the ctifier cooling columns; the third a 4 in. to the evaporator conden- r; and the fourth a 6 in. which divides into two 4 in. branches, e running north toward the fermenter section, which is now oken, and the other west to the evaporators. A 10 in. overflow m the main reservoir runs into an 8 in. drain pipe passing down e south wall of the building, into which various other drains are n. There is a second 6 in. drain at the east wall connecting other in lines.

The fourth water supply system is a fire protection service. On s system there is a 4 in. line, reducing as it passes upward, running up the south wall of the five-storey section of the building, fitted with hose connections at each floor and at the roof. From the first of these connections a length of hose is already laid north of the fermenting section. This was deemed advisable rather than a fixed iron pipe line, due to its flexibility in case of an explosion. On the fire system there are also a number of hydrants in the yard at convenient points.

ELECTRIC SYSTEM—The electrical power is supplied by the Toronto Electric Light Company, and is 550 v. 25 cycle three phase alternating current. It is stepped down in the different transformers to 220-110 v. as required. The electric wiring, both power and light, has all been put in conduit, with the switches, switchboards and fuse boards placed in small outside galvanized iron switc houses. There is one of the latter outside the main distillery door, receiving current from a transformer on the wall above, throug which the lines to the distillery section are controlled.

There is a second house on the roof of the fermenting sectio at the west end. It receives current from the previously mentione transformer, and contains the controls for the fermenting sectio lines and the motor for the seed tank drives. The shipping roo switches, light and motor for butyl plant, are in a galvanized ir box outside the shipping room door. The transformer for th boiler house is on the south wall outside, with a switchboard ju inside the west door. The fan motor runs directly on 550 v. Th shop motor, fuse box and switches are just inside the new doorwa The yard is now lighted with high power lamps equipped with r flectors, and the offices, drafting rooms and laboratories are bri liantly lighted with special semi-indirect fixtures. The motors use are all of the induction type, with special oil bath non-sparki starting boxes.

COMPRESSED AIR SYSTEM—The compressed air is supplied fro the compressor on the stone floor of the Gooderham & Worts ma building. A 2 in. overhead line runs to the distillery, from whi various connections are taken off to supply the air drills and rive ers used on construction work.

SHOPS—The shops of the Gooderham & Worts Company we until the present time, used exclusively for doing the work requi by the British Acetones. This resulted in much loss of time owi to the distance away and the frequent travelling back and forth. Recently, however, the filters were removed from the filter room and the room fitted up as a steamfitters' shop. The door into the distillery was bricked up, and a new doorway at the south end opening into the yard put in, the walls cleaned and the lighting improved. The north half is equipped as a stockroom, with various racks, drawers and a counter dividing it from the south half. In the south half are placed the different benches, with machines and vices, a 4 in. pipe cutting and threading machine, a small drill press, and two-wheel emery grinder, and acetylene welding outfit. The power is supplied from a 7½ h.p. motor, and there is a small portable forge outside in the yard. At the south wall opposite the door is the pipe rack.

The carpenter and coppersmith shops of the Gooderham & Worts Company are still used, as the time lost due to their distance away is not great, the trips back and forth not being so frequent in this work.

GIRLS' QUARTERS—The south-east corner of the fermenting section of the distillery, formerly used as a superintendent's office, is now fitted up as the girls' quarters, comprising girls' messroom, toilet, etc.

SUPERINTENDENT'S OFFICE—There has just been built a small separate superintendent's and time office, located in the yard at its narrowest point before reaching the General Distillery property. This building is equipped with an office for the superintendent, timekeeper and stock clerk. There is also provided an entrance for the workmen fitted with a time clock. There will also be installed here a watchman to prevent the entrance of anyone to the plant without the proper authority, and also to relieve the men of matches or other dangerous materials. The watchman is now located in the only entrance to the distillery building proper, other than the girls' entrance, which is through the girls' quarters, and prevents the carrying in of matches, etc., there.

OFFICES—The two-storey section of the distillery building in the south-east corner has been remodelled and fitted up as the offices of the British Acetones. The lower floor contains the business office and distilling laboratory, and on the upper floor is the drafting office and the office of the general manager, which is also used as the board room.

Staff —Labour Staff—The construction staff at present employed has recently been considerably improved through the acquiring of a competent and experienced superintendent, who has been able to put his entire time and attention on the actual construction work, resulting in much smoother working and better and faster work. The mechanical superintendent has charge of the construction work, and has under him the steamfitting force, consisting of a foreman and eight steamfitters and helpers; the carpenter force, also under a foreman, consisting of about three skilled carpenters and three men for the rougher work, who also handle the concrete work; and the coppersmith force, comprising the smith and his helper. There is also an unskilled force under a foreman of about nine men, who handle the cleaning of the acetone drums, the heavy hoisting work, the cleaning of the different parts of the plant, and the loading of the railroad cars.

Operating Staff—The operating staff consists of the boiler room section, composed of three shifts of three firemen each; the operating engineer force, of three shifts of three men each; the milling staff, of one shift of six men; and two mash floor attendants.

The fermenting section is also worked in three shifts in charge of the fermenting foreman, who has under him four girl operators. The distilling section is also in three shifts, composed of two girl attendants under the direction of an experienced still man. The drum filling is taken care of as required by an experienced man from the Gooderham & Worts Company.

Engineering Technical Staff—This department is under the direction of Mr. E. M. Shaw, of the Imperial Munitions Board, and consists of three draftsmen.

Business Staff—The business staff consists of a skilled stenographer and assistant, under the supervision of an accountant from the Gooderham & Worts Offices.

Edward Metcalfe Shaw.

APPENDIX I—INOCULATING ARRANGEMENTS.

To reduce the possibilities of contamination that are always present when inoculant is transferred from one vessel to another the 5 gallon pails now in use to transfer the inoculant from the laboratory to the 100 gal. inoculating vessels described previously are being replaced by three small 5 gal. culture vessels.

CULTURE VESSELS—These culture vessels are similar to the inoculating vessels previously described. They are of copper, with hemispherical steam jacketed bottoms and flanged covers. Each cover besides the gland for the $\frac{7}{8}$" central shaft, is fitted with a $\frac{1}{4}$" gauge connection, a $\frac{1}{2}$" gas outlet, and two 1" pipe openings, one for the thermometer and one for the filling gate valve. The gland for the shaft, as are the glands on the other inoculators, is fitted with a funnel device for carrying antiseptic sealing fluid. In the side of the vessel is a $\frac{3}{8}$" sampling cock and the jackets are provided with two $\frac{1}{2}$" connections, one near the top, being for the steam inlet, and water outlet, and that near the bottom for water inlet and steam exhaust. There is also a $\frac{1}{8}$" pet cock in the jacket. The vessel outlet is 1" and runs into a 1" cross through the lower opening of which the inoculant passes, and thence through a Y into the inoculating line to the 100 gal. inoculating tanks. One side opening of the cross is for a steam sterilising connection and the other for a drain for contaminated mash to the sewer.

The vessels are equipped with a hand operated stirring gear consisting of a copper blade or scraper, conforming to the vessel's shape, to keep the interior of the vessel clean, and of two radial blades set at an angle to beat down the "head."

The culture from the laboratory will be emptied from the flask into one of these 5 gal. culture vessels, from which it will be run into a 100 gal. inoculating vessel and in turn from this 25 gal. lots will be run into the 600 gal. seed tanks (containing 500 gals. of mash) and each of the seed tanks will be used to charge one fermenter of 25,000 gals. of mash.

There will be thus now four stages in the plant, instead of three, which will all be carried out in closed vessels and pipes.

NEW LOCATION—At the present time there is also a proposition under consideration to remove the whole inoculation department over to the third floor of the distillery proper, at the west end increasing the number of seed tanks to 16 or more and the inoculators and culture vessels proportionately in order to increase the output of acetone. In this case a 2,000 gall. cooker fed from the mash line will be added. This department would then be in charge of a separate foreman. A bacteriological laboratory is also proposed to be placed on the floor above.

FORCED INOCULATION—Another important change in the inoculating arrangements recently installed and now successfully at work, is the installing of a small 2" rotary belt driven pump with a capacity of some 2,500 gals. an hour at the proper speed, but now operated so that it empties a seed tank in 20 minutes or at a rate of 25 gals. per minute. It is located at the east end of the battery of 600 gal. seed tanks, since the seed tank emptying line or fermenter inoculating line has been altered so that it now runs from west to east and drops vertically from the east end to the mash line. The pump is completely submerged in a tank of antiseptic liquid and is belt driven from the main seed tank drive. It draws the inoculant from the seed tanks and discharges it under pressure through 2" line into the top of a T placed in the mash line from the coolers (see drawing 84). There is also a 2" by-pass around the pump. The inoculating line just before the T is reached is provided with a 2" blow off valve and a 2" drain on the branches of a 2" cross and between the cross and T is a 2" gate valve. This arrangement renders the inoculating of the large fermenters more positive without introducing any further danger of contamination. The low pressure steam now admitted through a 1" pipe at the west end of the inoculating line beyond No. 9 seed tank thus sterilises the whole line through to the gate valve just mentioned and blows off through the blow off valve.

HEAD MIXER—Another scheme being worked on here and about to be installed as an experiment in one seed tank is an arrangement of blades and baffles, for carrying the head down into the liquor and thoroughly mixing the two. In the seed tank are riveted two vertical copper baffles 12" wide extending across the tank, one just above the propeller and the other about 9" above the first. Between the two baffles and above the top baffle fixed to the rotating shaft are two paddles 8" wide, set at an angle to beat down the head. The baffles are provided to prevent the whole mass of liquor rotating as a whole and the paddles and propellor are to beat down and draw down the head and liquor, mixing the two and insuring that the whole of the inoculant gets to the inoculating pump suction. Fuller details and results will be available after trial.

EDWARD METCALFE SHAW.

APPENDIX 2—DISTILLING AND RECTIFICATION.

In order to increase the output of the plant, the capacity of the stills and rectifiers has had to be increased. The question has been considered carefully and a course of action decided upon. The contracts have been let and work on them is now proceeding. It is expected the alterations and additions will be completed in about three weeks or a month. The changes are as follows:

DISTILLING—The capacity of the original 6 ft. dia. beer still on acetone work is from 6,000 to 7,000 gals. per hour. The still is of copper built up of a 6-54" sections, each containing 3 plates, a 7'-4" top section containing one plate and two 5" spiral beer heating coils and a 6'-6½" lower section containing calandria, etc. Three of the middle sections of this still are to be removed and used in the construction of a second still. The top section and that next it containing the beer entrance are to be lowered, the vapour and beer pipes lengthened and the remaining equipment of the old still left as at present.

NEW BEER STILL—The new second still will be constructed of he three sections of the old still, together with a new bottom and op. The new bottom will be comparatively shallow and contain a " perforated copper steam soil with a brass fitting for connection o a 3" steam line and be fitted with a brass washout plug, and an utomatic valve with copper bend and float for controlling the slop utlet. The section is also equipped with gauge glass and pres- re gauge. No calandria is being fitted in the new still because of e difficulty of obtaining the necessary tubing and the compara- vely small saving effected by using the calandria as compared th using live steam direct. If desired, a calandria can be added er.

The top of the new still will be 7'-10" high and contain two tes, one new and the other an old one moved from the top of the section immediately below the present top section. This is done order to provide room for the beer line entrance between the d and 3rd plates down which necessitates the increasing of the cing of these plates from 18 to 24 inches. The top section will fitted with a flanged cover in order to be able to put in the al beer heating coils at a later date if found necessary.

NEW BEER HEATER—The large molasses cooler (formerly a steam condenser), see section on Original Plant, is to be used as a beer heater for the new still. This cooler is contained in a ¼" boiler plate shell 42" diameter by 20' 3" long and contains 63-2" outside dia. x 18' long 18 gauge copper tubes fitted into cast iron headers by means of glands. This cooler is being thoroughly overhauled, cleaned, and the necessary new openings put in it.

This "heater" will be connected to the new still with 10" pipe and to the condenser with an 8" pipe; the beer line between heater and still is of 5" copper tubing.

The present beer condenser is to be used for both stills by making slight alterations. The vapour head is to be removed, the present 10" opening closed, a division plate inserted between the centre of the tube plate and the inside of the top of the dome and an 8" opening provided in each compartment. An 8" vapour line from each still and heater will pass through an 8" gate valve into each of these two 8" openings. The existing arrangement of the tail box will be retained.

RECTIFICATION—In the rectification section the present two rectifiers taking charges of 13,000 gals, as described previously in the section on the Existing Plant, and now used, one for preliminary and the other for secondary rectification, are to be both used in future for preliminary rectification, which will necessitate only slight alterations in the piping.

NEW CONTINUOUS ACETONE STILL—For the secondary rectification a new Modified Barbet Continuous Still is being built by the E. B. Badger & Sons Co. of Boston, Mass., capable of dealing with 14,000 lbs. of acetone per 24 hours. The elevations and plans showing the general arrangement accompany this report. Briefly, the arrangement of the still is as follows:

The acetone to be purified or rectified is elevated through a 3 supply pipe to a 3' x 3' constant level reservoir just below the roof. The level in this tank is controlled by a float acting through a chain on a Mason Regulating Valve on the feed pump. From the reservoir a 1½" line drops vertically to the operating floor, where control valve is located, and then rises and enters the bottom of 13" heater on the top floor. From the top of the heater a 2" line drops to the top of a 54" Exhausting Column which is supplied with steam at the bottom through a 2" pipe from a 2" Mason Regulating

Valve controlled by a 16" Steam Regulator on the operating floor. The steam regulator is actuated by the pressure at the base of the rectifying column through a 2" pipe. The slop from the bottom of the exhausting column escapes through a 4" slop seal and 4" pipe to the sewer. A ¾" line from the bottom of the column runs through a Vapour Separator to a Slop Cooler and Tester on the Operating floor. A ¾" line runs from between the 12th and 13th plates of the exhausting column through a Pressure Bottle at the third floor into the top of the rectifying column, while a second line 1¼" dia. starting from the same level runs to the steam regulator. These latter lines are for regulating purposes.

The vapour from the exhausting column passes up through a 5" pipe and into the base of a 36" Rectifying column standing on the third floor. There is a 2½" returns line from the latter column to the top of the exhausting column. The vapours from the rectifying column pass through a 5" pipe to the top of the 13" heater, from the bottom of the heater to the top of a 21⅝" Dephlegmator and from the bottom of the latter through a 4" pipe to the top of a 16" Condenser. The latter three units are side by side on the top floor. Three returns lines, 2½", 2" and 1½", run from the heater, dephlegmator and condenser respectively into the 2½" line and into the top of the rectifying column.

From the top of the rectifying column a 1½" line loops down o the third floor where a control valve is located, and thence into he top of a 36" Auxiliary Rectifying Column standing on the ourth floor, from the bottom of which a 1½" line drops to the top f a 13" cooler on the operating floor and passes from the bottom f the latter vertically and through a flow meter and valve to the outh one of two Testers or Tail Boxes. The vapours from the top f the Auxiliary Column pass through a branching 4" pipe to either e top or below the first plate of the rectifying column.

The liquor from the bottom of the condenser passes through a gulating bottle and thence either through a returns line to the ctifying column or through a 1¼" pipe and flow meter and valve the north Tester on the operating floor.

BUILDING REINFORCEMENT—The new beer still and the new beer ater are being placed in the same position as regards elevation as e old still and the old heater. They are being placed west of the esent units in the second panel of the building from the east wall. e new continuous Barbet Still is being placed at the north wall in the third panel from the east wall, and therefore just west of the new beer still. To carry these additional weights the building is being strengthened by means of steel columns and beam reinforcements extending from the top floor right through to concrete footings, so that the old steel work carries practically no additional load.

EDWARD METCALFE SHAW.

APPENDIX 3.—BRAN DISPOSAL.

The bran as it drops from the scalpers is now picked up at the ground floor level by the suction of a 35" Sheldon Suction Fan and discharged through a long 12" galvanized iron pipe, vertically and over the court and intervening buildings to an 82" Cyclone Separator on the roof of the Gooderham and Worts malt house. This latter building is now not in use.

From the separator the bran drops vertically and is deflected by valves into either of three chutes which carry it to either of three wooden hoppers placed in the fourth floor of the malt house.

The bran is drawn from these hoppers, sacked and sold to farmers and others for cattle food.

EDWARD METCALFE SHAW.

SECTION 7—IMPORTANT DETAILS.

SECTION 7(a)—COOKER STIRRING.

COOKER STIRRING.

STERILISERS—At the beginning in the reconstruction of the yeast tanks to form cookers, it was considered necessary from experience gained in England to sterilise the inside surface of the tanks, and to this end the steam steriliser shown in drawing No. was devised. The device consisted of two bent 2 inch pipes, screwed into the 3½" cross on the bottom of the central rotating 3½" wrought iron pipe. Each pipe was bent to rotate within 1 inch of the bottom and side of the tank and had a slit sawed in it which was afterwards brought together. The slit under the steam pressure (14 lb. Locke Regulator System) inside the pipe opened up slightly allowing a sheet of steam to play on all the tank surface reached by the mash, during the rotation of the central pipe.

STIRRERS—The stirring of the mash was also deemed advisable, during the cooking period and was done by means of the cone stirrer (see drawing 9) consisting of the frustrum of a cone 26 in. deep 36 in. diameter top and 66 ins. diameter bottom, built up as shown in order to permit of its passage through the manhole. The stirrer was assembled inside the cooker and mounted on the central pipe, 20 in. from the tank bottom. Similar smaller stirrers were used in the four original large seed tanks and are still in use, running at about 40 r.p.m.

DRIVE—The drive employed was electric, from two 7½ h.p. induction motors, one to each pair of cookers, hung on the wall, controlled by oil starting boxes, and driving through 3 in. Balata belting and countershafts, a shaft rotating in bearings carried on a special pedestal on each cooker roof, carrying a pulley (driven from fast and loose pulley above) and a mild steel 1½ C.P. single thread worm meshing with a 14.32 P.D. 30 tooth cast iron worm wheel set screwed to the central rotating pipe. The latter rotated at 20 r.p.m.

DIFFICULTIES—This arrangement was used for some time but due to the great inertia of the wide spreading parts and the mash resistance the starting and operating torque was excessive, lubrication exceedingly difficult and wear on belt and worm wheel exceedingly rapid, resulting in the teeth of the latter wearing practically through.

PRESENT STIRRERS—In the meantime as a result of further experience gained in the actual operation of the plant and of addi- ional experiments it was found that the sterilising of the inside urface of the cookers was unnecessary and that results sufficiently ood as far as cooking and stirring were concerned were obtained y simply blowing directly into the mash steam from the 14 lb. ystem, through the ends of 4 ft. lengths of 1 in. pipe, carried by e central 3" rotatable steam pipe rotated occasionally by hand. s a result the other arrangement was abandoned in favor of the tter simple hand operated arrangement.

One of the motors is now used for the seed tank and culture ssel stirring and the other for the steamfitters' shop drive.

EDWARD METCALFE SHAW.

SECTION 7 (b)

NEW MASH LINE AND CONTINUOUS COOKING.

APP. 1—EXPERIMENTS ON RAPID STERILISATION AND STARCH SOLUTION.

NEW MASH LINE AND CONTINUOUS COOKING.

A complete new arrangement of the portion of the plant between the mash tubs and the cooler is now under construction (see drawing No. 83). This includes relocation, re-arrangement, redesign and reconstruction of practically all the units between, including pump, mash line, digesters and cookers.

The location of the present mash line was subject to grave defects, not the least of which lay in the fact that it was exceedingly tortuous, containing some 10 right-angled bends and 10-45 degree elbows in its 400 ft. of length. The centrifugal pump was also deemed insufficient in capacity to handle the mash required for the proposed increased output.

Mash Pump and Control—The new line commences in a 5" cross placed in the 5" mash tub emptying main (the other two branches of the cross leading to the centrifugal pump and a previously used steam engine driven plunger pump respectively) from which a 5" suction line passes under the tubs to a 14 x 10¼ x 10 duplex steam pump, that was already in place on the stone or machinery floor of the main building. This pump was employed in the Distillery days for pumping bay water.

The pump is fitted with a Mason standard pump pressure control on the steam, and a 4" blow-off by-pass on the water end between the discharge and suction discharges into a vertical 5" line passing up through the mash operating floor to the floor above. The pump which is directly below the mash tubs is to be controlled from the mash operating floor, thus eliminating one intermediate control element between mashing and cooking. It will be noted that the mash line has been increased in size from 4 to 5 inches.

Digesters—On the second floor the mash line leads to two horizontal U's of 5" pipe, placed on the floor. These U's have straight legs 12 ft. long, except the first leg of the first U, which is 21 ft. These U's form the heat receiving part of the Digester, the long leg containing two sets of ½" digester nozzles, the first consisting

6 nozzles and the second of 5, while the remaining legs of the U's each contain a set of 5 nozzles.

These steam nozzles are of ½" pipe bent to point downstream and bored out to ⅜" diameter at the tip. They are welded into the 5" pipe at intervals of 20", alternately on the off centre. The one off centre is so shaped that the steam jet imparts a swirling motion to the mash, while the one on the centre blows directly down the centre of the pipe.

The jets are supplied through 3 separate 1½" steam lines with the three control valves located at the centre of the mash operating floor.

The mash line proceeding from the digester passes through 2 elbows into the mash line proper leading to the cookers. In the second elbow are tapped connections for a dial thermometer and pressure gauge which are located near the ceiling of the operating floor, together with a second pressure gauge indicating the steam pressure in the line supplying the nozzles. There is also a thermometer pocket in the mash line for the insertion of an ordinary thermometer for checking up the dial thermometer.

The mash foreman is thus in full control of the mashing, pumping and digesting arrangements, simplifying the operation of this part of the plant, besides making the control more positive. Another important reason for placing the Digester at the mashing end of the line was in order to use the long length of pipe efficiently lagged to form part of the digester.

The system provides that whilst the steam pressure on the digester will be from 50-60 lbs. the pressure in the mash line will fall to say 45 lbs. at the cooker end. At the rate of 12 fermenters a day (25,000 gals. each) or 200 gal. a minute of mash the velocity in the 5" pipe will be 230 ft./min. The new line from the digester to the cookers is about 400 ft. long, so that this arrangement gives the mash about 1½ minutes of cooking under a pressure which is gradually falling to the cooker end to 45 lbs. with a temperature of 92 deg. F. By this means the mash is not only treated at a high emperature, but is churned up and thoroughly agitated. This ction is expected to do a considerable amount of the cooking, and rom experimental results obtained will probably complete the sterisation, even though the ground corn used may as a result of this gesting arrangement be considerably coarser, thus increasing the illing capacity at the same time as mash quantities are increased.

MASH LINE—The mash line part of the digester passes through the 180 deg. bend fitted with the gauge connections, and thence north over the court, over the roof of the barrel store-house and enters the east wall of the fermenter house, just below the roof, and over fermenter No. 7. The line then passes west over fermenters 7, 8 and 9 to what is now No. 4 cooker, but which will be No. 1 in the new arrangement. All pipes are efficiently lagged, and the bends between digester and cooker are of bent pipe. There is a uniform fall totalling 3'-6" from the digester nozzles to the cookers, so that the line drains to the cookers. The new line thus passes by entirely different route from that of the old line, is much less tortuous and is altogether more efficiently designed and constructed.

CONTINUOUS COOKING—For continuous cooking the present cookers are being used with only minor alterations or more properly additions (see drawing 80). These additions are such as not to render the cookers useless for operating as at present on the batch system, and as the old mash line is to be left in place there will be the present arrangement to fall back on in case any defect in the system is discovered.

At the end of the 5 inch mash line is placed a pressure gauge and recording thermometer for the fermenter foreman's use in keeping account of the condition of the mash coming over. The 5 in. line runs into a special 4" angle valve through which the mash passes and vertically downward through a 4" pipe, through the roof of cooker No. 1 (formerly No. 4) 1½ ft. from the side and out through a special spraying nozzle 10'-6" from the bottom, or at the level of the mash, distributing the incoming mash fairly uniformly over the top surface of the mash in the vicinity of the spraying nozzle. The location of the outlet at the bottom on the opposite side, together with the fact that the access of heat, except at half-hour intervals when for one minute the steam stirrer is operated, is only with the incoming mash at the top, prevents the mash short circuiting directly from the inlet to the outlet at the bottom without remaining its full time in the cooker.

EXPLODING VALVE—The exploding valve shown in drawing No 79 is of special design and construction, combining an exploding valve and relief valve in one. The whole of the above arrangements are based on the results of experiments carried out here. (Se appendix to this section of report). It was found that after period of cooking under steam pressure and then suddenly exploding down to a lower pressure the large lumps of maize and even the starch cells were largely broken up and the mash rendered absolutely sterile. The period of cooking is provided in the mash line and the exploding valve takes care of the explosion of the mash.

In the experiments none of the friction and agitation occurred as is proposed in the system being described. It is therefore expected that the cooking will be carried to a further stage than in the experiments.

Some tests were made subsequently on the existing installation of digesters, mash line and cookers at various times, and showed conclusively that using steam to bring up the steam pressure in the pipe to 14 lbs. by means of the 18 nozzles of the digester, and with only 50 feet between the last nozzle and the cooker the mash entering the cooker was always sterile.

This led to the conclusion that 1½ minutes of digesting at 45 lbs. with the agitation and turmoil consequent on its rapid motion through the long mash line would be quite sufficient to render the mash sterile and quite likely also to do a considerable amount of mashing and cooking. It is therefore conceivable that the cooking period in the cookers proper may be reduced to such an extent that three or even two cookers will suffice for the increased quantities which will be dealt with in the future.

In starting operations in the digester line it is necessary to safeguard the line against water hammer action, the special valve takes are of this also.

As will be seen, the valve is a 4" angle valve, the disk f which is pressed against its removable seat by three eans, a spring, a hydraulic piston and a dead weight. The pring is "floating" and when a surge comes along the line the ressure rises to a pressure above that from which the exploding usually done and therefore compresses the spring, which due to e suddenness of the action and the small passage leading to the ater piston, may be considered as having its outer end fixed. This lows the valve to open and relieve the pressure. For ordinary orking a pressure of water is maintained in the cylinder on the ter end of the valve spindle equal to 22 lbs. due to the head of ter in the distillery reservoir at the roof. This pressure on the piston is sufficient to allow such a valve opening as will mainn a pressure of 40 lbs. in the mash line, with a cooker pressure in No. 1 of 15 lbs. whilst allowing the valve to discharge an amount of mash continuously through it equal to that delivered by the pump. In order to allow of varying the mash line pressure from 10 to 15 lbs. the dead weight device is provided. The latter by varying the dead weight which acts through levers as shown provides the variable factor.

CONTINUOUS COOKERS—The mash entering the first cooker from the exploding valve is sprayed over the surface of the mash by the distributing nozzle, the velocity of the liquid being acquired by the explosion, and the vertical drop. Between each pair of cookers about one foot from their tops is an 8" pipe connection, fitted with an 8" gate valve in each. In No. 1 and 2 cookers an iron plate shield extends from within 6" of the cooker bottom to close to the roof in front of the 8" opening, so that the mash passing through this 8" pipe from No. 1 to No. 2 and from No. 2 to No. 3 cooker comes from the bottom of the cooker in each case. At the outlet end of these 8" pipes in No. 2 and No. 3 cookers is arranged a deflector constructed of welded plate, so designed that the mash is deflected to right and left in the cooker.

The mash entering each cooker is thus fairly uniformly distributed and the outlet is as far as possible from the inlet, thus preventing short circuiting of the mash.

Any settlement of sludge is prevented by stirring with the existing rotatable steam jet arrangements which are to be retained and worked in sequence, No. 3 cooker first, then No. 2 and No. 1. The reason for this is that any possible short circuiting that may result from the stirring is limited to the effect in one cooker only, thus preventing any mash passing through without at least 66 per cent. of the full period of cooking. This action may result in slight occasional and partial undercooking to the extent only of one per cent., but cannot jeopardise the safety through non-sterilisation.

No. 3 cooker is to be the final cooker, and in this cooker the mash level is to be maintained at 9 ft. above the bottom instead of 10' 6" as in Nos. 1 and 2. The mash outflow from this cooker is through a 5" pipe which passes through the tank bottom at the opposite side to the mash entrance and extends surrounded by a second 10" pipe which reaches from within 6" of the bottom to close to the roof. This arrangement of outflow is for the purpose of preventing the pump lowering the mash level below the 9' level whilst at the same time drawing the mash from the bottom of the cooker.

The steam from the first three cookers passes from No. 3 into No. 4 tank, through the 8" connecting pipe fitted with an adjustable back pressure valve for maintaining the pressure at any desired value in the No. 3 cooker. This pipe is also provided in No. 3 cooker with an elbow and short nipple in order to draw the steam from as high a point as possible, besides eliminating the possibility of mash splashing over. No. 4 cooker is to be used as a low pressure exhaust steam reservoir.

The mash level in No. 3 cooker is automatically controlled by means of a Fisher Tank Control. The float of this device is of heavy copper and large size and operates through a lever and spindle extending through a gland in the tank side. On the outer end f the spindle is a second lever, one end of which operates through chain or rod, a pump regulating valve in the cooler pump steam ine, and the other end of the lever carries a compensating weight. The cooler pump thus draws the mash from the final cooker at the ame rate that the mash pump, under the mash tubs, pumps it into he first cooker through the exploding valve.

Exhaust Steam Reservoir—From tank No. 4 which is to be sed as an exhaust steam reservoir at 5 lbs. pressure a 9" steam ne will be run to the two beer stills (one under construction). This ne will be connected through a 4" pressure reducing valve to the ve steam, so that should the pressure in the line drop below 5 lbs. ve steam will be admitted. In addition, provision will be made r admitting exhaust steam from the pumps to the 9" line. A T ill be inserted in the exhaust main leading to the feed water eater and on the heater side of the T a gate valve. From the T 8" line will run to the 9" line and will be fitted just before reach-g the latter with a back pressure valve to maintain the pressure the line at 5 lbs., and this back pressure valve will be by-passed permit the flow of exhaust steam from the pumps into the 9" e from the exhaust main.

The low pressure steam will be admitted to each still above the sh level and below the first plate. The quantity admitted will be der direct control of the still attendants, and should the beer in e bottom of the still at any time contain butyl it will still be pos-le to admit live steam through the existing steam coil arrange-nt and boil it out.

To heat the boiler feed water it is proposed to force the water from the coolers through the tubes of the two evaporators (formerly used for slop evaporation), and pass the slop from the stills around the tubes. These evaporators are such that the feed water will be 6 min. in the ⅝" bore brass tubes in each one thus securing a good heat transfer and high temperature of feed water. The boiler feed pump drawing from the evaporators will have a static head of some 10 ft. of water on the suction side.

COOKING OPERATIONS (STARTING)—The action of the system is as follows: In commencing operations the mash foreman turns on some of the steam jets of the Digester and the steam gradually works along the mash line, warming it up, and finally building up a pressure forcing open the exploding valve and passing through the first and second cookers to the third. The steam builds up in the three cookers a pressure dependent on the adjustment of the exploding valve which at the beginning may be set to explode to a lower pressure than when operating normally. The valve between No. 3 cooker and the exhaust steam reservoir is a back pressure valve set to maintain the same, or slightly smaller, pressure as the exploding valve, say 12 lbs. The system is thus completely warmed through and on the mash foreman getting the signal from the fermenter foreman to send over the mash he starts the mash pump and the mash enters a hot system. The mash foreman then regulates his steam jets to get the right temperature of the mash at the Digester end, and it is his business to see that this does not vary.

By the time the mash reaches the cooker end of the mash line thoroughly digested and sterile, the fermenter foreman can tell from the recording thermometer and pressure gauge its condition and instructs the mash foreman if any variation is required. The mash explodes through the valve from its pressure of say 45 lbs. down to 12 lbs. in No. 1 cooker, the initial pressure being determined by the adjustment of the exploding valve and maintained in the cookers by the back pressure valve between cooker No. 3 and the exhaust reservoir.

Cooker No. 1 gradually fills up until the 10'-6" level is reached when the mash flows over into No. 2 cooker, filling it in turn. All the cookers were originally under 12 lbs. pressure, but the mash passing over will probably restrict the passage so that a slight drop in pressure will occur, which will necessitate an increase of say 1 lb. in pressure in cooker No. 1, and because of the adjustment of the exploding valve a corresponding slight increase in pressure in the mash line. The steam passing through the 8" connecting pipe assists the mash over, and together with the deflectors thoroughly agitates the mash. No. 2 having been filled to a 10'-6" level, the mash and steam escape through the 8" pipe into cooker No. 3, and again there is a slight drop in pressure caused, and a consequent rise of pressure in cookers 2 and 1 and the mash line. The pressure in cooker No. 3 is finally 12 lbs. (governed by the regulating valve between No. 3 and the reservoir), in No. 2 say 13 lbs., in No. 1 14 lbs., and probably in the mash line 47 lbs. From No. 3 cooker the mash is drawn by the cooler pump at the same rate that it enters the system (through the float control), and discharged to the cooler. The lower the pressure in No. 3 cooker, the less will be the cooling that the cooler will have to do per gallon of mash.

When commencing mashing and cooking operations on Monday he stills will probably be stopped and therefore no low pressure team will be required. The steam from the cookers will then scape through the back pressure valve into the exhaust steam eservoir and build up a pressure there and in the 9" line of say 5 lbs., which is maintained by a back pressure valve in the 8" pipe eading from the 9" line to the existing 8" exhaust main to the feed ater heater in the boiler room. The pump exhausts, when the tills are not working, pass directly to the feed water heater, hile the reducing valve governing the admission of live steam to he low pressure line from the reservoir to the stills simply mainins a pressure of 5 lbs. in the line and the reservoir. The steam berated from the explosion and cooking thus escapes from the 2 lbs. pressure in No. 3 cooker to a 5 lb. pressure in the reservoir, nd thence through the 9" line and 8" back pressure valve to the xhaust main to the feed water heater.

Cooking Operations (Normal)—The ordinary normal operan of the continuous cooking system is of a similar nature to at just described for commencing operations. The mash exodes into No. 1 cooker, passes over into No. 2 and then into No. 3, d so to the cooler pump. The time during which the mash would eoretically, assuming no short circuiting, be in the three cookers uld be, assuming a rate of 200 gals. a minute, and the capacity the tanks 700 gals. per foot of depth, 105 minutes or 1¾ hours the three cookers in series, an average of 35 minutes per cooker. About 36 hours after cooking begins, when the stills commence operating, the valve will be closed in the exhaust main cutting off the exhaust feed water heater, and at the same time the by-pass around the back pressure valve maintaining the pressure of 5 lbs. in the 9" line and exhaust reservoir will be opened, allowing the exhaust to pass into this line and reservoir instead to the heater. This exhaust, plus the cooker exhaust, aided when necessary by live steam admitted through the 4" reducing valve, will maintain a pressure of 5 lbs. in the reservoir and 9" line and supply the stills with the greater part of the steam they require. It has been calculated that the steam liberated from the cookers alone will be sufficient to operate one still. When the exhaust steam is cut off from the feed water heater the feed water will be heated by the slop coming from the beer stills, as both the slop and feed water will be passed through the evaporators.

COOKING OPERATIONS (FINISHING)—At the end of a run when the mash stops coming over the cooler pump will cease drawing because of the lowering of the level, and the present outlet line will then be used to empty first No. 3, then No. 2 and No. 1, as at present in the ordinary batch system. Whilst doing this in order to secure proper cooking the present 15 lbs. steam system can be turned on, thus cooking as ordinarily.

This arrangement incidentally enables a difficulty at present existing to be overcome. Owing to the flat bottoms of the cookers it is difficult and slow work to empty them. In the new arrangement as soon as No. 3 fails to keep the pump full No. 2 is opened. There is no objection to some mash from No. 2 flowing into No. 3 as will certainly occur. When the drainage of No. 2 and No. 3 runs short, No. 1 is opened, and so at the end it will be found that the pump and cooler will have been kept at full normal speed of working, and the final drawings of three cookers will keep the supply of cooked mash up till they are quite empty.

The stills will be in operation for some time after cooking has ceased, and to supply them with steam the pump exhausts will discharge into the 9" line and reservoir, and any steam lacking will be made up through the 4" reducing valve from the live steam main.

When the stills stop running the valve in the exhaust main will be opened, permitting the exhaust to pass to the feed water heater and the by-pass around the back pressure valve in the line between the exhaust main and 9" low pressure line will be closed, preventing the exhaust passing into the reservoir and low pressure line.

EDWARD METCALFE SHAW.

APPENDIX TO SECTION OF REPORT ON NEW MASH LINE AND CONTINUOUS COOKERS.

EXPERIMENTS ON RAPID STERILISATION AND STARCH SOLUTION.

There were two series of experiments carried out at Toronto on the subject of rapid sterilisation and starch solution; in the first the whole maize was treated, and in the second the ground maize, freed from bran.

FIRST SERIES—OBJECT—The first set of experiments were made for the double purpose of eliminating the grinding and securing the rapid sterilisation of the starch solution.

APPARATUS—The apparatus used was of a very simple type. A piece of two-inch pipe, twelve inches long, was fixed in connection with a steam system carrying 120 pounds pressure. The pipe was fixed vertically, with a tee at the bottom end, carrying in a horizontal direction a half-inch steam connection, and vertically a one-and-a-half inch cock fixed into the tee. A steam vent was provided at the top.

TESTS—This tube could be charged with whole maize, some fifty r sixty grains being used in these experiments. The grains were reated direct by means of the steam only, and also with a small uantity of water added. They were subjected to the full heating ffect of the steam which flowed out through them, with an escape t the top of the tube, for periods ranging from one to three min- tes, the amount of escaping steam being just sufficient to ensure e full temperature in the tube corresponding with the steam pres- re. Steam pressures from fifty to ninety-five pounds were used.

RESULTS—It was found that with ninety-five pounds steam essure and a three-minute period of treatment the grains were ghtly discoloured. The experiments were made from these ex- eme high limits down to fifty pounds pressure with one minute atment.

The idea was to cause water at the full temperature to penetrate every part of the grain. When the period of treatment determined upon had elapsed, the steam supply and vent were both closed, and the stopcock was struck open by a rapid blow, so as to give as nearly as possible an instantaneous release of pressure. The sudden release of pressure causing perhaps ten per cent. of the water in the grain to turn into steam, blew the grain to pieces.

This effect was perfectly obtained at the higher pressures, and very imperfectly obtained under the lowest conditions of pressure and time.

It was found, however, that the pressure of eighty pounds of steam, with a two-minute period of treatment, gave the best all-round results. The solid and liquid matter was collected inside a tin can sixteen inches in diameter and three feet deep, when the explosion was caused to drive tangentially against the inside of the can near the top. The non-gaseous particles were found to consist of four groups: the husk, complete except for being split; the germ, complete but soft; a considerable amount of starch in solution; and the remainder in an extremely fine form, showing under the microscope perhaps thirty to forty per cent. of complete starch cells.

No tests were made of sterility in this series, as the main object had been accomplished, viz.: to prove the possibility of very rapidly reducing whole maize grains to a state in which the starch and proteins would be separated from the husk in a condition ready for cooking. Sterility if not complete at this stage would certainly be rapidly completed under any form of cooking which would put the whole of the starch in solution.

SECOND SERIES—OBJECT—The second series of tests was for the purpose of determining the least time necessary to secure sterility and solution of the starch through treating ground maize with high steam pressures for short periods and then exploding. The apparatus used in these experiments is shown on drawing No. 40.

APPARATUS—Referring to this drawing, both the vertical an the sloping vessels were ordinary hot water boilers, capable o working at 100 lbs. gauge pressure, such as are used in connectio with house hot water systems. The vertical vessel was charg with 10 gallons of mash from the mash tun, steam was admitted the bottom through a pipe which gave a swirl, and at the sa time a small amount of steam was allowed to escape from the top of the vessel. By this means the mash was heated up to temperatures corresponding to the pressures which are shown in an accompanying table, which gives the results of one typical set of the series.

TESTS—This treatment was carried on under varying conditions of pressure and time, at the end of which the cock connecting the vertical and sloping vessels was quickly opened, and the contents of the vertical vessel were exploded by pressures ranging from fifty to eighty-five pounds into the sloping vessel, whence steam was llowed to escape at pressures varying from ten to twenty-five ounds.

This gave definite temperature and explosive difference between he two vessels.

RESULTS—The following are the results of one of the tests made n October 26th, 1916, in brief form:

Test.	Intial Press.	Time at Initial Press.	Exploded to Pressure.	Incubated for.	Result.
1	50	5 min.	10	24 hrs.	sterile.
2	97	"	13	"	"
3	80	"	25	"	"
4	75	"	15	"	"
5	65	"	15	"	"
6	55	"	15	"	"
7	50	"	10	"	"

It will be seen from the table that in all cases a twenty-four hour boratory test indicated sterility.

Several samples of this exploded mash were inoculated, but the sults of the fermentation indicated imperfect starch solution.

The question as to the reduction in the size of the particles has ceived much consideration. It is considered by the bacteriolosts that the difficulty in obtaining complete sterility is increased hen spores exist in the middle of the larger particles, and under me conditions may even be protected by a water-resisting layer, that the destructive effect of the temperature combined with e presence of water is not so readily obtained; and, further, under e circumstances such spores are not subject to desirable disinrating effects through movement.

These considerations have led to efforts being made, as in the new mash digesting line, to soften and break up all the larger particles, so that as far as possible sterilisation and cooking can be perfectly performed continuously under the most favourable conditions.

Edward Metcalfe Shaw.

SECTION VII (c).
RAPID COOLING SYSTEM.

RAPID COOLING SYSTEM.

Refer to drawing 6, 7, 8, 12, 30, 30A, 35, 41 and 84, also various photographs.

Designed Conditions—The coolers in use at Toronto have been designed to meet the special conditions of this work.

(1) Absolute tightness of joints and connections.
(2) Self-cleansing.
(3) Rapid continuous cooling.
(4) High efficiency of the cooling surface.
(5) Economy of water.

The first and more compact cooler was perfectly satisfactory so far as the mash conditions were concerned but required water to the extent of 5 to 6 times the quantity of mash cooled.

The second was equally satisfactory on the mash side and reduced the water required when worked for extreme economy to 1- of that required by the first cooler and by more than 50% as at present worked. This was of further value because of the higher temperature of the water, resulting in a considerable fuel economy. On a separate page the working results of both coolers are tabulated.

Operation—The first cooler was able to deal with the full quantity of maize for which it was designed, viz.: 5,000 gallons per hour reducing the temperature from 240 degrees to 96 to 100 degrees, as required.

The heat transmission was unsatisfactory on account of the circulating water not interfering sufficiently with the hot film of water on the outside of the pipe.

From an inspection of the drawings and also of the photographs accompanying this, it may appear strange, because it looks as if the turmoil created in the water would be such as to bring about a very rapid exchange of heat between the copper pipe and the water.

RESULTS—From the records attached it will be seen that the rise in temperature of the water when the cooler was working at a rate of about 6,250 gallons (4 hours per fermenter) per hour, was only 26 degrees, leaving a temperature difference of 60 degrees between the cooled mash and the cold water, while at the same time there was a temperature difference of 174 degrees between the temperatures of the heated water and the hot mash.

GENERAL NOTES ON THE WORKING OF THE NO. 1 COOLER—It was not known whether the nature of the mash was such that from time to time one or other of the tubes of ⅞ bore, 1 inch outside diameter, by 120 feet long, would become choked, and therefore an elaborate arrangement of cocks was attached, see drawing 12, so that any one tube could be separately cut out of the circuit and cleaned under high pressure.

The results obtained during the eight months of actual working, however, show that there is no such danger. The high pressure at which the liquid is forced through the pipe, aided probably by a certain jolting of the pressure, keeps the pipes reasonably clear during a run. At intervals of 9 to 12 hours the pipes are scoured out with clean sterile hot water a 15 minute operation; otherwise no cleaning is necessary.

It is noticed, however, that when the cooler is first put into ction is has a slightly greater efficiency than it has when 25,000 gallons have been passed through. This is undoubtedly due to some slight deposit on the surface which ceases to increase beyond a certain point.

CLEANING—Another method of cleaning the inside of the pipe, s by closing the outlet, keeping the water round the pipe, and urning high steam pressure into the mash supply pipe. This leads o a condensation of steam throughout the whole pipe, loosening the eposit after which the pipes are blown through and the process s repeated, with a final blowing out before starting again to cool.

It has been found unnecessary to do anything more in order to ep the inside of the pipes in good working condition.

COOLING WATER—The water used for cooling has been city water, the analysis of which is as given at the end of this section. This analysis was made by the Toronto Department of Public Health about one year ago—summer of 1916.

This water is obtained from Lake Ontario, and is drawn from the lake at a distance of 3,200 ft. from the shore of Toronto Island at a depth of 79 feet. It is filtered and treated by chlorine for any possible bacteriological contamination. The temperature at which this water reaches the distillery ranges from 35 degrees in winter to 58° F. in summer.

SCALING—Once since the cooler was started the cover was taken off for the purpose of observing any encrustation effects on the outside of the pipes, and it was found that a slight deposit, some 1/20 of an inch in thickness, was apparent on the first set of convolutions out of the eight comprising the length of the cooler. Beyond this no deposit was found. It will be noticed that no deposit was occurring at the point of the highest temperatures.

Under the conditions under which the cooler was fixed, considerable inconvenience was found in watching and controlling the rise and flow of the temperatures, so that the man in charge was kept quite busy the whole time. This can be improved.

COOLING SURFACE—It will be noted that there are six copper pipes, the total cooling surface in contact with the hot mash being 6 x 24=144 square feet, the heat transmission amounting to a total of 9,375,000 B.T.U.s per 144 sq. ft. or 65,100 per sq. ft. and divided by the average temperature difference of 125=511 B.T.U.'s per square foot per hour per degree temperature difference Fahrenheit.

This compares with the normal transmission of 250 BTU's per square foot per hour per degree temperature difference as obtained in standard evaporators, where heat transmission is much more easily obtained.

GENERAL NOTES ON MAKING OF NO. 2 COOLER—This cooler was designed not only to deal with a larger quantity of mash per hour, but to ensure a higher efficiency per square foot of surface.

It will be noticed that cooler No. 1 required five to six times as much water as the quantity of mash to be cooled, as against 1.2 to 3 times required by the new cooler, according to the working conditions.

Plans of this cooler are attached, and it will be seen that while the conditions under which the mash flows through the pipe are the same as in cooler No. 1. An effective means of compelling scouring action on the outside of the pipe has been provided, the action being now similar to what occurs with mash inside the pipes. And, in addition to this, it will be seen that the sloping baffles cast in the water passageway not merely cause a continual cross-flow of the water over the pipe, but at the same time cause the whole body of water to circulate at right angles to the direction of its general movement in the water passageway.

This cooler is constructed in four sections, in such a way that any one section can be opened by taking off the cover, while the copper pipe connections are made on the same plan as those in connection with Diesel engines, affording an absolute security and tightness.

The coils can be readily moved, and by taking off the outside copper connectors any section of pipe which may get choked can be dealt with independently. The small rectangular passage, planed lengthwise, at the top and bottom of the water passage allows of drainage of the box on the one hand, and of the scouring out of the air on the other.

It will be noticed from the photographs that the four thermometers with steam and water and mash controls are now all at one end, and can be observed and manipulated without the operator moving.

This cooler was designed at a time when it was thought that it might be necessary at intervals of, say a few months to open up the boxes for the purpose of cleaning the outsides of the copper pipes, or of removing these pipes; but it would appear from the continued use of No. 1 cooler that such a contingency is remote, and in building another cooler of the same general size and capacity it seems quite safe to dispense with the four covers, bolting the boxes together in pairs, with double jointing and wrought iron plate between.

By this means a much more compact arrangement could be obtained at reduced cost, while the objection to the height of the cooler, which is now excessive, would be removed.

Detailed Description of No. 1 Cooler—The first cooler built in the spring of 1916 consists essentially of a series of copper coils, contained in a cast iron box. The mash is forced through the coils from one end of the box to the other, while the water passes around the outside of the coils in the reverse direction.

The coils, (see photographs and drawings), are of copper tubing, 1" outside diameter ⅞" bore No. 16 gauge. There are six separate coil circuits in parallel each made up of eight unit coils in series. Each unit coil consists of a length of 15 ft. of tubing coiled to form 5½ figure 8 coils one above the other. Each loop of the eight was formed by bending around a 4" diameter former so that the outer diameter of the coil was finally 6¼" and the overall length of the two loops 12" while the depth of the 5½ coils between planes perpendicular to their axis was 12½". The beginning of each coil is at the top at one end to which is braced a special brazing metal coil connection, see drawing 7, which bring the coil through the lid, while the end of the unit coil is at the bottom and opposite end and is brazed to the corresponding end of the next unit coil. The other end of the second unit coil is at the top and is brazed to the corresponding end of the third coil and so on until the 8 unit coils are brazed together in series, the eighth coil passing through the lid with a coil connection as at the beginning. Each coil thus contains 120 feet of tube and the six parallel sets 720 feet. The area or surface in contact with the water is 31.4 sq. ft. per set and a total of 188.4 sq. ft.

The six parallel sets of 8 coils in series are placed together side by side and mesh together, sliding into one another sideways so that the overall width of the six coils is 24". (It was found that three unit coils could be compressed into a volume 12 x 12" x 13" deep.)

Lengths of ¼, ⅜ and ½" galvanized wrought iron pipe as shown in the photograph were placed in the free spaces between the coil convolutions for the purpose of reducing the free water flow in such a manner as to more efficiently wipe the hot film off the pipes. To prevent short circuiting of the water through the comparatively free passage down each side of the box, cast iron baffles, see drawing 8, representing one-half a coil were slipped into the cast iron box and the lid bolted on.

The cast iron box (see drawing No. 6) is of ⅝" average thickness 100" x 24" x 12½" inside and provided with strengthening ribs as shown. The overall outside dimensions are 9' 4" x 29¼ x 17¾". The water inlet and outlet are 5" in diameter, bell mouthed and fitted with thermometer pockets. The 5" size was provided but found unnecessary, 4" pipe now conveying the water to and from the box under the city pressure. The cast iron box has a ribbed lid through which the coil connections project and are locked tight with lock nuts and washers.

The six coil connections at each end are connected up with the complicated system of piping shown in drawing 12 to a 4" header placed above the lid of each end. This arrangement was provided in order to make it possible to cut out any coil at will (as it was thought possible that coils might choke up with the thick mash) and blow steam, air, acid or alkali through to clear it out. This has been found unnecessary under actual operating conditions and there are now simply copper tubes between header and coil connections.

DETAILED DESCRIPTION OF NO. 2 COOLER—The second cooler was built in the fall of 1916 and is of somewhat similar construction as egards the coils, but differs considerably in the water circuit rrangements. It is composed of four separate units connected ogether so that the mash passes in series through all four while he water divides into two circuits each passing through two boxes n series. The four units are arranged one above the other vertic- lly.

The coils are of the same size tubing as in No. 1 cooler, namely " outside ⅞" bore and No. 16 gauge copper. The shape of the il was altered to make construction simpler, while still obtain- g the same results, so far as the mash flow inside the pipe is con- rned. Each coil (see photographs and drawings 30 and 30A) is a t wriggle, formed by bending the tube with a special device to a ½" radius loop first one way and then the other. Each coil con- ts of two 15 ft. lengths brazed together after bending and forms loops of a total length of 30 ft. There are eight of these 30 ft. ils in each box, ¼" clearance between two adjacent coils and pas- ge walls. Each box, therefore, contains 240 ft. of tubing, a total rface of 62.8 sq. ft. In the four boxes or the complete cooler re are 960 ft. of tubing with a surface of 251.2 sq. feet.

The coils lie in 1½" x 10" deep passages, cast in the boxes and e coupled through the ends of the box by Diesel joints either to e coils in another box or to the mash inlet or discharge. These nts are of steel, the flat steel ring being pressed by the nut on he flange formed on the copper tube securing tightness by con- trating the pressure forcing the copper against the steel.

The boxes are of cast iron 9'-11" overall long by 14 7/16" the inside dimensions being approximately 9' 6" x 10⅛" x 10". The coil passages are cast with baffles on the sides, sloping in different directions on either side of the passage their function being to drive the water backwards and forwards across the passage, wiping the hot film off the tube surface, and also to circulate the water in a direction at right angles to this chief movement and thus to thoroughly mix hot and cold streams of water. The lids or covers are on the side of the box in order that the coils might if necessary, be easily removed should they choke up. It will be noted that the box is extremely strong structurally, allowing a heavy internal water pressure. The boxes are coupled by alternate feet and water passages at alternating ends, thus also providing for the flow of water from box to box. As arranged now the hot mash coming through a 4" pipe enters a cast iron connection (drawing No. 35) from which 8 copper tubes lead through Diesel joints and connect to the 5 Diesel joints at the west end of the bottom box. From the east end of this box copper tubes lead from the Diesel joints to the joints on the corresponding tubes at the east end of the second box. There are similar tube connections between boxes 2 and 3 at the west end and between 3 and 4 at the east, and from the west end the mash passes through a second cast iron coil connection to the pipe (see drawing 84).

The water enters the top box at the west end through a speci elbow and the oval opening on top of the box and flows in th reverse direction to the mash flow, around the outside of the tub in the cast passage to the east end where it passes downwa through the oval outlet into the second box. The oval outlets a provided with a baffle to throw the water away from the passa and prevent short circuiting. The water passes through the secon box and out through a standard 4" flange opening at the back of th box at the west end. The oval opening between box 2 and 3 at th west end has been blocked by a plate.

The water for the second pair of boxes enters the third b down through a flanged opening at the back and passes throu boxes 3 and 4 as in the former two and leaves the bottom box the west end through the oval outlet and a special elbow pedes casting to the 4" pipe (see drawing 84).

COMPARISON OF AVERAGE RUNNING CONDITIONS OF OLD AND NEW TYPES OF COOLERS AT THE BRITISH ACETONES, TORONTO, LIMITED.

	New Cooler.	Old Cooler.
Temperature of Inlet Mash	246°F.	243
Temperature of Outlet Mash	98.5°F.	99
Fall in Temperature of Mash	147.5°F.	144
Temperature of Inlet Cooling Water	41.2°F.	43.6
Temperature of Outlet Cooling Water	113.4°F. 81.5F	67
Rise in Temperature of Water	72.8°F.	23.6
Quantity of Mash, gals. per hr.	9,090.9 gals.	5,200 gals.
Quantity of Water, gals. per hr.	11,410 gals.@113.4°F.	
	12,870 gals.@ 81.5°F.	
	24,280 gals. Total	31,750 gals.
Gals. of water per gal. of mash	2.671	6.11 gals.

APPENDIX 1.—CHEMICAL ANALYSIS OF LAKE ONTARIO WATER.

Appearance			Cloudy
Odor	Cold		[illegible]
	Hot		Nil
Reaction to Litmus	Cold		Nil
	Hot		Alkaline
Chlorides			9.0
Nitrogen as free Ammonia			.004
Nitrogen as Albuminoid			.05
Oxygen Consumed			.51
Total Solids			120.0
Solids in Solution			108.
Suspended Solids			12.
Loss on Ignition (Total Solids)			60.
Loss on Ignition			55.
Alkalinity (Lacmoid) Bicarbonates		103	
Carbonates		2........	105.
Alkalinity (Phenolphthalein)			1.
Permanent Hardness			32.5
Total Hardness			132.5
Iron (colorimetric)			.1
Siliceous Matter			3.84
Iron Oxides, Albumins and Phosphates			.17
Lime (CaO)			43.4
Magnesia (MgO)			12.2
Sulphates (SO4)			10.5
Free Carbon Dioxide			1.

Numerical results expressed in parts per million.

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SECTION 7 (d)—FERMENTATION TANKS.

FERMENTATION TANKS, WITH NOTES ON FOAMING AND METHOD OF INCREASING YIELD.

Defects of Fermenters—These tanks were formerly used for the fermentation of molasses, and the dimensions are given in another portion of the report (Refer to Existing Plant). The old pipe arrangements for the introduction of new liquor and for the drawing off of the beer are generally speaking retained. Very serious trouble in working the plant is experienced, owing to the difficulty in clearing the flat bottom of the tanks of the head which settles down at the end of the fermentation, and up to the present the very slow and unsatisfacory method of partially removing this has been by the condensation of steam inside the tank, together with swirling steam jets.

It will be seen at once that these tanks are extremely difficult to manipulate, especially in view of the fact that the bottoms of the original tanks rest simply on brickwork, and that an internal pressure of under half-a-pound to the square inch is sufficient to float the top and sides of the shell, so that at anything above this pressure the bottom of the tank bellies and the sides and top of the tank rise.

They are even more difficult to handle when the pressure inside is less than that of the atmosphere, and as it has been deemed necessary to steam the tanks between each fermentation, it is only by the exercise of the greatest possible care that accidents can be avoided. Prior to the provision a few months back of the special vacuum relief valves (see drawing 67) on two or three occasions the bottoms of tanks were lifted and the pipe connections broken.

The operation of steaming out the tanks with pressures below half-a-pound to the square inch means a long period of sterilisation.

The total capacity of the tanks up to the top of the sides is 31,800 gallons, and the volume of mash dealt with is 25,000 gallons. This headroom is not sufficient when a brisk foaming takes place, and there has been up to the present a loss when this occurs, although it has been customary immediately to put on the beer pump, which empties the tank at the rate of about 8,000 gallons an hour. This evil will probably be entirely removed under the system now being introduced (see Separate Finishing and Foaming Tubs).

Additional Fermenters—In the new fermenters (see drawings 18 and 36) it will be observed that the tanks still have comparatively level bottoms, but strengthened by being riveted to I beams, although there would be great advantage in having conical bottoms with a sufficient slope to make drainage easy of the heavy matter in the beer to the outlet. It was, however, impossible to do this without interfering seriously with the general arrangement of the existing fermenting tanks, cookers, piping, etc. It would further have involved alterations to the building owing to the headroom not being sufficient.

The arrangement of the fermenting tanks in relation to the mash tuns, cookers, pumps and beer still is anything but satisfactory, the system of piping being complex and the resistance of the flow of the mash and the beer being unnecessarily great.

The mash and beer lines are four inches in diameter. While this was quite satisfactory for the operations in molasses fermentation, with only nine tanks it is rather small for moving the mash and beer at the present output from 16 fermenters, especially when the pressure is small, such as at the end of the fermenting process when the fermenter is nearly empty.

Every care has been taken to rearrange from time to time as experience has shown to be best the relations and methods of operating the different valves, but it has been found impossible to get anything that is reasonably fool-proof or even safe, unless constant supervision and thought and care are exercised in adjusting the valves for the mash, beer and steam circuits. This is particularly the case in connection with the sterilisation of the mash lines, where it has been found necessary to arrange the flow of the mash, the steam circuit, drain-pipes and safety-valves in such a manner to make it possible to clear the mash out of the pipes, thoroughly sterilise every connection, provide for safety in case of the mash pump being started without a discharge into a fermenter being provided, etc.

In connection with the beer line, contamination was unquestionably caused on more than one occasion owing to the beer not being thoroughly cleared out of the pipes, which are not treated for sterilisation, and the final discharge valve being closed. Under these conditions considerable gas pressure, giving an unpleasant odour, generated in the pipe system, and leakages with contaminating s took place back into the fermenters. The valves, which are of the gate type, have been found very difficult to keep tight, owing to heating and cooling action, and further owing to mash preventing the valve gates from being driven thoroughly home. The double valve system, with steam connections between, described already in the section on the Existing Plant, has therefore been installed on the beer line, so that when the valves are not being used the steam will keep the space between the valves sterilised and any leakage which takes place will be of sterilised matter.

Another difficulty has been in connection with the steaming of the fermenters, causing high temperature in the building, both by radiation and conduction. It is not convenient to lag these tanks, since under certain conditions it is desired to cool the outside of the tanks with water. After considering various propositions it has been decided that the best means of protecting the staff operating the system from excessive heat would be by building up from the working platforms partitions following the curvature of the tank and four inches away from it to a height of four feet, and bringing cold air conduits from outside the building to the level o the platform, and at the same time putting ventilators in the higher part of the roof. The working platform would thus be protected as far as possible from radiated heat, and will also be kept co by the flow of cold air, which will be to a large extent trapped unti it is drawn up by the hot air rising between the partition and th tank towards the discharge in the roof.

Any attempt to keep the building cool simply by dischargin large quantities of air from the top would defeat itself, since th heating capacity of the tanks is so great that little would resu in the way of cooling, and at the same time a great amount of he would unnecessarily be discharged from the building.

FOAMING.

POSSIBLE EXPLANATION OF PHENOMENON—The phenomen of foaming is not understood. There is no known reas for the action of the fermenting mass, although it m reasonably be assumed that it is due partly to the sudden rele of occluded gases in conjunction with a certain phase of the f mentation which sometimes occurs, the liquor assuming the c loidal state, and thus opposing the release of the gas.

Under such conditions it is probable that the gas generated minute volumes at an infinite number of points is not able to c lect in a large enough volume to rise until a certain stage has b reached. At this stage the surface tension of the liquid on the outside of the minute volumes of gas, having been sufficient to hold the gas at a pressure above that due to internal pressure, is upset and the imprisoned gas expands freely, collecting into larger bubbles. When this occurs at one point it instigates similar action throughout the whole of the mass. Under such conditions the volume of the liquor will increase, tending finally to fill the whole tank, from which it is finally discharged at considerable pressure.

This explanation seems more probable than that there should e any sudden increase in the actual generation of gas, although n view of the obscurity attached to the action of the enzymes it is ossible that there may be increased rate of starch decomposition ccurring.

METHODS OF ELIMINATING OR COUNTERACTING—Various meth- ds have been suggested, and some have been tried, for dealing with is trouble. Amongst them are the following:

CIRCULATING THE BEER—A pipe system four inches in diameter as been arranged in connection with a centrifugal pump capable f discharging fifteen to twenty thousand gallons per hour, and quid has been drawn from the bottom of the tank and discharged t the top of the tank above the level of the free surface of the quid.

The idea was that such a circulation might do two things, viz.: ix up the head which at about this time collects on the top of the uor, and also give a discharge of the gas, which would then be eed from the liquid. This was tried, but without good results.

STEAM INJECTED INTO THE BEER—Another system is in use efer back) having four 1 inch diameter steam pipes, radiating m the centre, at the bottom of the tank, perforated with holes t an angle to the tank bottom), through which discharge of am gives a circulation of the mass of the liquid. This does not e good results in prevention of foaming, but was useful in stir- g up the semi-solid liquid when the tank is nearly empty, thus isting emptying.

STEAM JETS INTO THE "HEAD"—Another means was to dis- rge steam at high pressure slightly above the top level of the id, or still higher, near the top of the tank (refer back). It been found that this is partially successful, as in passing through the "head" or mass of foam it evidently causes the liberation of a considerable amount of gas.

WATER COOLING—The use of water cooling rings described previously have also proved partially effective if applied in time in arresting the foaming.

STEAM JETS AND WATER COOLING—A combination of the steam jets and cooling ring is now used when indications point to a case of foaming in order to gain time to put the beer pump into operation. The steam jets blow the foam against the cold surface of the tank, partially checking the foaming and gaining valuable time to enable the beer pump to start drawing beer from the fermenter, thus lowering the level and giving more room for the foam.

THE USE OF OILS, ETC.—Experiments have been made for the purpose of determining whether the use of oils, acetone or ether would have the effect of liberating the gas from the top surface of the fermenting mass. Any of these is found to be good in connection with what is termed frothing, *i.e.*, formation of large gas bubbles, which sometimes occurs at an early stage of the fermentation; but the results are not good when tried on the real foam which is characterized by the presence of as much as fifty per cent of the volume of the liquid in very minute gas bubbles.

The following method has been devised and is now in course of application to the fermenters for the prevention of foaming, and also to increase the yield of acetone from the fermenters.

SEPARATE FINISHING AND FOAMING TUBS—The yield of acetone has been found to be over ninety-five per cent at from eighty to eighty-five per cent of the time occupied until the yield ceases. Further, there is reason to believe that the condition of the fermenting liquor is such that no foreign bugs can successfully compete with the B. Y. bacillus at this stage, hence it becomes possible systematically to withdraw the fermenting liquor from the fermenting tank at a point before complete yield of acetone is obtained, and at about the time when foaming would occur, in order to increase the duty of the tanks and prevent loss by foaming. This plan is now about to be put into operation.

The arrangement which is now being installed for this purpose (July 16th) is as follows:

The 4" line connecting the two east and west beer lines (see drawing 81, from which the beer pump suction is taken off has been replaced by a 6" cross header connecting into the east and west beer lines through 4 x 4 x 6 tees with a 4" valve on each side. From about the middle of this 6" cross header a 6" branch leads from a 6" tee to a 6 x 4 x 6 tee. On the 4" branch of the latter tee the suction of the existing 7 x 5 x 12 beer pump, 8,000 gals. per hour at 80 strokes per minute, is connected, and on the 6" branch a new 10 x 6 x 12 duplex steam pump will be connected, capable of handling 11,700 gals. per hour at 75 strokes per minute.

Both the new pump and the existing pump will discharge through a 5" pipe which will rise vertically to below the operating platform and thence south under the floor and over the court to the fermenting cellar of the Gooderham & Worts Co., where it will discharge into either of three 50,000 gal. tubs. The line is kept as clear as possible by using long radius fittings.

These fermenting tubs are of wood, with copper bottoms, and are 25 ft. in diameter, 16 ft. high, with a capacity of 49,395 gals. They were formerly used for whiskey fermentation. The three tuns to be used have been roofed with a conical sheet iron cover (24" rise), culminating in an 18 inch ventilator and fitted with a 15 x 20 manhole. They are thus provided with means for discharg-ng the hydrogen gas outside the building and are kept reasonably lear of air, but otherwise have no protection against contamina-ion.

The beer and foam from these tubs is drawn off through two uctions, one drawing beer from the bottom and the other with special float controlled arrangement drawing at the same time ome of the head floating on the beer.

By this means both foam and beer are drawn off simultane-usly and thoroughly mixed during the subsequent pumping, so at the beer still receives a homogeneous liquor.

A new 10 x 6 x 12 duplex steam pump, placed at the north wall the building containing the tuns, draws beer and foam from the o suctions through a 5" pipe, and discharges it through a 4" e over to the two beer stills (one in course of construction). is pump is fitted with an automatic relief by-pass and an auto-tic pressure control, so that it always maintains a pressure fficient to deliver the beer to the top of the stills. Under the new arrangement the beer still service pump and tank on the third floor will be dispensed with. Each branch of the beer line leading to either still will be fitted with a valve at the operating floor which the attendant will regulate to suit the still operation, and the automatic control on the pump will regulate the pump operation to suit.

This system then with its two beer pumps of large combined capacity permits of the rapid emptying of any fermenter on the first indication of incipient foaming, and the discharging of the beer across into the large tuns where there is ample capacity to allow for foaming without loss. Even if more than one fermenter starts foaming at the same time the arrangement of the beer line and large cross header permits of the emptying of the tanks at an equal or greater rate to that at which the foam rises.

The suction arrangement in the tuns as previously stated thoroughly mixes the foam and beer into a homogeneous liquor, which is delivered continuously and at a constant rate, under easy and direct control of the still attendant, to the beer still. The still may thus be operated more efficiently because of the continuity through not having to wait for a fermenter, and also because of the homogeneous beer dealt with, foam itself having a bad effect on the still operation.

It is expected that this system will increase the possible yield, and duty of the fermenter tanks appreciably, since not only will they be emptied more rapidly but it is hoped that they will now only be in operation during the period when contamination is a source of danger, and that is during approximately eighty per cent of the whole period of fermentation. This latter advantage will only be obtained if the disturbance of the fermenting liquor is found not to interfere with the bugs completing the fermentation. It will probably be put in operation when at least 95 per cent of the total yield of acetone has been obtained.

Edward Metcalfe Shaw.

SECTION VII (e)—GAS DISCHARGE FROM FERMENTERS

GAS DISCHARGE FROM THE FERMENTERS.

Quantity, Rate and Composition—The total amount of gas discharged from a fermenter of 25,000 gallons, is approximately 90,000 cubic feet=5 c.f. per lb. of maize. The maximum rate discharge is about six to eight thousand cubic feet per hour.

The approximate analysis of the gas and vapour discharged is, carbonic acid gas, 50%, hydrogen 50%, with small quantities of acetone, water vapour and hydrogen sulphide and possibly traces of ammonia.

The carbonic acid gas is below 50% at the beginning of the fermentation, increases to 50% about the middle and becomes greater than 50% towards the end, but the average percentage during the whole fermentation is 50.

UTILISATION OF THE GAS—Considerable attention has been given to the possibility of utilising these gases, particularly with reference to the hydrogen and acetone.

GASES AS A FUEL—One suggestion was to burn the gases, using the heat to save coal. Without considering the cost of an installation for this purpose, the heat available would save the consumption of 1.25 tons of coal per fermenter. At $6.00 per ton for coal this equals .22 cents per pound of total weight of Acetone and Butyl Alcohol obtained per fermenter.

One grave objection, however, to the burning of the gases is the danger involved through enclosing the gases in pipes, and of having explosions either in connection with the conduits or with the gases when they were consumed, and it does not appear wise to run a serious risk to the plant and incur considerable expense to reduce the cost of the product by .22 cents on say 22 cents or only ne per cent.

ACETONE RECOVERY—Another suggestion was to recover the cetone and plans were prepared and parts of the plant purchased r doing this by means of compressing the gases and cooling them nder conditions where probably seventy-five per cent of the cetone could be recovered.

GAS COLLECTION—This plan for dealing with the gas was as folws: The gas was brought from the top of the fermenter rough an elbow and short length of 4" pipe, in which was placed T carrying a 3" weighted safety valve, to the front where it ssed through a second elbow, a gate valve and into one end of a s measuring box, as shown in drawing 26-24" diameter and 4 t long and fitted with dividing plate with an 1½" orifice in it.

The original 8 tanks were bolted together, the final 4 welded. A manometer was connected across the orifice plate, measuring the drop in pressure and thus giving a measure of the gas discharged. In some respects this answered well, but there was constant leakage, and it was found impossible to prevent a tank when foaming from filling up these vessels with fermented liquor.

The 4" discharge pipes from the drum were collected in an 8" W. I. header leading to what is now No. 9 fermenter, which was fitted up as a gas receiver. The gas receiver carried a battery of three 3 in. safety valves and from it the gas was drawn through a 4" and a 5" line to the compressing and extraction plant.

PROPOSED COMPRESSION PLANT NO. 1—The first compressing plant was laid out and partially erected to recover from the gas any acetone contained by freezing it out. Thus the 4" line mentioned above led to a gas drum from which the existing 12 x 1 compressor north of the rectifiers and an 11 x 11 x 12 Westinghouse compressor draw and discharged into a compressed gas header.

Through the 5" line gas passed to two belt driven Rand Air Compressors, one an 6" x 8"—54 cu. ft. per minute, and the other a 10" x 8"—179 cu. ft. per minute which discharged the compressed gas at 60 lbs. gauge into the compressed gas header. These compressors were belt driven at 250 r.p.m. by two steam engines acting as air engines.

From the header the gas passed through two 100 h.p. exhaust feed water heaters used as coolers, one employing water and th other cold gas as the cooling agent and through a steam separato to pick out the acetone and into the steam engines used as ai engines one a 12 x 16 and the other 8 x 10" high speed. Th exhaust (expanded cold gas) from these engines passed through second separator to pick out any further condensed acetone an through one cooler (feed water heater) and out to the atmospher

PROPOSED COMPRESSION PLANT NO. 2—As a result of furthe consideration and experience together with the installation of new fermenters, the design of the plant was altered.

In the 4" line leading to the gas boxes from the fermenter between the gate valve and the box a 4" gate controlled side outl for air was fitted. No. 9 fermenter was refitted as a ferment and a gasometer designed using one of the scale tanks as a gas meter, fitted with a new bell. This gasometer took the surpl from the gas header and the main 8" header passed along to the redesigned gas plant. This header fed the two Rand Compressors and the Westinghouse placed together. The large engine was retained as the gas expansion engine and the high speed engine was used as a steam engine. One of the "feed water heater" coolers was retained, the other being replaced by a cooler made up of pipes.

The construction of this plant was stopped because of an explosion which occurred on Nov. 10, 1916, at 11 a.m., which showed the danger to the whole plant if the gases were retained in the building, a faulty connection in the electric light circuit having caused the explosion.

PROPOSED COMPRESSION PLANT NO. 3—It was deemed advisable therefore, to place the compressing and acetone recovery plant elsewhere than just south of cookers 3 and 4, where it was being erected. Consequently the design of another plant and building was started. The building was to be erected on another part of the property and the plant fitted up with gas engines working on the cold fermenter gas from which the acetone had been extracted as n the other plant. The use of gas engines was impossible in the fermenting room due to risks of explosion. Due to further difficulties the whole scheme of acetone recovery from the gas was bandoned and the following system of piping laid out and its construction proceeded with.

GAS DISPOSAL ARRANGEMENT NO. 1—The arrangement then aplied was as follows (see drawing 63): From the upper central ange of the fermenter the gas passed through a short 4" nipple, bow and a second nipple, through a 4 in. gate valve to the side utlet of a 4" tee. From the upper outlet of the tee a 4" gas pipe d through the roof and was fitted at the top with flange carrying 1½" orifice plate which was arranged so that it could be enrely removed when the gas discharge became high. The gas scharged directly into the air. The lower outlet of the T was ted with a drain so that no contaminating liquid could fall back the gate valve disc. In addition a steam jet was arranged rough the T discharging on the disc of the valve. This jet was ays in operation when the valve was closed but introduced a ious possibility of contaminating through negligent operators.

Frothing System—In conjunction with the above a frothing system was laid out and partially installed. On the side of each fermenter 12" from the top a 3" flange was riveted to which a 3" gate valve was bolted. From the latter a 3" line passed down through the floor and through the branch of a Y into a 3" frothing header. This header received the froth from each fermenter and carried it to two of the scale tanks from which it was to be drawn by the beer pump and sent to the still. The line was fitted with water flushing connections and all the bends were through Y's and 45° elbows to give as free a run as possible. It was, however, finally considered inadvisable to try and control or make use of the foam and the scheme was abandoned retaining only the gas outlet arrangement at the top which permitted the foam, by removing the orifice plate, to discharge on the roof.

This arrangement of gas discharge was continued in use for about two months and was finally displaced by the system now being followed of discharging the gas by means of the most direc route to the outside of the building.

Present Gas Disposal System—The arrangements adopted fo this purpose are indicated on drawing No. 60, which shows a devic which has been found to be entirely satisfactory in practice and perfectly safe means of discharging gas. This provides an accur ate and safe means of regulating the gas and steam pressure an of the steam discharge when sterilising the tanks, at the same tim giving effective safety against collapse through a vacuum formin in the tanks, certainly preventing any serious damage should ever other precaution fail. The first of these was installed in No. fermenter about March 24, 1917.

This device consists principally of a cast iron cross and a ga vanized iron box. The cross is a special casting arranged to eith screw into the 6" flange of the original fermenter or to bolt to t flange and close nipple screwed into the 4" flange of the new fe menters (the latter construction was used in order to keep a f 4" diameter outlet). The front flange of the cross is set at angle so that the gas pipe bolted to it has an upward slant of 1 10, in order that any liquid carried out in the gas may drain ba into the fermenter. The other two openings of the cross are clea ing openings, provided with hinged bolted flanges, the upper for cleaning the cross itself and the fermenter top in the imme ate neighborhood of the outlet, and the back one to permit of the swabbing out of the gas pipe with a long swab.

Fermenter Safety Device—The device proper is in the form of a 6" square galvanized iron box about 46" long becoming circular at the top where it is flange jointed (millboard gasket) to the 6" exhaust galvanized iron pipe and with an open bottom. There is a dividing plate arranged as shown which is shaped to eliminate all pockets and crevices around the flange for the gas pipe, which might possibly afford a hiding place for bugs or make cleaning difficult. The dividing plate has cut in it a rectangular orifice with a notched upper edge permitting the easier discharge of gas and eliminating the sudden release of a large quantity that would occur under a flat edge with the consequent surging. This orifice is equivalent in area to a 4" pipe, and the lower edge of the dividing plate is also notched. There is a gate controlled by a lever which may be slipped in front of the orifice in the dividing plate which carries an 1½ in. circular orifice. The operating lever of this gate is bent as indicated and moves in a closed sector (with thumb screw fastener) to catch any drip and keep the handle dry. Around the box a few inches below the water level is riveted a perforated ring to dampen out surges and prevent liquid slopping over.

This box is arranged inside a 10" x 30" can into which the anti-eptic water is poured from a pail or other container, through the rger lip, and overflows through the hooded overflow which pre-ents the liquid level exceeding the proper value. The can is also rovided with a second lip and bailing handle for emptying and ith a pair of roller handles. This can is suspended on sash cord rried over pulleys on the pipe frame and counterbalanced by a st weight. There are movable brackets on which the can is hung t different levels and the frame work is arranged with horizontal ms on which the can may be rolled out of the way.

A large funnel underneath catches the overflow or froth and rries it through a 6" pipe to the drains in the flow below.

Action of Device—The action is as follows:

Steaming, Cooling and Filling a Fermenter—The can is at its per level and the gate open, the device then acts as a safety lve relieving at 10" of water through a 4" pipe.

Fermenting—1st stage. The can is at the lower level and the gate closed, giving free gas discharge through an 1½" orifice the pressure on which is measured by the manometer on the fermenter.

Fermenting—2nd state. The can as in 1st state gate open, giving free discharge of the greater volume of gas now generated through a 4" pipe. The gate is opened after the pressure on the manometer shows 5 or 6 inches on the 1½" orifice.

Foaming—The can is further lowered until just sealing the end of the square box and the foam overflows the can and drips into the funnel. After foaming the can is cleaned out and replaced.

EDWARD METCALFE SHAW.

SECTION VIII.—AUXILIARIES.

SECTION VIII. (a).

BUTYL SALTING PLANT.
APP. 1—ALTERATIONS.
APP. 2—BUTYL RECTIFICATION.

BUTYL SALTING PLANT AND SALT RECOVERY SYSTEM.

The Butyl Salting Plant at Toronto, is a dual continuous system, composed of two distinct units; the salting plant proper, and an auxiliary salt recovery plant, either of which may be operated independently of the other, and both of which operate continuously, differing therein from plants operating on the batch system.

The plant was designed to operate under the following conditions:

The crude butyl as it comes from the rectifier at Toronto, is run into a tank B, where an aqueous layer of about one-third the depth settles out. This aqueous layer contains approximately 8% butyl, and is pumped back and redistilled. The butyl overflows from B into a second similar tank B2. The butyl passing into B2 from B is about 75% dry, but this may possibly run down to as low as 70%. A pump draws the butyl from B2 and discharges it into either a large outside storage tank, from which it is drawn as required for salting, or directly into the salting plant reservoir. The salting plant was designed to deal with butyl 30% wet. From each fermenter of 25,000 gallons, are obtained 400 gallons of we butyl, and at a rate of 6 fermenters a day, there would be 2,400 gallons of butyl to be salted per day, or 100 gallons per hour. Allowing for a possible doubling of this rate or 12 fermenters pe day, and still further, a margin for other contingencies, the plant was designed to handle 240 gallons of wet butyl per hour.

Tests at Toronto have shown that after one minute of vigorous steady shaking, in a graduated cylinder, and three minutes of settling, the depth of liquid being 10 inches, the resulting butyl is 92% dry. In 240 gallons of wet butyl, 70% dry, there are 72 gallons of water, of which say 55 gallons will be salted out to bring the butyl up to 93% dryness. It is expected that the average will be 93% dryness. This water will take up about one-third its weight of salt when saturated, or 183 lbs. (26% of brine by weight is salt at saturation), which will increase the bulk about 15% or say 8¼ gallons. Therefore on this basis, there will be 55x8¼—63¼ gallons of saturated salt water separated out per hour. The total quantity of butyl, water and salt water to be dealt with by the plant is thus 248¼ gallons per hour. In the drum, the time allowed for salting was set at five minutes, and the total quantity of liquid being 248¼ gallons per hour, the salting drum was required to hold 5/60 x 247 say 20½ gallons of the mixture. As the drum would normally be about one-third full, the total capacity was fixed at 70 gallons. The drum speed was provisionally set at 60 r.p.m. until experimentation allows a proper speed to be determined.

The salt water rejected in the plant specified, would be 63¼ gallons per hour, which must be handled by the evaporator or salt ecovery plant. Steam is supplied the evaporator at 100 lbs. per . inch, gauge (338°), the inlet temperature of the solution being set at 210°, an inlet temperature difference f 128°, 45% or 58° of which is the rise in temperature of the lt solution. The latent heat of solution, where steam is discharged is 960, so that the quantity evaporated will be 58/960 or % of its volume. The evaporator thus must handle 100/6 x ¼ or 1,050 gallons per hour of solution, in order to recover the 3 lbs. absorbed per hour in salting. From data established at asgow where .622 sq. ft. of surface with a steam pressure which ve 40° rise of temperature, 140 gallons per hour were pumped rough the tube, hence with a higher steam pressure giving 58° e of temperature, 203 gallons per hour can be put through, and s to do the work required in this case '622x1050/203=3.21 sq. are necessary. This area is given by 4 tubes 5/16" bore 11' 6" g and to afford an ample margin 6 tubes were put in the evaporator giving an area 5.75 sq. ft.

DESCRIPTION OF SALTING PLANT.

See Drawing No. 56.

The crude butyl as it comes from the rectifier is run into a tank B1, (13,400 gallons capacity, formerly used for wine storage) on the ground floor of the distillery, and allowed to settle, the drier butyl running over through a 2" overflow, located about one foot from the tank top, into a second similar tank, B2, (previously a spirit storage tank) from which it is drawn by a reciprocating steam pump (wine pump formerly) and discharged into a large outside storage reservoir B3 (400,000 gallons, formerly molasses tank), or directly into the inside wet butyl storage tank R, (2,500 gallons capacity, formerly slop tank) of the salting plant. From the outside tank the wet butyl may be drawn by a large reciprocating steam pump P1, at one time used for molasses, and raised into the small reservoir R, previously mentioned. From the latter the wet butyl runs under the influence of gravity through a 2" pipe, in which is a 2" float controlled balanced valve, into the hopper H of the salting drum, washing in the salt added at this point, either by shovelling or from the salt recovery system to be described later. The salt and butyl pass from the hopper into the salting drum through a hollow journal.

The salting drum, (see drawing 47), is belt driven from counter-shaft driven from a small 5 h.p. vertical steam engine (se note in appendix). The drum rotates at about 60 r.p.m. in speciall designed pillow blocks, and requires little power to operate. Th interior of the drum is divided by disks into seven chambers, an there are four paddles or blades extending throughout the whol length of the drum. Communication between the chambers is b means of a 6" diameter hole in each disk, or through a rectang lar slot.

The operation of the drum is as follows:

The mixture of wet butyl and salt, passes from the hopper int the first chamber, and as the drum rotates the blades successive pick up the salt and let it slide off into the wet butyl, stirring t mixture thoroughly. Once during each revolution, a deflector opp site the rectangular slot cuts off a portion of the salt and guid it into the next chamber. The drum axis being horizontal, and t inlet opening 4" in diameter, while the holes in the disks are 6 the liquid flows from chamber to chamber through the 6" ho and also through the rectangular slots when below the axis. In this way the salt and butyl pass on from chamber to chamber, being constantly agitated by the paddles, and the water in the mixture dissolving salt until, upon reaching the last chamber, when the drum is being properly operated, the water is thoroughly saturated with salt, and comparatively little undissolved salt is present. The rate of flow of the liquid through the drum, and the quantity of salt are under easy and direct control, the latter depending on the former. The mixture of 93% dry butyl and saturated salt solution, flows out through the 5" diameter outlet in the other hollow journal.

From the salting drum, the mixture flows into and through an observation chute O.C. in a broad shallow stream. In the chute the mixture may be momentarily arrested from time to time by means of a small flap gate, and examined through the glass windows to see that just a slight amount of crystal salt is coming through insuring thorough saturation of the water. In this way the amount of salt admitted to the drum, may be properly regulated to suit the rate of flow of butyl, so that the water is saturated and very little excess salt passes over.

The observation chute ends in a passage way leading into a settling tank T, (see drawing 49). This passage way is so designed that the mixture of dry butyl and saturated salt solution in passing into the tank, imparts to the whole body of liquid in the tank, a rotary motion. The object of the rotary motion is to obtain a low velocity and more time for the thorough or complete settling out of he suspended salt. The passage way is further so designed as to be readily accessible through the hinged observation window, for cleaning out accumulations of salt. A large proportion of the salt carried out of the drum in suspension, drops to the bottom of the ettling tank and the liquid remaining (dry butyl and saturated alt solution) flows out through the elevated overflow. The salt hat settled out drops to the cone shaped bottom of the tank, and is rawn off occasionally through the salt valve V, (see drawing 48) nto flat pans or pails and returned to the hopper H. This is the nly manual handling of the salt in the plant, except at starting.

The liquid proceeds from the overflow of the settling tank into e pump reservoir R2 (see drawing 54), where the rotary motion d elevated overflow are made use of to effect the complete separ-tion of any remaining suspended salt. In this tank is arranged a float which controls the stop cock in the butyl supply line above, allowing the wet butyl to flow in only as fast as the pump draws the salted mixture from the tank.

The small rotary belt driven pump, (see appendix), draws the butyl saturated salt solution mixture from the reservoir R2, and discharges it into the main dry butyl storage reservoir R3 (formerly molasses storage tank) where the separation of the dry butyl and salt solution immediately takes place, the former rising to the top, and the latter settling to the bottom. The depth of salt solution at the bottom of R3, to effect a proper separation, need not be more than one foot, possibly less. The separation is so definite that even with small depths there is no danger of any butyl passing out of the drain. There may of course, be any quantity of salt solution kept in R3, but the greater the amount of salt solution stored, the less storage capacity is available for dry butyl, whilst with a small quantity of salt solution, the pressure of the butyl above it, will feed the evaporating system.

The dry butyl may be drawn off from the tank R3 through either of three 2" connections located at three different levels in the tank. To the south of R3 is a duplicate tank, in the same building. This will be used for dry butyl storage purposes and connections are arranged between the two tanks so that butyl may be run from either of the three 2" cocks in R3 into the second tank.

This constitutes the Butyl Salting Plant and it may be operated entirely independently of the second part of the plant about to be described.

SALT RECOVERY SYSTEM.

The saturated salt solution settles out in the dry butyl storage reservoir, on the bottom, and runs out under the influence of the static head in the reservoir (due to dry butyl and salt solution) through the original 4" drain connections and into a new 1½" supply line leading to the float chamber F.C. (See drawing 54.) (Evidently the head of salt solution and dry butyl in R3, must be greater than in the float chamber for flow to take place.) The 1½" supply line is provided with water connections for washing out possible accumulations of salt, which are not however expected. Normally 63¼ gallons per hour of saturated salt solution will be handled containing 183 lbs. of salt.

The salt solution is admitted to the float chamber through a 1½" ball float valve, in order to maintain a constant level of liquid in the chamber and to prevent flooding. The float chamber and exploding chamber, are really one vessel, as the two are in direct communication through a 2" opening protected by a baffle. The solution passes through this opening into the exploding chamber (where the liquid has a rotary motion for reasons given later) and out through the elevated overflow and a 1¼" return line, to the suction of a second small rotary pump E3, (see appendix), which discharges into the evaporator E. (drawing 46), through a ¾" pipe. This pump must handle about 1,050 gallons per hour.

In the evaporator the salt solution is pumped from a header into six copper coils (entering at 210°) through which it flows under pressure, while the coils are surrounded by live steam under a pressure of about 100 pds., flowing in the opposite direction through the passages in which the coils are laid. The solution is thus heated under pressure to a temperature of 268° and passes out through the second header and returns through a ¾" delivery line o the exploding chamber. The evaporator is provided with water onnections for washing out the coils together with air vent and rain for condensate.

The hot salt solution is maintained at the required pressure n the tubes by a needle throttle valve (drawing 54). On entering e exploding chamber, 6% of the water is evaporated, and the epositing in fine crystals, of about 6% of the salt in solution re- lts. The needle valve is so placed that the jet issuing from it ves to the liquid in the exploding chamber, a rotary motion, which gether with the elevated central overflow, gives the salt oppor- nity and time to settle. There are two overflows provided, one which will cause the needle valve to discharge freely, the other bmerged. It is not known at present, which arrangement will ve the better results in the way of crystals of suitable size. The lt settles to the cone bottom of the tank, and is fed as required rough the salt valve V2, into the hopper H and salting drum. e evaporated steam escapes up the exhaust pipe which is pro- ded with a moisture drain to prevent any condensed steam drip- g back into the exploding chamber.

The salt solution coming in through the float valve just com- nsates for the water evaporated and keeps the quantity of liquid the system constant.

Generally speaking, this plant is designed to utilise as fully as possible, the advantages of continuous methods. The liquids and salt are reduced in quantity at each stage, to the smallest amount, consistent with certainty of action, and the two advantages of small quantities under treatment and small size of apparatus are obtained.

The plant is capable of easy control by one attendant.

At the rate of 6 fermenters a day, 2,400 gallons of wet butyl must be dealt with each day, and 240 gallons uses 183 lbs. of salt, so that 1,830 lbs. of salt can be recovered daily instead of being thrown away. At present prices of $11.50 a ton for crushed rock salt, or $13.50 for clean salt crystals, the salt used represents say $12.00 a day with only 6 fermenters. At a wage of say $4.00 for 10 hours and coal used 15 cwt. at $4.00 a ton, a total of $7.00 the saving of salt will easily pay for working of the plant.

Much of the plant we shall use was already on the premises, when the buildings and equipment were taken over by us.

EDWARD METCALFE SHAW.

APPENDIX TO BUYTL SALTING PLANT REPORT.

There have been found, as a result of actually operating the plant, several changes necessary in the construction of the plant In the first place, the steam engine drive proved unsuitable and was replaced by a 3 horsepower induction motor, 750 r.p.m., driving through a countershaft to the drum direct. This drive ha proved entirely satisfactory.

It has also been found necessary to place on the inlet end o the salt drum a gland as shown in drawing 69 to prevent leakage

The small rotary pumps originally arranged for were deeme unsuitable, finally, and replaced by a 3 x 2 x 4 duplex steam pum to handle the butyl-salt solution and a 6 x 4 x 6 duplex steam pum to handle the salt solution in the evaporating part of the plan Small galvanized iron pans 18" diameter x 6" deep, were made t slip under the settling tank to receive the salt.

The salt was found to stick in the cone bottoms of the settli tank and exploding chamber and the agitators shown in drawing 7 were installed that in the former hand operated and in the latt driven by belt from the drum. Those have been found fairly sa isfactory.

With regard to the operation of the plant as shown after some time in actual use. The salting portion of the plant is imminently satisfactory having handled 600 gals. of wet butyl per hour and salting to 92 to 93% dryness. This part of the plant proved itself easy of manipulation, lent itself readily to accurate observation of the results, quality of butyl, etc., and close regulation of salt supply by means of the observation chute. The settling tank was effective in the removal of undissolved salt. The results obtained by the evaporation portion of the plant were disappointing. The heater proved most efficient and satisfactory, but the great difficulty arose through the escape of considerable salt up the exhaust with the steam and through the caking of the salt in extremely hard formations all over the interior of the vessel and its fittings. As a result the original vessel was heightened with the same results and with even a 7' 6" diameter by 6' tank and the needle valve at either side or top of roof the results were poor. Finally the latter tank was used with a large copper steam coil, simply boiling the brine but again the salt froze on the tubes in an extremely hard crust, rendering the coils useless.

Having in mind then, the comparative cheapness of the salt used ($11.00 to $13.00 per ton) in comparison with the value of he butyl dealt with, the extremely difficult nature of the problem nd the pressure of other more important work, it has been re-olved to abandon for the time being the salt recovery system and se only the salting plant itself.

Edward Metcalfe Shaw.

APPENDIX 2—BUTYL ALCOHOL RECTIFICATION.

Recently instructions were received to increase the dryness f the butyl alcohol beyond that obtained by simply salting and e butyl alcohol at Toronto is therefore now put through the fol-wing system of rectification:

Storage and Settling Tank System—The crude butyl om No. 1 rectifier passes to a 13,400 gal. copper spirit nk B1, in which an acqueous layer settles out at the ttom and the drier butyl overflows through a 2" pipe about one t from the tank top into a second similar tank B2 entering the ter 30" from the bottom. From B2 the butyl is drawn by a

12 x 10 x 20 simplex steam pump(formerly slop pump) and discharged through existing 4" piping to the large 1,250,000 gal. outside storage tank, west of the shipping room. From this large reservoir the wet butyl is pumped by an 8 x 10 x 12 simplex steam pump (formerly molasses pump) through a 4" line (partly existing) into a 7' 6" diameter x 6' high galvanized iron tank—1,500 gal. tank (built for acetone storage but replaced by larger). From a point 2 ft. from the bottom of this tank, to allow of any further settling out of water at the bottom, a 1" line passes to the hopper of the salting drum.

SALTING PLANT—The butyl is salted in the salting drum, salt being fed in by hand and the butyl, brine mixture passes to the settling tank, where the solid salt settles out, overflows into the pump reservoir and is pumped by a 3 x 2 x 4 duplex steam pump through a 1" line into the north one of two 18,000 gal. steel tanks in the shipping room, entering the latter midway between top and bottom. In this large tank the butyl and salt solution separate and the dry butyl overflows through the top one of three 2" overflows into the south 18,000 gal. tank. From this latter tank a 6 x 4 x duplex steam pump (formerly used on the salt recovery system draws the dry butyl through a 2" line and discharges into a lin made up of various sizes of pipe, most of which was in place in th old plant, across the intervening buildings and Trinity Street t the Gooderham & Worts Still House and into either of two 11,00 gal. copper still supply tanks. From these latter a 3" copper lin runs to either of three Gooderham and Worts stills No. 1, 7,00 gal. No. 2, 7,000 gal. or No. 3 4,000 gal.

RECTIFICATION SECTION—The butyl rectification is carried o entirely in Gooderham and Worts equipment. From the kettle No. 2 still, which is now used for butyl rectification, the vapors pa through a 16" pipe to the column (8 sections and 23 plates) a thence through a 14" pipe to the goose. From the goose a pipe leads to either of two condensers and from the condensers t liquor passes to the tail box.

The runnings from the tail box are directed through either two 2" lines to the centre of Gooderham and Worts No. 2 Ta House, containing sixteen 9,100 gal. copper tanks or to either two 3,600 gal. copper tanks (formerly alcohol), south of No. Still. From the ends of the 2" lines in the centre of No. 2 ta house, lines of hose are employed to carry the runnings to any one of the sixteen tanks. The last runnings are directed into the two 3,600 gal. tanks from which a 2" line drops to 6 x 4 x 6 duplex pump which discharges vertically to the long line by which the butyl is brought over from the salting plant. This same line is thus used for both delivering the butyl to the rectifying section and for returning the last runnings. The above pump may also be used to empty the rectifying kettle should a bad charge at any time require to be removed.

Returns—The last runnings are thus pumped back to the salting plant where it is discharged into the top of what was formerly the 2,500 gal. steel salting plant supply tank. This tank is arranged similarly to the 1,500 gal. galvanized iron tank so that there is provision for aqueous layer to settle out. A 1" line leads from a point 2 ft. above the bottom to the salting drum hopper, where the upper layer of the returns is salted. The lower layer that settles out in this tank is returned by a belt and gear driven single plunger pump (3" x 7") through a 1¼" line to the bottom of the 13,400 gal. tank B1, and the lower layer in the latter ank is removed at intervals by a 6 x 8 x 12 pump (formerly spirit ump) and returned through a 3" line for re-rectification.

The butyl will be run into the drums directly from the tanks in e Gooderham & Worts No. 2 Tank House, probably using the xisting alcohol racking off arrangements.

The butyl obtained by this system is 99½% dry while the best btained at Toronto by simply salting was 92-93%.

Edward Metcalfe Shaw.

SECTION VIII. (b)

CONTINUOUS FERMENTATION SYSTEM.

XPERIMENTAL PLANT FOR TESTING CONTINUOUS FERMENTATION.

An experimental continuous plant for fermentation with the izmann bug has been under construction since the fall of 1916. essure of other work has held back the completion though most the work is done. It is designed to ferment about 700 galls. 24 hours.

The necessity for such a method of working has largely disappeared since the present plant has run for three months without contamination spoiling a single fermenter, but the completion of the work seems advisable because success would mean reduced cost of construction, working expenses and increased safety as regards yield and accidents.

Some work had already been done in connection with continuous cooking when this plant was first started and from the experiments made it appears certain that the time required for sterilising the mash and for getting the starch in solution can be cut down materially. Continuous cooking is now being applied on a large scale to the Toronto Plant—see section of report on New Mash Line and Continuous Cooking.

Difficulties of Ordinary Fermentation—Considerable difficult is met with on account of the uncertain nature of the fermentation as carried out under the existing system—the rate of fermentation and the frequent frothing and foaming of the fermenting liquor. This has not merely affected the periods, but has also caused trouble from the sudden increase in volume for periods of as long as two hours, during which there is frequently some loss of the fermenting liquor from the tank.

Possible Advantages of Continuity—It is believed that con tinuity through a series of fermenting vessels, arranged to allow for a continuous flow from one end of the system to the other, ma result in more uniform conditions of fermentation, while the effec of an increase in volume at a certain stage, though likely to b always happening in the same vessel, would result, should the in creased volume be abnormal, merely in bringing about for a shor period a more rapid discharge of the completely fermented bee from the end vessel.

Continuous Inoculation—The system of fermentation pr vides for the possible continuous reinoculation of the system, that should the system act as perfectly as is possible the spor originally introduced into the inoculating system will supply fro the seed stage a continuous amount of fresh inoculant.

In this connection, and in view of the uncertainty which present prevails as to the variations in the vigour and efficien of the bugs, provision is made by means of which a number of pi of a suitable length are fed from the end of the seed circuit by eans of small pumps immersed in antiseptic fluid, so that the ength of time which any of the seed takes to pass to the end of he inoculating circuit varies, say, from two up to twenty days.

By having at least two separate circuits for each period the inculant introduced into the beginning of the seed stage will, it is hought, provide from the assortment of spores, having, perhaps, idely different properties, a uniform inoculant. Such a system, f course, at least provides for absolute sterility.

It may be stated here that it has not been made clear up to the resent to what extent the continuous system may dispense with he introduction of fresh inoculant. Obviously, having once harged the system there will always be B.Y. bugs in the first ank.

Observation and Testing Facilities—The system of continuus cooking provides a constant quantity of mash, which is reguted as to flow for the main fermenting system and for the seed stem. There is considerable uncertainty as to what really hapns at the different stages of the fermentation, and therefore the elve tanks in the series are provided, with long glass windows, hich will generally be kept covered, with a suitably placed winw on the opposite side of the tank so that a powerful light can thrown over nearly one-half the depth of the fermenting liquor, lowing observation to be taken of the conditions of fermentation.

Among other arrangements provided are those for distributg the seeded mash in the first tank in a thin stream, so as to enre uniformity as far as possible.

Another provision made allows of the introduction into any nk of fresh inoculant, or of experimentally testing the effect introducing other forms of food for the bacteria, or chemicals h as alkalies or antiseptics.

In view of the possibilities arising in connection with foaming the surface of the liquid, or of the collection of solid matter at bottom of the tanks, a system is provided by means of which e of the gas drawn off from the system can be forced at high ssure through suitably placed perforated tubes in the bottom of h vessel.

Control—The general system of flow is controlled by the differe of pressure in the first and last vessels, which may amount to as much as two pounds to the square inch. The whole of th gas flows from one end to the other of the system, and is discharged from the last tank. It can, if desired, be drawn off a one or more intermediate points.

Absolute precautions are taken to prevent contamination in th system, and for this purpose any cocks or testing tubes are immersed in pots of antiseptic liquid.

The whole system is designed in such a manner that should i prove successful the existing plant of the British Acetones can b reconstructed to work on this system, and this work can be done a small cost and without putting more than two fermenting tank out of the total number out of commission at any one time.

Apparently the point most in doubt is whether such a syste can be worked continuously without adverse influences arising i the series of vessels. Naturally, until the system has been trie and in view of the present state of knowledge, it is impossible t say; but it can at least be said that there is no known cause whic will operate adversely.

Full details and results of the working of the plant will be se on as soon as the plant has been completed and fully tried out.

EDWARD METCALFE SHAW.

SECTION VIII (c)—IDEAL PLANT.

IDEAL PLANT

FOR PRODUCING BUTYL ALCOHOL, ACETONE AND METHYL ETH KETONE, FROM CORN BY THE WEIZMANN PROCESS.

GENERAL—It will be evident from the accompanying sectio of the Report on the British Acetones, Toronto, Limited, that the have been difficulties to cope with, many of which have arisen fr the fact that an existing plant was being adapted to new us These difficulties could be avoided or eliminated in the design a construction of an entirely new plant. It was with this in mi that the plant shown in drawing 64 attached was designed embod ing as far as possible and compatible with other essential con tions all the principles, arrangements and details of constructi shown by 12 months' work on the Toronto Plant to be necessary convenience, safety and efficiency in such a factory. This pl together with the accompanying description, is therefore put record more to define experience up to date than as a perf arrangement.

The plant is based on the use of material and equipment now in use at Toronto, re-arranged with such modifications as have been shown to be advisable.

OUTPUT—The plant based on the use of sixteen 30,000 gal. fer-menting tanks (although additional ones are under consideration) which, under the improved conditions of this ideal plant, would be capable of fermenting 10 fermenters a day or 250,000 gals. of mash, resulting in 5 tons of acetone per day and 10 tons of butyl, or if converted, in approximately 9 tons of methyl ethyl ketone, hat is a total of 14 tons per day of solvent.

LOCATION—In the design a location on a waterfront is assumed, ogether with railroad facilities enabling the raw materials, corn nd coal to be brought in either by rail or boat and the delivery f the solvent also in either way. The plant is laid out then on a ectangular plot of ground roughly 5½ acres, divided into prac-ically equal halves by the railroad right of way and with a berth or vessels in the middle of one side.

RAW MATERIALS—HANDLING CORN—On one side of the berth or the vessels is the corn elevator with a capacity as at Toronto f 1,000,000 to 1,250,000 bushels. This elevator would be arranged ith unloading equipment both marine and rail and provided with mply conveying equipment for handling the grain, transferring om one bin to another, and delivering to the mill across the rail-ad tracks. Ample grain handling facilities have been shown to very necessary at Toronto in order to dry the grain by trans-rring from one bin to another, eliminating dampness, which ren-rs grinding slow and screening difficult. The Toronto Plant is ithout such equipment, and is under a serious handicap in this spect as the grain can only be turned by hand.

COAL—On the other side of the berth is the coal storage which the case of Toronto, must be ample to eliminate shut downs as urred last winter through a shortage of coal and uncertain rail-d deliveries. To overcome danger from spontaneous combus-n from the large quantities stored, under water storage might resorted to, in concrete pits with coal handling equipment for rine or rail unloading and delivery to storage, and from storage boiler house by overhead conveyor across the railroad tracks.

FIRE PROTECTION—At the end of the slip is located the fire service pump house complete with boilers and pumps, drawing directly from the slip and capable of discharging 2,000 gals. of water per minute at 100 lbs. pressure.

The buildings on the land side of the railroad track are arranged in the form of rectangle with the distillery and storage building in the centre. Between the various buildings are ample passageways provided with light tracks and turn tables and cars for the transporting of heavy materials.

MILL—The corn is delivered from the elevator to the mill by the overhead conveyor. The mill approximately 50' x 50' is located as shown and has a capacity of 4,000 bushels a day and is equipped with eight run of steel rolls and other necessary equipment, capable of handling this quantity.

MASHING—Next the mill, in the same building, is the mashing section also 50' x 50'. The mashing equipment consists of four mash tuns properly equipped and with a capacity of 16,000 gals. per hour. Over the tubs are the meal storage hoppers and weighing gear fed by conveyor from the mill and feeding the tuns through chutes under gravity.

POWER—The mill and mashing equipment is driven from the engine room (30 x 50) next the mashing room. Here is located the main steam engine driving the countershaft which extends through mashing room and mill. Here also is the mash pump and digesters with controls and gauges extending through the wall to the mash room.

DIGESTING AND COOKING—The mash is drawn from the mash tuns by the mash pump capable of dealing with some 200 gals a minute and forced through the digesters and 5" mash line across the passage to the fermentation building (100 x 125), through the exploding valve into the first of three 8,000 gal. steel cookers. In the mash line the mash is digested under 50 lbs. of steam and in the cookers probably cooked on the continuous principle under about 15 lbs. pressure or less. The fourth tank shown is an exhaust steam reservoir as at Toronto. The cookers are designed for higher pressures than at Toronto and built with cone bottoms (45° slope) so that the arrangement of the piping would be slightly different.

Cooler—A cooler pump under float control from the final cooker and with a capacity of 200 gals. per minute, forces the mash through the cooler of the same type as at Toronto but larger and with slight improvements which are being embodied in No. 3 cooler here which is now being built. The cooler in the ideal plant is capable of cooling 200 gals./min. 150° F. The cooler water is used everywhere possible throughout the plant, for mashing, boiler feed, etc.

Fermenter—From the cooler the mash is delivered through 5" mash pipes properly protected on the positive system from contamination and arranged with long radius bends 45° elbows and Y's to offer least resistance to the fermenters entering the latter at the centre of the bottom. The fermenters are sixteen in number arranged as shown. They are built to withstand pressures of 5 lbs., have conical bottoms and are equipped with the devices and equipment that has proved satisfactory here, including vacuum valve safety device, thermometer, etc. The inlet and outlet is a single opening at the bottom of the conical bottom and is 6" in diameter. The fermenters are arranged in four groups with the piping as shown, the filling and emptying lines being one above the other, the former 5" and latter 6" and the valves properly safeguarded with steam locks, etc., against contamination.

Beer Lines and Pump—The 6" beer line from each group of fermenters passes by the most direct route and with easy bends to either one or two pumps with a capacity of 20,000-25,000 gals. an hour which discharge the fermenting beer before completion of fermentation to the Finishing Tanks.

Inoculation—The inoculation equipment is arranged on the floors above the continuous cookers and consist of six 5 gal. culture vessels, six 100 gal. inoculating vessels on the top floor and sixteen 600 gal. seed tanks arranged on the intermediate floor. The feed from one to another is by gravity. Besides this equipment is a laboratory on the top floor for the staff in charge of the seeding vessels. The inoculant from the seed tanks is forced into the mash line under pressure by a rotary pump (2,000 gals. hr.). The seed tanks are of steel or copper with conical bottoms, capable of withstanding internal pressure of 15 lbs.

Foaming and Finishing—The fermenting liquor from the fermenters is pumped at a high rate through the 6" line across the central passageway of the plant to four 40,000 gal. foaming and finishing tanks on the ground floor at one end of the distilling and rectification building. Here the fermentation is completed and the beer and foam drawn off simultaneously by a 200 gal./min. beer pump and discharged vertically to the distillation section.

Distillation—In the distillation section the beer first passes from the beer pump to the two 6,000-7,000 gal. an hour beer stills. The stills with their heaters and condensers are on the floors above these tanks and operate on exhaust steam from the central exhaust steam reservoir. The runnings from the still tail box pass through the wall to the storage tank building where it is stored in a 15,000 gal. copper tank. The slop from the stills passes through a line to the heat recovery unit in the boiler room (evaporator) where it is used to heat the feed water.

Rectification (Preliminary)—The preliminary rectificatio is taken care of by two kettle rectifiers each taking a 15,000 gal charge. The charge for these rectifiers is drawn from two tank in the tank house and pumped into the kettles by a simplex stea pump. The rectifiers are complete with columns, goose dephleg mator and coolers and the runnings are directed to the prope tanks (15,000 gal.) provided in the tank house.

Acetone Rectification—(Secondary)—The secondary rectification of the acetone is carried out in a continuous Barbet Aceton Still capable of dealing with 14,000 lbs. per day of finished acetone This still is shown in the rectifying room. The finished aceton from this still is directed to the storage tanks in the tank hous with a capacity of 8,000 gals. (glass lined) giving ample margi over a car load.

Butyl Salting and Rectification—The butyl alcohol fro the first rectification after settling out the aqueous layer in the ta house (15,000 gal. tanks) is pumped to the salting plant on th ground floor of the rectifying building. From the salting pla feed tank (2,000 gal.) the upper layer passes to the salting dru and thence to the first of a pair of settling tanks and overflo from the first into the second; from the second the salted butyl pumped to the third of the battery of three rectifiers from whi it passes 99½% dry to the dry butyl storage tank or tanks in the tank house.

METHYL ETHYL KETONE—Provision is also made for a methyl ethyl ketone plant as shown. This plant, capable of dealing with ll the butyl from an acetone factory of this capacity, could, from ork done here on the design of such a ketone plant, be housed in building 50 x 50 or the size indicated. Here the butyl would pass hrough the various stages and rectifications and finally pass to the ank house methyl ethyl ketone. Should a sulphuric acid recov-ry plant be necessary on the usual tower system a separate build-ng will be required.

SHIPPING—The shipping room is shown on the drawing of mple size for drum washing and racking off purposes and conveni-ntly located with respect to tank house and railroad. The ship-ing room is connected by pipe lines with the different acetone, utyl and ketone tanks and is provided with drum washing tank, latform scales, drum handling and loading equipment.

RECEIVING—The empty drums and construction material is re-eived from the railroad cars in the receiving room next the ship-ing room. The drums are then passed through the doorway di-ectly to the shipping room as required.

BOILER ROOM—The boiler room occupies one whole side of the ctangle and contains 2,400 h.p. of boilers. The coal is delivered conveyor from the storage and dropped into hoppers which feed rough chutes and mechanical stokers. Flue gas is carried off a brick stack and fans are provided for forced draft.

PIPE LINES—The pipe lines are all provided where necessary th ample sterilising connections, drains and also with sterilised ter washing connections. They are of larger size than in the ronto plant and fitted with malleable fittings.

LABORATORIES—The laboratories are located as shown, the bac-riological as near as possible to the fermenting section, with a all branch laboratory next the inoculating room, and the dis-ling laboratory next the rectification building.

Shops—The steamfitters' and carpenters' shops and mess room are in a separate block of buildings, conveniently located with regard to practically the whole plant.

Offices—The business offices, engineering offices and girls quarters are as shown in a convenient and handy location. The girls rooms being over the offices and communicate by bridges with the fermenting floor and rectifying rooms.

Edward Metcalfe Shaw.

DRAWINGS.

No.	Title.
1.	Stuffing Box for Cookers.
3.	Step Bearing and Outlet for Cookers.
4.	Sterilisers for Cookers.
5.	Steam Connection for Cookers.
6.	Cooler.
7.	Coil Connection for Cooler.
8.	Baffles for Cooler.
9.	Stirrer for Cooler.
12.	Header and Piping for Cooler.
18.	Fermenters.
20.	Acetone Storage House.
21.	Drum Washing Tank.
22.	Gauging Vessels.
26.	Gas Measuring Box.
30.	Cooler.
30A	Cooler Details.
35.	Mash Inlet for Cooler.
36.	Reconstruction of Fermenter No. 1.
38.	Piping to Inoculators.
40.	High Press. Cooker.
41.	Piping to No. 1 Cooler.
46.	Evaporator.
47.	Salt Drum.
48.	Salt Valve.
49.	Settling Tank.
51.	Salt Drum Pillow Blocks.
54.	Exploding Chamber.
55.	Salt Drum Hopper.
56.	Butyl Salting Plant.
59A	Rectifying.
60.	Safety Device for Fermenters.
61.	Distillation System.

CURVES.

TABLE.

EMBER, 1

BRITISH ACETONES, TORONTO LIMITED

SUPPLEMENTARY
REPORT
ON THE
FERMENTATION DEPARTMENT.

EMBER, 1918.

H. B. SPEAKMAN.

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BRITISH ACETONES, TORONTO LIMITED.
FERMENTATION DEPARTMENT.

A report on the work and the results obtained during the period from April 30th, 1917, to November 11th, 1918.

N. W. PIRRIE, ESQ.,
Director of Propellant Supplies,
Imperial Munitions Board,
Ottawa.

DEAR SIR:

I propose in my report to follow the scheme underlying the earlier one, a copy of which is appended, and to bring before your notice the bacteriological principles which have been considered and followed in the development of the plant, and in the routine work of producing acetone and butyl alcohol.

LABORATORY WORK—The problem of preventing the occasional sluggishness of the culture of the fermenters, and the resulting oss of time from slow fermentations has continued to demand ur attention. The organism in the various stages passes through seven cycles or generations covering a period of eight days. Ex-erience has shown how difficult it is to predict from the physio-gical and morphological characters of one generation what those f succeeding generations will be. The loss in vitality is very radual and we have endeavored to reduce the length of time and e number of generations required to produce from a test tube lture the volume of culture required to inoculated eight or ten rmenters daily. We no longer sub culture in the laboratory but ch day's culture in the seed tanks is derived from a new spore lture taken from the stock. The following stages represent the ogressive increase in bulk:

Spore Tube.
Monday—2 test tubes (Sealed and anaerobic).
Tuesday—5 test tubes (Open).
Wednesday—2 flasks (4 t.ts. used) 1 test tube to stock.
Thursday—2 Culture Vessels.

Friday—2 Inoculators.
Saturday—8 Seed Tanks.
Sunday—10 Fermenters.

The organisms which form spores at the termination of their life histories are the normal and most virile forms. Therefore, by starting daily a new batch and bringing the fermenter stage as near as possible to this early active condition the results obtained are improved and made more constant. During the last two years by our system of storing spore tubes of the most active cultures we have selected a more uniform and vigorous culture living under the conditions obtaining in this process.

At intervals various batches of maize media prepared in the laboratory have been found to be incompletely sterilised in spite of the fact that the usual methods had been adopted. Owing to the presence of resistant spores in the meal and the jelly-like nature of the medium the preparation of tubes and flasks requires constant care and I attach the greatest importance to this portion of our work.

There has been a large increase in the number of sterility tests to be made and the number of samples to be titrated and examined microscopically, consequently the laboratory situated some distance from the factory was found to be unsuitable for our needs owing to the loss of time involved in passing to and fro, and the fact that the bacteriologist in charge was not within easy access A new laboratory was equipped for routine work, and put into operation early this year, and the old one we retained for research work. This new laboratory is situated in the General Distillery Building and is in direct communication with the factory.

In addition to the problems in direct connection with the production of acetone which will be mentioned later, other problem have been under consideration in the research laboratory. It wa hoped that the increased knowledge of the physiology of the process would lead to greater efficiency and by improvements in ou methods to better practical results. Owing to the fact that th part of the work could only be done as extra voluntary work b the staff, we have not been able to make very rapid progress, an when the work ceased here the problems enumerated below we still being investigated.

(1) The isolation and identification of the organic acids produced during the fermentation.

(2) The isolation and identification of the intermediate sugars formed in the hydrolysis and oxidation of starch.

(3) The toxic effect of the lower members of the fatty acid series on the Weizmann Organism.

(4) The nature and significance of the relationship existing between the following physiological characteristics of the fermentation:

(a) The acidity curve.

(b) The rate of total gas evolution.

(c) The changes in the relative percentages of carbon dioxide and hydrogen.

(d) The rate of production of acetone and butyl alcohol.

Both from the practical and purely scientific points of view the continuation of this work is worthy of consideration.

The members of the laboratory staff have during this period acquired a large amount of new knowledge regarding the organism, and when problems of importance have arisen in the factory this has been of great value.

CULTURE VESSELS—The changes in connection with the early stages of the culture in the factory, which are foreshadowed in my ast report have been carried out. The pails are no longer used, ut have been replaced by culture vessels holding approximately he same volume of mash. These vessels are an integral part of he whole plant system and the inherent difficulties and risks in onnection with the preparation and transference of the pail cultures have now been eliminated. After a long experimental period hree culture vessels were connected to the inoculators in October, 917, and have given every satisfaction. The detail of these vessels was most carefully considered to ensure sterility and proper mperature conditions. In January, 1918, when the seed portion f the plant was enlarged and transferred to another part of the ctory the battery was increased from three to six units. Four f these were in constant use and the extra ones enabled us to keep e battery always in good mechanical condition and provided for possible increase in production.

INOCULATORS—The only change has been in the number of its in the battery from three to six. On one or two occasions inulators have been slightly contaminated, and we have been made realize the value of the antiseptic oil cup around the propeller shaft on the gland and careful attention to: (a) The manhole cover gasket and (b) all air valves.

The line connecting the culture vessels and inoculators is continually under live steam pressure when not being used to transfer inoculant. When the latter operation has to be carried out the line is sterile but at a high temperature. To wait until the line is cool is impossible when necessary operations have to be carried out in fairly rapid succession in the plant, and apart from the loss of time there is a possible danger of contamination. At the same time experience has shown that the heat of the line has an injurious effect on the comparative small volume of culture, namely three and a half gallons, which passes along the line. When the new plant was erected provision was made whereby the line could be cooled to the room temperature, and still remain sterile by connecting to it a sterile water chamber. The latter during the greater part of the day was gradually filled with condensed water from live steam, and being continually under fifteen pounds pressure the water remained sterile. After a charge of cool sterile water had passed through the line the inoculant was transferred to the inoculator.

SEED TANKS—The battery was increased in January, 1918, from nine to sixteen units and transferred to a separate room. The diagrams and drawings of the seed tanks will show how the filling line which formerly discharged into the seed tanks about three feet from the base has been lowered and arranged so that the seed tanks are filled from the bottom, through the same connection that the semi-fermented mash passes along later as inoculant for the fermenters. The system of valves with the seal of sterile water from the live steam connection prevents contamination and filling from the base eliminates much of the noise and frothing which occurred formerly, caused by the mash at fifteen pounds pressur discharging from the filling line into the seed tank. The steam used in cooking the seed tank mash passes along the discharge lin and so prevents any blockage due to lumping in the line. On sev eral occasions when separate live steam connections were used th inoculating line connection had to be cleared by blowing liv steam into the seed tank before the inoculant would pass along int the fermenter, such an operation does serious injury to the cultur

For several days in the early part of January the seed tank were extremely poor and for some time no explanation was forth coming. The inoculators were normal and our methods of working the seed tanks had not changed with the exception of the above alterations, which had no real bearing on the fermentation itself. In order to expedite cooling the hot mash, and also to break up any head which had formed during the fermentation extra beaters had been placed on the shaft, being fastened just below the surface of the mash. When everything else had been as far as possible eliminated an endeavor was made to see if the beaters were responsible for our failures. A temporary connection was made from the inoculators to the base system of valves on the seed tanks and the inoculant instead of falling into the surface of the mash was injected at the base by gravity. Seed tanks inoculated in this way were normal. It seemed clear therefore that the upper beaters were neutralising the effect of the propellor at the base, that the ulture was not being incorporated into the mash and being in an erobic atmosphere failed to develop. There was no contamina- ion which would have explained the complete loss of vitality. When the beaters were removed no further difficulty was encountered. This instance indicates the constant possibility of mechanical fficiency in one or more minor operations being injurious bacteriologically in the major sense.

MILLING—A detailed description of the operations carried on n the mill will be found in Mr. Shaw's report. During the last ear on some days the demands made on the mill were in excess f its capacity for the production of cleaned meal. In order to aintain our output the meal from one or two of the stones was n directly to the bins and not passed over the screens. The fer- entations did not suffer from the presence of the larger amount protein and fibre.

MASHING—In considering how to increase the output of acetone means of other than the erection of new fermenters two possi- lities presented themselves, namely: By increasing the volume of ash in each fermenter, and by increasing the percentage of solids the mash. The only objection to the first of these was the in- eased possibility of foaming towards the end of the fermenta- n. This objection was eliminated by covering four of the large rmenters in the Gooderham and Worts cellar thus converting m into reservoirs where mash could be pumped and allowed to ment through if foaming did occur. Careful tests were made to find whether pumping the fermenting mash and storing in a tank which was not sterile would injure the organism and prevent the completion of the conversion of starch into acetone and butyl alcohol. In the laboratory we found by careful experimental work the point of time during the fermentation when large amounts of the culture of the organism (see previous report) which has been present in contaminated fermenters in the factory can be introduced into the Weizmann culture without destruction of the latter. It became quite clear that after twenty hours of fermentation time when the acidity was falling mash pumped over would be able to withstand the possible contamination in the storage tanks. The endothermic heat produced was sufficient to maintain the required temperature.

The second possibility had to be considered from two points of view. What was the maximum concentration of maize in the mash which could be consumed by the organism without lowering our percentage yield? What would be the effect on the mechanical efficiency of the plant for mashing, cooking, and cooling? In the laboratory it was found that until a concentration of 14% is passed there is no appreciable loss in the percentage yield and no loss of time in the fermentation period. We therefore proceeded to gradually increase our concentration in the factory and made careful observations of (a) The time of fermentation. (b) The yield per gallon and the weekly yield per pound. (c) The efficiency of the mash floor and coolers. (d) The sterilisation and cooking of the mash in the cookers. In October, 1917, the maize in each fermenter was increased from 18,000 to 20,000 lbs. Our yield of acetone per gallon went up from 35 ccs. to 37 ccs. on the average and the weekly yield of around 8.5% was maintained. There was no loss visible in the mechanical efficiency of the plant. A similar result was obtained when towards the end of October the maize per fermenter was raised to 24,000 lbs., *i.e.* 10% mash. The te gallon average gradually went up from 37 ccs. to 41 ccs. of acetone. Above this concentration we encountered difficulties in pumping the mash and the efficiency of the coolers diminished.

The standard fermenter since November, 1918, has been 24,0 lbs. of meal in which with the water made up the total volume of 24,000 gallons of mash.

COOKING—During the first week in July, 1918, the connection with the continuous cooking system were completed. The mash for the fermenters on four days in the week was cooked and sterilised by the new method. The whole of the apparatus (described in engineer's report) worked smoothly and the operating staff in this Department quickly mastered the few necessary directions. All other conditions of working remained normal.

During the whole of this experimental period the mash discharged from the system was sterile and none of the fermenters were lost on account of contamination. When the end of the half days programme was reached, and the cookers had to be emptied and cooled individually, *i.e.*, by the old system, we found that there was a considerable deposit of the heavier constituents of the mash at the base of each cooker, and the pumping and cooling of these charges from the cookers was a slow and difficult operation.

The fermenters filled in this way behaved uniformally, and had the following characteristics: (a) the organism deteriorated rapidly; (b) the maximum acidity was above the normal; (c) the period of fermentation was prolonged and the yield per gallon below the average. Our yield for the week was 7.3% instead of the average yield of 8.5%. We returned to the old method of discontinuous cooking.

The difficulty seemed to be a fundamental one. If the mash in the several cookers were agitated violently by mechanical means or by strong jets of live steam the whole idea of a steady stream of mash would break down and not only would the mash be insufficiently cooked but there would be grave danger of mash passing rapidly through the system and into the fermenters unsterilised. On the other hand by omitting agitation the mash was not cooked throughout and the starch unprepared for the organism. It is not possible to say whether on further trial by increasing the pressure in the mash line better success could have been obtained. It should be stated however that the preparation of a starch medium for either a yeast or bacteriological fermentation is an operation in which the time factor plays an essential part and cannot be sacrificed by the use of high pressures. The problem involves a more detailed discussion of the chemistry of starch, apart from all mechanical consideration.

COOLING—The cooling system has not been changed in character during the period covered by this report. A second cooler of the later type designed and described by our Mr. Shaw in his last report has been in continuous operation. They have given every satisfaction to this Department both as regards ease of operation and sterility. Owing to the facts that temperature conditions in the fermenter are most important, and the necessity which exists for absolute sterility I feel that the coolers have contributed very largely to the success of the plant.

H. B. SPEAKMAN.

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BRITISH ACETONES, TORONTO LIMITED

SUPPLEMENTARY REPORT

ON THE

DISTILLATION AND RECTIFICATION

OF

ACETONE AND BUTYL ALCOHOL.

December 16, 1918.

D. Alliston Legg, A.I.C.

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BRITISH ACETONES TORONTO, LTD.

December 16th, 1918.

MR. N. W. PIRRIE,
Director of Explosives,
Imperial Munitions Bd.,
Ottawa, Ontario.

SIR:

The accompanying report supplements the previous one, dated uly 21st, 1917, indicating the changes that have been made, and he method of operation which was in force at the time of closing he plant.

The general methods used in the distillation of Acetone and utyl from this process can be modified in numerous ways and ere in the case of the British Acetones, those which could be ost readily and speedily adapted to the existing plant. The first ortion of the report briefly describes the plant and process with eference to the accompanying flow sheet, the second part deals ortly with the distillation as carried out and with laboratory con-ol methods.

You will observe from the yield and production sheet at the end, at during the operation of the plant a net total of 2,871 short ns of acetone were produced with a yield of 7.76% on dry corn ashed.

I am sir,

Your obedient servant,

D. ALLISTON LEGG.

BRITISH ACETONES TORONTO LIMITED.

FINAL REPORT ON THE DISTILLATION OF ACETONE AND BUTYL ALCOHOL, PRODUCED IN THE WEIZMANN FERMENTATION PROCESS.

D. ALLISTON LEGG.

PART I.

PROCESS AND PLANT LEADING TO PRODUCTION OF "PURE ACETONE."

On completion of fermentation, or when the fermenting liquor has reached a safe stage as regards contamination or on the development of "foaming" the beer is pumped from the fermentation to any of:

FIVE 50,000 GAL. FINISHING TANKS—These are wooden tanks with sheet iron covers and are vented to the air. They receive by pump from the fermenters and deliver to a sump tank in which a stirring gear is provided. The fermentation is allowed to finish here and the beer is then pumped via the stirring sump (this for the purpose of delivering a uniform mixture of head and slop) to either or both of:

TWO BEER STILLS—These are 6 ft. in diameter with 10 plates and 69 boiling caps on each and work in conjunction with a beer heater. Each still can handle about 6,000 gals. per hour of beer and deliver from 600-700 gals. per hour of AB of S.G. about 0.880 and containing about 20-23% acetone, 45-48% Butyl Alcohol, 42-3% Ethyl Alcohol.

Heat is provided by exhaust and live steam.

The AB from these stills passes to either of:

TWO COPPER AB TANKS—These are graduated and the quantity of all liquid withdrawn is measured and an estimation of the acetone and butyl alcohol content is made. On this measurement and on the determination of the content of these tanks at th end of the week, is based the weekly estimate of yield. The AB is rectified in either of:

TWO DISCONTINUOUS RECTIFYING STILLS FOR 1ST RECTIFICATION—Old spirit stills with 37 x 5 ft. column, 24 plates, 7 boiling caps on each. Kettle 13,000 gals. Goose dephlegmator. Steam coil heating.

A typical charge for either of these stills would consist of:

About 10,000 or 11,000 gals. of AB, containing about 20-23% Acetone.

3,000 or 2,000 gals. of A1, containing about 25-30% Acetone.

As soon as the coils were covered gentle heating would be commenced and on the completion of the charging the boiling up would be continued for about 10 hours before draining off any product. The following indicates approximately the results and time of distillation:

	Time taken to run product.	Nature of Product.	Amount of Product.
Heating up	10 hours		
1st A1	10 minutes	Washing out condenser	20-50 gals.
A3	12 hours	Pure Acetone, about	2,000 gals.
A2	1-2 hours	Acetone less than 50 minutes per manganate test, about	400 gals.
nd A1	3-4 hours	Intermediate fraction Acetone—ethyl alcohol—Butyl CB mixture, about	2,000 gals.
1	10 hours	Norman butyl alcohol. CB mixture plus some ethyl alcohol, about	6,000-7,000 gals.
R	10 hours	Butyl plus higher alcohols and butric acid	20-30 gals.

The "Pure Acetone" fraction is run to either of:

4. GAUGING VESSELS—These are 100 gals. each, receive from ther rectifiers and deliver to A2, or if acetone is satisfactory to ther of:

TWO GLASS ENAMELED 4,500 GAL. PURE ACETONE STORAGE AND HIPPING TANKS—From these tanks the pure acetone can be tested in bulk and then racked off by gravity into drums.

The A1 fraction is run to either of:

Two Copper A1 Tanks—11,000 gals. each. Piped so as to receive from tail box of either rectifier and the continuous still, and to deliver by pump to either of the discontinuous rectifiers.

The A1 is an intermediate fraction, rich in ethyl alcohol and containing as well, about 25% of Acetone, some butyl alcohol and small quantities of aldehydes, ketones and secondary alcohols. It is recirculated in the first rectification system.

The A2 is run to either of:

Two Copper A2 Tanks—11,000 gal. tanks, provided with means for stirring and diluting with water. Piped so as to receive from any of the rectifiers and to deliver by pump to the constant level tank of the Badger continuous still.

The A2 is strong acetone but fails to stand a satisfactory permanganate test.

The B1, or butyl water constant boiling mixture passes into:

B1 Tank—This is a copper tank of 13,000 gal. capacity and is provided with triple gauge glasses. The B1 separates into two layers and the top layer overflows into:

B2 Tank—A copper tank similar to the B1 tank and connected by pump with:

B2 Storage Tank—A 1,250,000 gal. steel storage tank. Receives by pump from B2 and delivers to salting plant feed tank.

The bottom layer of B1 or "Weak Runnings" is pumped to beer sump and thence back to Beer Still. The Last Runnings consists of a few gallons of higher alcohols together with esters and acids. It flows into the:

LR Tank—A 400 gal. steel tank from which the LR is racke into drums.

The A2 fraction (when sufficient has accumulated) is dilute in the A2 diluting tank to 25% strength and then passes to th

Badger Barbet Continuous Refining Still—This compris a 13 ft. x 5 ft. and 16 plate exhausting column and a 20 ft. x 4 f concentrating column with 39 plates. A small modern dephlegmator and auxiliary purifying column (not needed) were provided. This still is capable of delivering 75-80 gals. per hour of A3. The small quantity of "heads" is returned to A1 tank. The still delivers into three gauging vessels and then either to the "Pure acetone storage" tanks or back to the A2 tank.

PROCESS AND PLANT LEADING TO THE PRODUCTION OF RECTIFIED BUTYL ALCOHOL.

From the B2 storage tank the Crude Butyl Alcohol is pumped o a:

SALTING DRUM FEED TANK—This is a 2,500 gal. iron tank with auge glasses and feeds by gravity to a:

CONTINUOUS SALTING DRUM—An iron drum about 6 ft. x 2 ft. d provided with plate baffles. This drum is rotated whilst the lt and butyl alcohol are fed in through a hopper and trunion int. The brine and Salted Butyl are pumped to the:

SALTED BUTYL SETTLING TANK—An 18,00 gal. steel tank with uge glasses and an overflow to the:

SALTED BUTYL STORAGE TANK—An 18,000 gal. steel tank from ich the salted butyl can be pumped to either of two still charg g tanks.

The brine from the salted butyl is run to the "Beer sump" and nce to the Beer Still to recover any dissolved butyl alcohol.

TWO CHARGING TANKS—Two 10,000 gal. copper graduated rging tanks which can feed either of the:

TWO BUTYL RECTIFYING STILLS—Old discontinuous spirit stills ft. x 5 ft., 26 plates and three boiling caps in each plate, 7,000 kettle. Goose dephlegmator.

A charge for the Butyl Alcohol rectifying still consists of 7,000 of salted butyl alcohol containing approximately:

Butyl Alcohol	**84-85% by wt.**
Ethyl Alcohol	**6-7% by wt. (including small quantities** of Sec. al-**cohols).**
Water	**8% by wt.**
Ketone	**0.7% by wt.**
Salt (NaCl)	**0.2% by wt.**

The following indicates approximately the results and time of distillation:

	Time in hrs.	**Nature of Fraction.**	**Amount** in gals.
Heating up	**6 hrs.**		
First runnings	**2 hrs.**	**Ethyl Alcohol, ketones, and secondary alcohols into some butyl alcohol**	600-700 gals.
B1	**11 hrs.**	**Butyl water CB mixture and some ethyl alcohol collected. Till S G falls to .815 at 60° F.**	2,500 gals.
B3	**6-8 hrs.**	**Rectified butyl alcohol. About 99% pure**	3,800 gal
Residue	....	**Butyl alcohol and higher alcohols**	150 gal

The first runnings (FR) flows to either of:

Two Copper Storage Tanks (FR)—These are graduate tanks and can receive by gravity from the tail box and deliver b pump to the kettle. The FR on accumulating is redistilled.

The B1 flows to a 2,500 gal. tank and is then pumped back t the salting plant system for re-salting.

The B3 runs to either of:

Six Rectified Normal Butyl Storage Tanks (B3)—9,00 gal. copper storage tanks from which the B3 can be racked int drums, pumped to weigh tank, or delivered to M.E.K. plant.

The residue from the still is pumped to a storage tank and whe a sufficient amount has accumulated it is redistilled.

The First Runnings are redistilled to produce:

FRA 1. Ethyl Alcohol (ketones aldehyde).
FR 2. Ethyl Alcohol, with small amounts of ketones a higher alcohols.
B1 Butyl Alcohol with some ethyl alcohol. Returned butyl rectification system.

PART 2.

LABORATORY AND OPERATING CONTROL IN VARIOUS DISTILLATIONS LEADING TO PRODUCTION OF PURE ACETONE AND RECTIFIED NORMAL BUTYL ALCOHOL.

DISTILLATION OF FERMENTED MASH ("BEER")—On the completion of each fermentation a sample of the beer is taken and the approximate acetone content estimated by the following method:

500 cc. of the beer are distilled till 100 cc. of distillate is obtained. This is diluted to 1 litre and 10 cc. of this solution used for the estimation as follows: 10 cc. of solution plus 50 cc. of N soda plus 20 cc. of N/5 iodine are allowed to stand for 10 minutes. 55 cc. of N sulphuric acid are then added and the liberated excess iodine titrated back with n/10 thiosulphate.

The solutions are from time to time standardised under like conditions against pure acetone. A factor for conversion of cc. of iodine into cc. of acetone per gallon of beer is used.

This method is only intended to be a rapid means of determining the value of a fermentation or the occurrence of contamination in order to control its delivery to the still or its rejection.

It is found that contaminated "beers" yield bye-products including organic acids, aldehydes, and other objectionable products which are evident throughout the whole of the refining process.

The beer still has been briefly described and methods of control are as follows:

The beer is pumped from the beer sump to a header from which by valve control it can be delivered to either of the two stills in any desired quantity, any excess over that required being returned by by-pass to the sump. The beer passes through the beer heater and thence to the stills. The steam and beer feeds are co-ordinated so that no smell of acetone or butyl is detected on the lower plates and so that the S.G. of the condensate is approximately 0.875-885 at 60° F. This liquor is called AB (Acetone-Butyl Alcohol).

The beer stills throughout gave very satisfactory results.

The beer usually contained approximately:

0.7% Acetone.
1.4% Butyl Alcohol.
0.08% Ethyl alcohol.
Traces of other alcohols and ketones.

WEEKLY ESTIMATE OF YIELD—On account of the very rapid passage of the beer through the beer still and of the fact that the volatile constituents are rapidly and completely removed, it is assumed that practically no loss occurs, during this primary distillation. The weekly estimate of gross yield is, therefore, based on analysis of the AB produced.

Before withdrawal of AB for rectification the contents of the graduated AB tanks are mixed and a sample taken for analysis a check sample from the kettle being also taken. By keeping an account of this and by taking stock of AB at the end of each week, the weekly production of acetone and butyl alcohol is easily calculated.

The method of analysis is as follows:

5 cc. of the AB are diluted to 500 cc. with water and 10 cc. of this taken for estimation.

10 cc. of diluted AB plus 50 cc. of N soda plus 20 cc. of N/5 iodine allowed to stand 15 minutes. 55 cc. of N acid added and excess iodine titrated back with N/10 thiosulphate.

From the iodine used the acetone content is estimated.

The "total oil" (butyl-acetone-ethyl alcohol, etc.) is determine from a specific gravity curve obtained from artificial solutions o these constituents in their relative proportions.

By difference the "Crude Butyl Alcohol" content can be calculated.

This method, whilst not of great accuracy, on account of th traces of non-essential constituents is comparative and is rapid.

As regards the main constituents the AB has usually the following composition:

Acetone	20-24% by volume
Butyl Alcohol	40-45% by volume
Ethyl Alcohol	3- 4% by volume
Water	-37% by volume

1ST RECTIFICATION—The stills for this and the approximat amounts of the various fractions have been previously mentione The following method has given the best results:

The column, with the exception of top 6 plates, is left charg with water from the previous distillation. The charge of 13,0 gals. of AB and A1 is boiled up for 10 hours refluxing with t dephlegmater during this period. At the end of this time the pr duct is drawn off and almost immediately is of high purity. T

S.G. is taken at the tail box, and if satisfactory from this point of view, the product is run to one of the four gauging vessels, and the permanganate test is applied before running to shipping tank.

Our experience with this acetone indicates that if the permanganate test is satisfactory the other tests will also be satisfactory, so that this test is the only one used in distillation control.

As soon as a sample fails to stand 50 minutes test, the product is run to A2 tank, this being continued till product fails to stand 20 minutes permanganate test. It is then run to A1 till a test indicates that it contains less than 2% of ketone. This test is as follows:

1 cc. of the A1 is added to 25 cc. of N soda and 10 cc. of N/5 iodine added, the solution is allowed to stand for 5 minutes and then 30 cc. of N acid containing traces of starch and thiosulphate are added. If a blue colour is produced it indicates less than 2% ketone in product, if solution remains yellow it indicates that the ketone exceeds 2%. This test is applied by the still operator.

The remainder of the distillation consists in boiling out the CB mixture at as rapid a rate as possible, as very little fractionation is needed.

The fractions produced in this distillation are:

A1. Intermediate between acetone, ethyl alcohol, and butyl C.B. mixture. Varies from about 98% acetone at start to less than 2% butyl at finish.

Averages about 25-30% acetone and is redistilled with fresh AB.

A2. Acetone of correct S.G. but failing to stand permanganate est. Is redistilled with water in Badger continuous still.

A3. Acetone of correct S.G. and conforming to all other requirements of Government Specification.

B1. Butyl Alcohol-water constant boiling mixture containing bout 5-6% ethyl alcohol. It separates into two layers, the bottom which contains about 8-10% butyl and the top about 75% butyl

B2. Top layer of B1. Contains about 75% Butyl, 6% ethyl lcohol and traces of other alcohols and ketones. Is salted and ctified.

The only times when trouble was experienced with this distillan were when contaminated fermentation, which had only given comparatively small yield of acetone, had been put through the er still. In these cases comparatively small quantities of pure

A3 were obtained, and it was occasionally necessary to treat the A2 obtained with caustic soda or sulphuric acid to obtain a pure product.

REFINING OF A2—On accumulation of about 3,000 gals. of A2, this was diluted with 3 times its volume of water and the acidity just neutralized with soda. The diluted liquor was then fed to the constant level tank of the continuous still and from this via a slop preheater into the exhausting column of the still. Control was by temperature at base of the rectifying column and by purity and S.G. of product attested. This still gave very satisfactory results and needed very little attention.

The only time when trouble was experienced, was when the still was first operated. It happened that at this time bad corn was being used in the fermenters and this apparently lead to the formation of head and tail products which were not very easily handled. The head products were very bad smelling and apparently consisted of very low boiling thioaldehydes, the amounts, however, were so small that they were not easily separated but very markedly affected the permanganate test. When these were removed from the system and better corn was used, good results were obtained.

QUALITY OF PURE ACETONE.

The acetone produced by the Weizmann Fermentation Process is liable to vary slightly according to the quality of corn use and to the presence or otherwise of contaminating organisms i the fermented liquor. Experience indicates that either of thes causes may lead to the presence in the final product of minut traces of vital products which, whilst too small in amount to affec at once the permanganate test to a serious extent, may affe the stability of the Acetone. Some samples retained the sam permanganate test for a number of months after being exposed t light, whilst others have shown a variation after a shorter perio It has, therefore, been our policy as far as possible to ship only th purer fraction and not to attempt to dilute the acetone with pr duct which only just satisfies the specification.

The following may be regarded as an average analysis of o acetone:

Specific Gravity at 15.5° C.	0.7980
Acidity due to CO2	0.0012
Acidity due to Organic Acids	0.0000
Alkalinity to p-nitrophenol	nil
Residue on evaporation	0.0003%
Permanganate Test	2-3 hours

No turbidity on diluting with water.

It is noticeable that acetone produced by this process always leaves on evaporation a slight musty odour.

SALTING OF BUTYL ALCOHOL—Though the B2 or top layer of the constant boiling mixture may be distilled to obtain dry butyl alcohol without salting it is found on trial that the salting, by removing some water halved the number of distillations required to produce a given quantity of rectified butyl.

In practice B2 is salted from 75% dryness up to 90-92% dryness and the brine containing about 3-4% of butyl alcohol is returned to the beer still. Attempts to recover the salt by evaporation were not successful as the salt formed very hard cakes.

Salting with strong brine solution instead of with solid salt is also possible, but does not present on the whole, many advantages as the reconcentration of the brine solution without incrustation s difficult and it does not remove as much water as the solid salt.

The average composition of the salted butyl alcohol is about:

Butyl Alcohol	84-85% wt.
Ethyl Alcohol (including secondary alcohol)	6-7% by wt.
Ketone	0.6%
Water	8.0%
Salt	0.2%

RECTIFICATION OF BUTYL ALCOHOL—This can be carried out by veral methods, including the following:

(a) The top layer of the CB mixture (B2) may be distilled and y water present will be carried off in the first portions of distille in the form of a constant boiling mixture, leaving dry butyl cohol. This may be either pumped from the kettle and cooled, a dirty product is not objected to, or may be distilled off rapidly a clean product is desired.

By this method one only obtains about 30% of rectified butyl ohol from the distillation of a given charge.

(b) The B2 may be salted and distilled as before. In this case one obtains about 60% of rectified butyl alcohol in a single distillation.

(c) The B2 may be passed through a continuous still (our Beer Still would be suitable) the aqueous mixture being removed at the tail box and the dry butyl alcohol being removed from the slop pipe or lower plates of the still. The aqueous mixture could then be separated and the top layer again passed.

At the British Acetones, the second method (b) was adopted, as the stills for this were available and a clean product was required. The still used has been described and the control is briefly as follows:

The charge of 7,000 gals. is heated up, the first 600-700 gals. (found by experience to include most of the ethyl alcohol) being drawn off as FR. The second fraction or B1 taken off till temperature at top of column rose to 115° C. was returned to the salting system. The goose was then cut out and the rectified butyl alcohol rapidly distilled out of the kettle.

The FR1 contains on the average:

Ethyl alcohol	60-65%
Butyl Alcohol	20-25%
Other alcohols (Isopropyl Sec. Butyl)	2-3 %
Ketones	2-3 %

The rest being water and traces of impurities.

The Rectified Normal Butyl Alcohol contains:

About 98-99% n-Butyl Alcohol.
About 1% Higher alcohols.
About ½% Water.

It is water white in colour and has S.G. about 0.810-812 a
21°-15°C.

RECTIFICATION OF FR—Some of the FR has been redistilled wit
elimination of the butyl alcohol and yielding as the main produ
FR2 of following approximate composition:

Ethyl Alcohol	75-80%
Butyl Alcohol	5-10%
Other alcohols about	4%
Ketones	1% or less

The main effect of this distillation is to remove some of t
butyl alcohol which is returned to the salting system and also
remove some of the ketones which came over in the first runnin

YIELD OF ACETONE AND BUTYL ALCOHOL FROM COMMENCEMENT IN SEPTEMBER, 1916, TO CLOSE, NOVEMBER, 1918.

Approx. amount of dry corn mashed =	73,955,000 lbs.
Amount of dry corn distilled =	73,463,654 lbs.
Gross production of Acetone (Acetone estimated in AB) =	6,248,131 lbs.
Net production of Acetone—	
(a) Acetone shipped =	5,575,827 lbs.
Pure Acetone on hand =	154,846 lbs.
A2 on hand =	6,600 lbs.
Estimated in A1 on hand =	4,000 lbs
Total	5,741,273 lbs.

Gross yield of Acetone on *dry* corn mashed =	4.45%
Net yield of Acetone on *dry* corn mashed =	7.76%
Gross yield of Acetone on *dry* corn distilled =	8.5 %
Net yield of Acetone on *dry* corn distilled =	7.82%
Total production of "Crude Butyl Alcohol" =	
Rectified Butyl Alcohol transferred to M.E.K. Plant =	470,743 lbs.
Rectified Butyl Alcohol shipped =	3,044,977 lbs.
Rectified Butyl Alcohol on hand =	379,080 lbs.
Dry Crude Butyl Alcohol shipped =	2,011 lbs.
Dry Crude Butyl Alcohol on hand =	8,290,199 lbs.
Equivalent Alcoholic contents of FR =	462,384 lbs.
Equivalent Alcoholic contents of A1 =	11,440 lbs.
	12,660,834 lbs.

ield of Crude Butyl Alcohol on corn mashed =	17.12%
ield of Crude Butyl Alcohol on corn distilled =	17.23%

OTES:

(a) The totals of acetone and butyl alcohol produced are based on the ounts recorded as shipped in weekly report, *added to stocks on hand* at se of plant.

(b) The gross production of acetone represents the total amounts of etone estimated in AB as reported in weekly reports. The difference been the gross and net estimates of Acetone is not entirely due to distillan losses, as the method of estimation of Acetone in AB is not entirely ecific and includes the partial effect of the ethyl alcohol and of other imrities.

(c) The "Crude Butyl Alcohol" means "dry butyl, ethyl and other alcohols, efly the former."

BRITISH ACETONES TORONTO, LIMITED

STOCKS OF SOLVENT ON HAND NOV. 30TH, 1918.
ACETONE PROCESS.

Acetone.

Pure Acetone in Drums—

234 drums at 660 lbs. per drum =	154,440 lbs.
1 drum at 386 lbs. =	386 lbs.
	154,846 lbs.

A2

10 drums at 660 lbs. per drum =	6,600 lbs.

A1

2,000 gals. at 25% by volume Acetone =500 gals = 4,000 gals.

Butyl Alcohol (Crude)—

	Normal Wet Crude Butyl Alcohol.	Dry Crude N-Butyl.	Dry Crude Normal Butyl.
In large storage tank	913,929 gals.=	833,608 gals.=	6,818,912 lbs.
In No. 14 tank house	216,483 gals.=	170,155 gals.=	1,385,630 lbs.
In No. 2 tank house	12,500 gals.=	9,825 gals.=	79,582 lbs.
Residue from Normal Butyl		750 gals=	6,075 lbs.
	1,142,912 gals.	Total=	8,290,199 lbs.

NOTE—Dry crude butyl includes ethyl alcohol and small amounts of other alcohols and ketones.

Butyl Alcohol (Rectified)—

In No. 2 tank house	45,600 gals.=	369,360 lbs.
In M.E.K. plant—First Runnings (Chiefly Ethyl Alcohol)	1,200 gals.=	9,720 lbs.
		379,080 lbs.

	Wet.	Equivalent Alcohol Strength.
Tank No. 175 FR2	12,580 gals.=	11,477 gals.
Tank No. 176 FR2	11,666 gals=	10,577 gals.
Tank No. 174 FR2	7,312 gals.=	6,617 gals.
Tank No. 190 FR	12,528 gals.=	10,774 gals.
Tank No. 191 FR	8,762 gals.=	7,622 gals.
Tank No. 189 FR2	5,663 gals.=	5,323 gals.
Tank No. 177 FRA1	5,848 gals.=	5,438 gals.
	64,359 gals.	57,798 gals.

This is equivalent to 462,384 lbs. of dry alcohols.

A1 (Acetone-ethyl alcohol-butyl alcohol intermediate fraction).
2,000 gals. at 71.5% volume crude alcohols=1,430 gals.=11,400 lbs.
This is a very crude impure product.

DISTILLATION DEPARTMENT.

APPENDIX.

1. Record Sheets Used in Distillation Department.

2. Specific Gravity Curve for Acetone and Butyl and Ethyl Alcohol in AB.

3. Specific Gravity Curve for Water in Butyl Alcohol.

4. Diagramatic Flow Sheet of Acetone and Butyl Rectification.

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ANUARY

REPORT ON
THE MECHANICAL CONSTRUCTION AND EQUIPMENT
OF THE
ACETONE, METHYL ETHYL KETONE AND ACID PLANTS
OF THE
BRITISH ACETONES TORONTO LIMITED
AT
TORONTO, CANADA.

PART I.

ACETONE PLANT.

E. METCALFE SHAW, WH.SC., ASSOC. M. INST. C.E.
Engineer-in-Chief.
By
J. H. PARKIN, B.A.SC., M.E., ASSOC. MEM. AM. SOC. M.E.
Mechanical Engineer.

ANUARY 31, 1919.

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A REPORT ON THE MECHANICAL CONSTRUCTION AND EQUIPMENT OF THE ACETONE, METHYL ETHYL KETONE, AND ACID PLANTS OF THE BRITISH ACETONES TORONTO LIMITED, AT TORONTO, CANADA.

General Considerations Regarding the Process.—The manufacture of acetone for war purposes as carried out by the British Acetones Toronto Limited is by a bacteriological process, analogous in many respects to the manufacture of alcohol. A starch solution, prepared at Toronto from maize or corn, is inoculated with a certain culture, and the ensuing fermentation yields a beer containing acetone and butyl alcohol, accompanied during the fermentation by the liberation of hydrogen and carbon dioxide gas. The acetone and butyl alcohol are separated from the slop and from each other, and purified by ordinary methods of fractional distillation, presenting few, if any, unusual points.

In the production of acetone by this process the problem of the disposition of the butyl alcohol is a serious one. Two parts of the alcohol are produced to one of acetone, and the demand for it for commercial or war purposes is comparatively small. It has industrial uses, such as in the preparation of lacquers, as a substitute for fusel oil, and others, but these represent a small fraction of the production of butyl involved in the manufacture of acetone by the iological process at the rate practised at Toronto.

As a war measure, the best disposition that can be made of the utyl is to convert it into another solvent similar to acetone, viz.; ethyl-ethyl-ketone, or M.E.K.

The method for the conversion of normal butyl alcohol into ethyl ethyl ketone is fundamentally a catalytic one. The process in three stages, the first and last being purely catalytic, while e second is a chemical reaction offering no difficulties of a chemil nature. There is a plant for the conversion of butyl alcohol into E.K. at Toronto.

Under present conditions the M.E.K. plant is a necessary adjunct of the acetone plant working on the bacteriological process. Unless some use is found in future for butyl alcohol capable of absorbing the large quantities produced, an acetone plant must always include a conversion plant for the butyl.

From the standpoint of solvent production for war purposes, either for cordite or for aeroplane dope, the value of the conversion plant is enormous. It results in practically tripling the solvent production from a given quantity of raw materials consumed, while disposing of a by-product that otherwise would have to be allowed to accumulate during the period of operation, to be gradually disposed of in small quantities afterwards. If doubt exists as to the value of the ketone as a cordite solvent, no question arises regarding its use for dope, and the latter use releases an equivalent quantity of acetone for cordite purposes.

Both the bacteriological process for the manufacture of acetone, and the conversion process for the production of methyl ethyl ketone are new. The acetone process was first tried out commercially, on what was a large scale up to that time, in England early in the war; while the ketone process used at Toronto was evolved solely at the plant of the British Acetones Toronto Limited. Experimental laboratory work was carried on at Toronto with the latter process from the fall of 1916, while active construction work on the large scale plant was begun late in 1917. Investigations have been carried out, and plants of a similar type have probably been built in Europe during the war, but no information regarding th plants, and little with respect to the investigations, has reache Toronto.

Plan of Report—A report on the Cordite Solvent Plant a Toronto may be conveniently divided into two main parts:

Part I. Acetone Plant.

Part II. Methyl Ethyl Ketone Plant.

The part of the report dealing with the Acetone Plant will i clude a section on the acetone plant proper and a section on th Butyl Alcohol Department. The M.E.K. portion of the report w include a section on the M.E.K. plant proper, and a second secti on the Acid Concentrating Plant.

PART I.

THE ACETONE PLANT.

THE ACETONE PROCESS.

The biological process for the production of acetone is a simple one, provided certain fundamental conditions are not violated. The culture, unlike the yeast of the distillery, is anaerobic, and in addition weak and unable to combat even small numbers of foreign bacteria. The conditions imposed, therefore, are:

1. Use of an absolutely sterile mash.
2. As complete a solution of the starch as is reasonably possible.
3. Use of an absolutely sterile system.

If these conditions are perfectly fulfilled the culture works apidly, fermentation being complete usually after from 24 to 30 ours, and the resulting beer on being distilled and fractionated ields approximately 8.4% of acetone and 17.7% of butyl alcohol n a dry corn basis. (These are the average yields for the whole eriod of operation at the Toronto plant, twenty-seven months.)

DIVISIONS OF THE PROCESS—The acetone process may be divided to a number of more or less separate and essential elements or erations, which are:

(a) The preparation of the starch solution.

Where maize or corn is being used as the source of the starch is includes corn storage, grinding and bolting equipment, the ashing and cooking apparatus for mixing the corn meal and ter and boiling the mixture to dissolve the starch, and also to rilize the mixture, (this last is extremely important in this pro- s) and cooling device for lowering the temperature of the boil- starch solution down to a temperature suitable for growth of teria.

(b) The preparation of the inoculant or culture.

This portion of the work is started in the laboratory, and at a tain stage is transferred to the plant, where it is continued to proper point. The plant equipment required for this work in- les various sized closed vessels or tanks, together with the neces- accessories and piping, etc. The piping and tanks must be olutely bacteriologically gas tight.

(c) The fermentation of the starch in solution during which the acetone and butyl are produced.

For this portion of the process closed sterile tanks are required, provided with the necessary fittings and instruments for carrying on fermentation, watching progress and safeguarding the tank.

(d) The distillation of the beer resulting from the fermentation, first separating the acetone and butyl from the corn and starch waste, then separating the acetone and butyl, followed by their rectification or purifying. Ordinary alcohol, beer and rectifying stills may be used for this purpose.

(e) The various auxiliary elements which while not forming part of the process proper are essential to the working of the process.

These include the steam generation equipment requiring boilers, with the necessary coal handling and storage equipment, and engines or prime movers of some kind where power drive is required, provision of water, the shipping equipment for the finished product, and the handling equipment for fluids in process.

There are therefore a number of essential pieces of apparatu or equipment which must be provided for the carrying out of th process, each piece or element having definite and necessary functions to perform. Briefly, these essential pieces are:

ESSENTIAL PIECES OF EQUIPMENT.

(a) *Mill.*—Where maize or corn is being used as the ra material the function of the mill is to grind the corn to the prop degree of fineness, and separate the meal from the bran. Muc coarser meal can be used than in the production of alcohol.

(b) *Mash Tubs.*—The function of the mash tub at Toronto to mix the corn meal with the water, producing a homogeneo mash, which is then brought to the boil. These tubs need not closed, air-tight vessels. The main requirement is prevention "lumping" of the meal when mixing. It is possible (and this often done) to combine the mash tubs and cookers (referred next) in a single element or apparatus.

(c) *Cookers.*—The function of the cooker is two-fold; first, t boiling of the mash to dissolve as far as possible the starch, a second, the sterilisation of the mash. The first must be so do that the starch is not over-cooked or caramelised, and the seco involves the penetration and if possible the bursting of every starch cell by the steam in order to secure perfect sterility, which is absolutely vital.

The cooking may be carried out in any of several ways, a long period of cooking under low pressure or a short period of high pressure cooking, followed by the sudden release of the pressure in order thereby to burst the cells into which the steam has penetrated during the cooking. A combination of these two may be used also, a short period of high pressure cooking with explosion down to a lower pressure, followed by a reduced period of low pressure cooking. The degree to which the dissolving of the starch s secured is one factor determining the ultimate yield of acetone per pound of corn.

(d) *Coolers*—There are two methods by which the heat may be emoved from the mash after cooking to lower its temperature o that best for propagation or development of the bacteria.

1. *Cooling in Situ*—That is, cooking, cooling and fermenting in single tank. This is the method employed in the Naval Cordite Factory at Poole at first (see report by Arthur E. Hadley of 1916). t is exceedingly slow and inefficient in that long periods are occupied in the cooling process which might be employed to better dvantage on the fermentation or cooking processes, to which the nk is better adapted.

2. *Cooling in a Separate Cooling Device*—This is the method dopted at the start at Toronto, to which in a large measure the uccess of the plant is due. The application of this system necessitated the invention and development of a new form of high efficiency heat transmission device adapted to bacteriological processes. xisting heat transmission apparatus was inefficient and in many ses unsuitable to the work of this process. Properties necessary desirable in addition to high efficiency owing to quantity of heat be removed were self-cleansing, i.e., freedom from choking or ling with mash, durability (the process is continuous and breakdowns and interruptions cannot therefore be permitted), ready rilisation, avoidance of pockets and recesses in the mash passages, and absolute tightness both mechanically and bacteriologically. This last is perhaps the most important feature, and the e which resulted in the rejection of most stock patterns of apparatus.

The apparatus evolved at Toronto fulfills all these conditions perfectly, and in addition is inexpensive to build and has an exceptionally high efficiency.

(e) *Inoculant Vessels*—The growth of the inoculant during the early stages should be in a series of small vessels of increasing size, which reduces the time during which the fermenter proper is required for a given fermentation and also the loss should the original culture be contaminated.

The inoculant equipment included a series of closed air-tight vessels of different sizes arranged in series from the small ones to the large ones. Their function is a combination of those of cooker, cooler and fermenter (about to be referred to). Mash is cooked in these vessels, cooled, inoculated,—each tank being inoculated from the one next smaller, the smallest being inoculated from the laboratory, and after the proper period of fermentation used to inoculate the succeeding tank, the largest tank inoculating a fermenter. The relative sizes of the tanks of the succeeding groups or stages depend upon a number of factors. It is recommended that for the best results the inoculant should be 3% of the mash inoculated. This does not mean necessarily that succeeding stage vessels should each be 33 times as large as the preceeding one.

The inoculant from a vessel may be divided between two or more tanks, or on the other hand the inoculant from one, two or more vessels may be used to inoculate a single tank. The larger the quantity of inoculant relatively to the mash inoculated the quicker the fermentation. The sizes of the succeeding tanks are dependent on questions of operation, period of fermentation, rate of working, size of plant, size of fermenter, together with the manufacture element. From this it will be apparent that the size are largely determined from bacteriological data.

(f) *Fermenters*—The fact that the yield of acetone per poun of corn meal is small, coupled with the second fact that up to th present the maximum density of mash permitted by the bacteriologist has been 10%, means that in order to secure appreciable yield from fermenters the tanks must be of large size, and the anaerobi nature of the bacteria necessitates a closed tank. The ferment therefore should be a large capacity closed tank, and its function to contain a large bulk of mash and inoculant, protecting it fro foreign bacteria while the inoculant develops, while relieving itse of the gases generated during the fermentation. Added to th must be the possibility of thoroughly sterilising with as great speed as possible. For rapid sterilisation high temperature is necessary, for high temperature in steam, high pressure, and for high pressure a strong tank to withstand it. Tanks of the size employed for fermenting are not usually built to withstand high pressures, if any, so that the period of sterilisation is lengthened accordingly.

Another point in connection with high rate of working of fermenters is the desirability of a cone bottomed fermenter, with the inlet, outlet and inoculation connections combined in the one at bottom of the cone. This construction greatly facilitates emptying, strengthens the tank, and secures a more thorough mixing of the inoculant and mash and resultant speedier fermentation.

(g) *Stills*—The function of the stills is to separate the acetone and butyl from the beer, from each other, and to purify them, that is, rid of water and impurities. The first separation from the corn waste and slop presents no difficulties and is readily carried out in a beer still of less than the usual number of plates. The production of the pure acetone from the first distillate may be easily accomplished in a single rectification in standard discontinuous alcohol type rectifiers.

(h) *Storage*—Storage is required for the fluids and distillates n process and for the finished products, owing to the discontinuous ature of the operations and the varying rates of working and hipping. Sufficient capacity must be provided to take care of all ventualities, it must be provided where danger from fire or damge to tank is at a minimum, of such a material as in no way to have deleterious effect upon the liquid contained, and of such a form covered) as to prevent excessive evaporation (the liquids are very olatile) or fouling of liquid from outside.

(i) *Piping*—Piping is required for the conveyance of the varius liquids from point to point during the process. The pipes must st of all be tight, and in the case of the mash and inoculant pipg this is absolutely vital to prevent contamination, while in the se of the inflammable distillates the fire risk resulting from leaks obvious.

The pipes must be of suitable materials to resist corrosion by e liquid conveyed.

Pipes (and tanks) used for mash or inoculant must at all times maintained under live steam pressure.

Valves or cocks should be tight and of suitable material to withstand liquids. This is of particular interest with regard to the composition discs of globe valves. For the bacteriological piping no cock should be used, and valves should always be considered as of doubtful tightness and safeguarded by having steam on one side of them. Pumps may be of either the centrifugal or plunger type of standard stock patterns. No difficulty is experienced through leaks in the pumps, either mechanical or biological. The pump dealing with mash should preferably have large valves, and care should be taken to provide pumps made of materials not affected or corroded by the liquids to be pumped.

(j) *Boilers*—Boiler capacity sufficient to supply steam for sterilising tanks and pipes, for the stills and rectifiers, and for the various pump and other equipment is necessary. The pressure of steam employed will be determined by the strengths of the tanks, and it is wise to safeguard the tanks by so connecting them that steam of a pressure not greater than their safe working strength is admitted to them. As a matter of economy and heat efficiency all exhaust steam where practicable should be collected in an exhaust steam system and used where possible, as in mashing and beer stills. This may involve a three-pressure system, high for pumps, intermediate, for tanks, sterilisation, and exhaust, for stills and mashing.

CONVERSION OF A DISTILLERY—The acetone process being a bacteriological one resembling in many respects the manufacture of alcohol, the obvious and logical place to carry on the manufacture (other than building a new plant, which is to be avoided in wa time) is in a distillery. This is true because of the similarity o the fermenter processes, and further because of the stills, whic can be employed for acetone work practically without modificatio On the other hand, the fact that the acetone process is anaerobi introduces a distinct point of difference since the alcohol fermentation is aerobic and is carried out in open tanks of wood or stee

DESIRABLE POINTS IN DISTILLERY FOR CONVERSION—In examining a distillery with a view to its conversion into an acetone fa tory working on this process, the essential requirements in the wa of equipment are cooker capacity, fermenter capacity, stora capacity and boiler capacity. With these essentials the problem conversion is greatly simplified and involves chiefly changes in t tanks (covers) to render them air-tight, provision for apparat for inoculant production, cooling, and re-arrangement of piping. These essentials are seldom all present in a distillery, and the most suitable distillery for conversion is the one which requires least additions to secure the necessary essentials and in which the additions and alterations can be most readily made.

PLANTS TO BE CONVERTED—The plant placed at the disposal of the Imperial Authorities by Messrs. Gooderham & Worts and the General Distilleries Limited included at first the whole of the plant and equipment of the General Distilleries Limited and certain parts of the distillery of Messrs Gooderham & Worts. The former was a plant for the production of industrial alcohol from molasses, while in the latter whiskey was made from grain (see drawing 408). The portions of the latter plant originally placed at the Government's disposal included only milling and mashing facilities. These, through the patriotism of Messrs Gooderham & Worts, have gradu- lly been extended until practically the whole of the very extensive plant of the distillery has been taken over.

An examination of these plants showed that ample facilities for the rate of production then contemplated existed for corn and coal storage, steam production, mashing, distillation and storage, and the chief alterations or additions necessary were the covering of the fermenters, construction of cookers from yeast tubs and con- truction of coolers.

PRINCIPLES UNDERLYING TORONTO PLANT—In planning the pro- ss and its various details to be carried out at Toronto certain ecisions were arrived at and fundamental principles laid down as asic or underlying the whole proposition. These have been rigidly dhered to throughout, and on them the success of the plant has timately depended.

MASH VS. WORT—The first point to be settled was whether wort om malted barley or mash from crushed maize or corn was to be ed for the fermentation. Various factors affect the decision to be de, those in favour of the mash being the greater yield from the sh, the greater cost involved in the use of barley and of malt- g, while favouring the use of wort are the ease of handling the ar wort as compared with the thick mash, the difficulty of cool- g the latter and maintaining sterility, and the percentage of ids retained for cattle food when working with wort as compared with the absolute destruction (with exception of the bran) involved when using mash. A study of these various factors in regard to local conditions resulted in a decision in favour of the use of mash. This involved a departure from the method then in use at Poole, where wort made up of 1 part grain to 15 parts water by weight was in use, the grain comprising 86-90% crushed maize and 10-14% malted barley.

SEPARATION OF COOKING, COOLING AND FERMENTING—At Poole the wort was run into tanks and cooked, cooled and fermented all in the one tank. At Toronto these three operations are carried out in three distinct pieces of apparatus, which can thus be properly designed and constructed to carry out their respective operations more efficiently, resulting in greatly improved working of plant from all points of view.

The use of separate cookers of small size permits a higher steam pressure to be employed and more rapid and perfect cooking and sterilising

The use of a separate high efficiency cooler, as compared with the system at Poole of cooling the wort by means of huge iron cool ing coils in the tank, results in reducing the time of cooling from many hours for the 12,000 gal. charge of wort at Poole to tw hours for the 28,000 gal. charge of mash at Toronto.

There is also the great reduction in cooling water required, th greatly increased temperature of the cooling water leaving, enab ling it to be used for other purposes (mashing, boiler feed, etc.), an the elimination of the coating collecting on the coils when the latte are placed in the tank.

The use of the fermenter for fermenting only permits the tan to be properly constructed for this service alone, with the resul ant reduction in danger of failure through contamination, etc while improving the duty of the tank.

POSITIVE SYSTEM—Working with an anaerobic culture the u of the positive system has been a principle which in a large mea ure has resulted in the success at Toronto, enabling 3,480 fermen ers to be fermented without a failure.

By positive system is meant one in which the pressure is alwa from the inside outward, effectually preventing the entrance foreign bacteria. Vacua are carefully avoided at all times ever where. The positive pressure is secured by maintaining all tan and pipes under steam pressure when not in use, coupled with frequent flushing out with sterile water and steaming under high pressure. This ensures that whatever leakage occurs is of sterilised liquid or gas outwards from the system, while no ingress of unsterilised gas, air, or liquid can occur. The remaining danger is that of bacteria "growing" back into the system through a leak or leaky valve filled with mash. To overcome this danger, the use of plug cocks is under no circumstances permitted and valves are always considered as of doubtful tightness bacteriologically, and are safeguarded wherever possible by means of the "steam lock"—two valves with steam admitted between, or steam jet on the gate.

Fermenter Protection—The protection of the fermenter from a bacteriological point of view, that is, against contamination and mechanically against collapse or bursting, is of importance. Where fermenters are large and of light construction capable of withstanding only slight pressures, and much less vacua, the problem is rendered more difficult. Protection bacteriologically is carried out by maintaining steam on the outside of all pipe connections to the tank, by protecting valves through which air is drawn into tanks, as when cooling, by means of a large cotton-wool filters and by venting the gas generated through antiseptic water and discarding all commercial forms of vacuum and safety valves, owing to the impossibility of preventing contamination working into the tank through them. Mechanically the tanks are protected by specially designed vacuum valve and safety valve. The former is of large size and operates on a very slight vacuum, while the latter is in the form of a special safety device of the antiseptic water seal type, combining with its function as safety valve relieving at a small pressure other functions, including gas measurement, free gas outlet or foam overflow. The long continued run of successful ermentations at Toronto dates from the commencement of the se of the safety devices.

Mechanical Difficulties—The application of the principles bove enumerated, together with the fact that an existing plant as being converted into a new though somewhat similar use, and e inflammable nature of the product, was the cause of a number difficulties encountered in the work.

Difficulties Due to Application of Principles—The provis- n of the numerous steam connections and drains necessary to apply properly the positive principle to the system has resulted in a great multiplicity of piping. The use of structurally weak tanks rendered it necessary to work on very small margins of pressure in the system.

The handling of the thick mash (10% solids) necessitates the use of pumps with large valve area, constant regular flushing out of lines, and the protection of various instruments, pressure gauges, water gauges, venturi meters, etc., from choking. The former are protected by diaphragm, the water gauges by using extra large size glasses and providing for frequent blowing out with steam and venturi by inserting mash catching drums between the tube and recorder.

The maintenance of sterility, with frequent steamings and coolings, required special provisions with respect to these instruments, also in order that their connections might be sterilised.

Valves and cocks were a constant source of trouble through minute leaks, which was only finally eliminated by the use of the steam seal.

The rapid cooling of the mash, the amount required and the rate necessary was a serious problem finally solved by the construction of the present coolers.

The production of the inoculant, with the extreme care necessary in handling it, was a prolific cause of trouble through contamination when supplying first inoculant, leaks of many kinds, and lack of homogeneity in the inoculant.

Indication of the mash level in tanks proved difficult until the use of large diameter steam washed gauge glasses was introduced.

DIFFICULTIES ARISING OUT OF CONVERSION OF AN EXISTING PLANT—The adaptation of open alcohol fermenters to an anaerobic fermentation requiring absolute sterility necessitated the use of very low pressures, which required increased care in protecting and handling the tanks.

The tanks being comparatively flat bottomed were slow in emptying, which led to considerable investigation in an endeavour to speed up the emptying.

At the beginning the valves and fittings of the pipe systems were in bad shape and caused trouble through contamination.

The adoption of much of the original distillery piping without change ultimately resulted in a very complicated and in some cases awkward arrangement.

Difficulties Due to Inflammable Nature of Product—Not only is the product inflammable and volatile, but the gas produced during the fermentation, hydrogen, is also highly inflammable, and both these facts necessitated provision of adequate precautionary measures against fire.

PRODUCTION AND CONSUMPTION DATA.

Acetone—The plant at Toronto during the actual production period from August 18, 1916, to November 19, 1918, twenty-seven months, produced 5,703,385 lbs. or 2,851 short tons of acetone, while that shipped was 5,575,827 lbs., or 2,787 short tons. Of this production 3,524,540 lbs., or 1,762 tons, were produced during the 10½ months of 1918, or at a rate of over 2,000 tons per year. The maximum monthly rate attained was in October last, when from October 1st to 29th, 390,968 lbs., or 195 tons, were produced. The best week's production was that for the week ending October 29th, 1918, of 100,016 lbs., or 50 tons; this is at the rate of 2,500 tons a year, just 10 times that originally expected from the plant.

Butyl—The butyl production during the whole period has been 11,014,854 lbs., or 5,507 tons, of which 3,044,977 lbs. have been shipped as rectified butyl; 236,155 lbs. of rectified butyl are on hand, and 7,733,762 lbs. were "in process"—that is, in storage as crude, unsalted butyl (containing about 25% water).

Corn—A total corn consumption (wet meal, average moisture content 15.4%) of 86,547,000 lbs. has been made, or the pounds of corn per pound of acetone over the whole period is 15.2, while if the period since the last rejection only be considered this drops to 14.6 lbs. per pound of acetone.

No corn has been lost since April 13, 1918. Up to that time 421,000 lbs. of corn had been rejected out of a total of 7,534,875 mashed, or 5½%. The percentage loss over the whole period of operation is 0.48%.

The total number of fermenters put through was 3,958, with a total rejected of 25.

Coal—The coal consumption has been 92,878,742 lbs., or 46,000 tons up to the stopping of production, which means 16.3 lbs. of coal per lb. of acetone over the whole period of operation, or 14.0 lbs.

of coal per lb. of acetone for the period since the last rejection. The ratio of coal to corn has been steadily decreasing. In 1916 and the early part of 1917 twice as much coal as corn was used. This was gradually reduced during 1917 by improvements in the power department, until during the winter of 1917-1918 the amounts were equal, a ratio of one to one. From March of 1918 until July the coal consumption continued to grow less than the corn, reaching a minimum of 73% for the week ending July 2nd. After this the operation of the M. E. K. plant began to increase the coal consumption as compared with the corn.

ORIGINAL PLANT—The plant of the General Distilleries Limited which has been converted into an Acetone plant was one manufacturing industrial alcohol from beet and cane sugar molasses—see drawing 408.

The plant comprised distillery proper, filter room, boiler room, store house, and three large outside storage tanks.

The principal equipment consisted of nine 31,800 gal. open steel fermenting tanks, four 7,500 gal. yeast tanks, four 625 gal. second and five 128 gal. first yeast tubs. There was a 6 ft. diameter by 42 ft. long beer still, and two 13,000 gal. discontinuous copper rectifiers. Two double effet evaporators were in the distillery proper. There were also numerous copper spirit storage and weigh tanks.

The filter room contained a battery of 32 heavy cast iron charcoal filters.

A boiler capacity of 1,200 H.P. of Babcock & Wilcox boilers was contained in the boiler house.

The outside steel storage tanks, three in number, had an aggregate capacity of 1,875,000 gals.

For a detailed description reference should be made to the Report on the Acetone Plant of July 14, 1917, by E. Metcalfe Shaw.

This plant, as outlined above, has been converted into an acetone plant, working on the bacteriological process, capable of producing 2,500 tons or more per year of acetone. A full description of the construction of the new acetone plant is given in this report.

THE ACETONE PLANT—MILLING AND MASHING.

ELEVATOR—The Grain Elevator (see album pages 12-16) at the plant is of obsolete design of the bulk storage type. The building is of corrugated iron clad timber construction 118 ft. x 216 ft.

28 ft. to the eaves, with a storage capacity of from 800,000 to 1,000,000 bushels of grain in the main storage. At one end are four smaller bins with an aggregate capacity of 50,000 bushels. Unloading from railway cars is provided for at one end, where are located the car hauling gear, power shovels and elevator, while at the other end marine unloading gear was originally installed but has long since been dismantled.

The elevator was originally driven from a small separate steam power plant with rope drive, which has now been replaced by an electric drive through belts.

The elevator is seldom used in the ordinary course of operations. When corn is being received at a uniform rate it is unloaded directly at the mill, but if through freight congestion or other cause cars arrive in large numbers the excess corn which cannot be taken care of at the mill is unloaded at the elevator.

The elevator is principally used in the fall to accumulate a reserve stock of corn in order to be prepared for freight tie-ups during the winter.

MILL—The Mill (see album pages 24-28) is of a very early type (1859) of heavy masonry and timber construction.

The grinding is carried out by eight run of stones (54" diam- er, French burr) and ten steel rolls (9" diameter x 30") the lat- r dealing with the bran and "coarse middlings". Bolting capacity provided in five gyrating scalpers and one round reel; two addi- onal reels await installation. The scalpers are equipped with 14 nd 18 mesh screens. Grain storage is provided in bins in the ill of an aggregate capacity of 23,000 bushels, and corn meal orage capacity of 176,000 lbs., which is equivalent to 44 mash tub arges, or 7-1/3 fermenter charges.

The mill machinery is driven by a 28" x 60" single cylinder hori- ntal steam engine fitted with Brown valve gear. The engine erates under 60 lb. steam with 28½" vacuum, and develops 500 P. at 60 r.p.m.

The engine drives through mortised tooth (wooden) gear eels the stones and countershafts, from which the machinery of e mill is driven by belts. The engine also provides power for chinery in the Mash Department.

The bran from the corn is blown by a fan through 200 ft. of 12" e to the bran storage in the former malt house for sacking and ing to farmers for cattle food.

The mill has been operating normally 24 hours per day, 6 days per week, grinding about 4,000 bushels per day, but has a maximum capacity of 4,800, equivalent to 370 mashes per week as compared with a maximum so far attained of 300 when doing ten fermenters per day.

MASHING—The Mashing Department of the plant is situated in the same building as the mill, and is equipped with four wooden mash tubs (see album pages 29 and 31).

The charge of cornmeal for the tubs is weighed in a hopper car under the meal bins and discharged through chutes and feeding mechanism into the top of the tubs.

The tubs are of cyprus 16 ft. average diameter and 5' 6" deep, fitted with a 2½" diameter by 4' 0" long steam sparger and four concentric steam heating coils containing about 750 ft. of 2½" O.D. x 16 gauge copper tubing, with an approximate heating area of 490 sq. ft.

Three of the coils operate on exhaust steam (4 lb.), and the remaining one and the sparger on live (60 lb.) steam. The bottom portion of the latter coil is perforated, permitting the condensate to pass directly into the mash. The tubs are fitted with a heavy mixing rake driven from below through mortised wheels and shafting from the mill engine.

There are two water supplies to the tubs, hot and cold, both city (potable), the hot coming from the mash coolers.

OPERATION OF MASHING—The tub is filled to a depth of 37 corresponding to 35,000 gals. of hot water at a temperature of 140 If hot water is not available, cold water is used and heated by liv steam, and if the water is too hot, cold water is run in to secur the proper temperature.

The rakes are then started, the 4,000 lb. charge of meal sifte in, and the steam turned into the coils. The mash on reaching 21 has increased in volume to 46", or approximately 4,500 gals., an is pumped up through the digester to the Fermenting Departme

With this equipment it usually requires six minutes to fill a tu with water, seven to ten minutes to sift in the corn charge, 35 to minutes to bring to the boil, and 12 to 15 minutes to empty, a tot of from 63 to 71 minutes. The maximum speed of operation far attained of ten fermenters per day requiring sixty mash allows 96 minutes to a mash using four tubs, and no margi

There is thus a nice margin when working with four tubs, and the plant is enabled to operate on three tubs (72 minutes) in case of breakdown of a tub.

MASH PUMP—The mash is withdrawn from the tubs through a 5" W.I. pipe by means of a 14" x 10¼" x 10" duplex steam pump on the ground floor below the tubs, so situated that there is a minimum static head on the suction of 10 ft.

The suction piping is at present round-abount with a length of about 100 ft., owing to developments which have taken place in the plant. The pump is controlled from the mash floor, and is fitted up with a 4" relief by-pass between discharge and suction. The pump operates against a head of 35 lbs. normally, and discharges through a 5" W.I. pipe vertically some 25 ft. to the digester.

DIGESTER—The Digester (see album, page 32) consists of five lengths of 5" pipe arranged in hairpin bends 13 ft. long each, into which are welded thirty-four ½" steam nozzles. The nozzles are ½" W.I. pipe bent through 90° to a point downstream, constricted at the tip and drilled out to form a smooth ⅜" nozzle. The nozzles are inserted alternately on the centre line and 1" off the centre line of the pipe, and are arranged in three sets of groups, each supplied with either 60 lb. or high pressure steam through 1½" feed lines controlled on the operating floor (see album, page 31).

A pressure gauge and recording thermometer connection are tapped into the last bend of the digester, the instruments being located in a convenient position on the operating floor.

ACTION—The mash being pumped through the digester has live steam injected into it, raising its temperature from 212° to an average temperature of 240°—a 30° rise in temperature—which means that at the ten fermenters per day rate 84,000 B.T.U. per minute are being supplied to the mash by the digester, with a steam consumption of 86 lbs. per minute. The additional temperature secured by the use of the digester provides cooking heat in the long pipe line to follow, and the jets from the nozzles placed on and off centre churn up and violently agitate the mash, while imparting a swirling motion.

This arrangement of digester and controls enables the condition of the mash leaving the mashing department to be perfectly regulated. The pressure gauge and recording thermometer are in front of the operator at the pump and digester control valves, and he is thus enabled to maintain a temperature at the proper point. The chart from the recording thermometer shows temperature variations only 10° either way, the mean temperature being 240° and the pressure 28 lbs.

MASH LINE DIGESTER TO COOKERS—From the digester a 5" W.I. mash line runs some 400 ft. across roofs, in the open air but heavily lagged, to the Fermentation Department. The steam digester followed by the long mash line ensures that the mash is treated at a high temperature, coupled with violent agitation and mixing occasioned by its rapid passage through the pipe during the 70 seconds required for it to pass through the pipe (300 g.p.m., 5" pipe, 400 ft. long). This action results in the grains of corn and starch cells being very thoroughly broken up and penetrated by the steam, so that the line has an appreciable value as a cooker and gives practically complete sterilisation.

The drop in pressure in the mash line is from 20 to 25 lbs. and in temperature about 2 to 4°.

At the cooker end of the mash line (see drawing A383) there is provided a special 5" exploding valve discharging into the east or No. 4 cooker (this valve forms part of the continuous cooking system). A 3" drain and a 4" branch to the cooker filling main (see album, page 48), a pressure gauge and recording thermometer are also provided to indicate the condition of the mash and act as a check on the mash operations.

The cooker filling main is provided with a sleeve expansion joint between Cookers No. 2 and No. 3, a 3" drain at the end, and 4" branches from it enter the cookers about 3 ft. from the bottoms. The branches are provided with gate valves controlled by extension handles from the floor above, and a swing check valve to prevent back flow from the cookers.

COOKING.

COOKERS—The Cookers (see album, pages 47 and 48, drawing A381) are closed, steel, vertical cylindrical tanks 12 ft. diameter x 12 ft. high, 7,500 gals. capacity, with flat bottoms and domed heads, tested to 22½ lbs. static pressure, and normally operated at 15 lbs.

The tanks are provided with simple steam stirring gear, safety and vacuum valves, pressure and water gauges, the latter especially large and provided with steam cleaning connection and two outlets.

Outlet to Coolers—The principal outlet is a 5" mash outlet from the bottom into a horizontal mash header under the cookers eading to the cooler pumps (see drawings A384 and B385). Each utlet is controlled by 5" gate valve, and there is tapped into the utlet above the valve a ½" high pressure steam connection for ealing the valve against contamination and boiling up the mash ocketed in the outlet on top of the valve. The mash header is pro-ided with a 1" 15 lb. steam sterilising connection at the dead end.

Outlet to Seed Tanks—The second outlet is from the centre of he bottom of each tank and is 4" in diameter connecting into a 4" eed tank charging header. A special steel bowl casting is riveted the centre of the bottom of the cooker, and is tapped with a ½" eam connection for the same purpose as that in the other outlet. The second outlet branch is provided with two valves, a gate and globe valve, between which is tapped a ½" 15 lb. steam connec-on, thus providing a steam lock against contamination when both lves are closed.

Seed Tank Charging Header—The seed tank charging header provided with a 1" 15 lb. steam sterilising connection and 3" ain at the dead end, and at the outlet or west end with a gate lve and check valve set to prevent back flow to the cookers, be-nd which the 3" W.I. seed tank charging line rises to the seed nks (see drawing A388). A steam locked 1" drain is provided tween the two valves, and there is a 3" drain on the seed tank e of the check valve.

Process of Cooking—The mash is received at the cookers at a essure of from 10 to 20 lbs. and a temperature of 236° to 238°. e recording thermometer at this end of the mash line traces a ch more uniform temperature record than that at the other d. A cooker is charged with one and a half mashes, 6,900 gals., uiring from 20 to 25 minutes to pump in. The cookers are filled sequence. The mash is cooked for 1¼ hours at 15 lbs. pressure, ng steam forced in through the stirring device, which is also asionally rotated to prevent settling of the mash.

On completion of the cooking, *i.e.*, when the sample tests sterile, the mash is pumped out through the coolers, steam is applied to the top of the mash through the upper gauge glass fitting during emptying to assist in the emptying and also to clear the gauge glass of mash. It requires from 30 to 35 minutes, depending upon the season of the year which affects the temperature of the cooling water, to empty each cooker, and the cookers are emptied one after the other, the pumps and cooler operating practically continuously.

The inside surfaces of the cookers gradually become coated with a layer of mash, particularly the tops from splashing, so that once every two weeks (Sunday) the cookers are opened and cleaned. This is done by thoroughly scrubbing and scraping down the surfaces and finally washing down with hose.

COOLING.

The cooling equipment consists of a battery of specially designed mash coolers and two cooler pumps, which are situate under and south of the west two cookers (see album, pages 61, 6 and 63, and dwg. A389).

PUMPS—The two cooler pumps are a 10 x 7 x 12 an a 10 x 13 x 17 duplex steam pumps with extra large valves to a commodate the mash. The pumps are arranged in duplicate in ca of accident, and are supplied by the 5" cooker emptying heade and so situated that there is at least 8 ft. head on the pump suctio It would be impossible to handle the mash under these conditio without a head on the suction. The suction line to the pumps is a ranged with a 2½" drain, and each branch to a pump with a ½ steam sterilising connection. Connections are further provid for drawing sterile water (condensed steam) from a sterile wat tank through a 4" suction, or caustic soda solution from a stora drum through a 2½" line. The former is used for flushing out p poses, and the latter for cleaning deposits from the cooler co (see dwg. A289).

The pumps discharge through short vertical 5" pipes tapp with ½" steam sterilising connections into the hot mash hea to the coolers.

COOLERS—The coolers are of the Shaw copper wriggle t type (see album, pages 49, 59, 60, 61, 62, and 63, and dwgs. N

A389 and A403). The coolers were evolved at this plant and give complete satisfaction. The design of the coolers renders them peculiarly adaptable to this process, where high duty, self-cleansing and absolute tightness, bacteriologically as well as mechanically, are vital, and where small bulk, durability, minimum of attention, are of importance.

There are three units, only two of which (Nos. 2 and 3) are now used, the third (or No. 1) being of an obsolete type. Coolers Nos. 2 and 3 are each made up of five cast iron boxes, each about 12" x 12" x 10 ft. long.

Four headers, hot and cooled mash and hot and cold water, are placed in front of the coolers, from which the mash and water branches are taken off to the coolers, which are connected in parallel. Three of the headers are placed above the coolers, and one on the floor. From the 5" hot mash header from the cooler pumps " W. I. branches are taken off to the coolers, and 3" outlets from the coolers connected into the 5" cooled mash header.

The cooled mash header, which contains a 4" x 2" venturi meter tube and recording thermometer, connects into the fermenter mash r filling main (see dwg. 388).

A 2" inoculation line from the seed tanks is tapped into the cooled mash header between the venturi and the mash main. The cooling water supply header from the municipal system is 4", and from it 4" branches lead to the cooler units, and from the last cooler box 4" outlets pass to the hot water header on the floor. From this latter header the hot water is drawn by a 12 x 10 x 20 and a 7 x 8 x 12 single plunger pumps, and pumped to the various points about the plant where the hot water is used.

OPERATION OF COOLING—The hot mash from the cookers at temperature of 245° (15 lbs. pressure) is pumped continuously through the two coolers in parallel, keeping the cooled mash temperature at the point set by the bacteriologist, generally about 98°. The cooling water inlet temperature varies from 35° to 70°, depending on the season of the year, and the outlet temperature s from 160° to 180°.

At the ordinary average rate of working a cooker of 6,900 gals. mash is cooled in 30 to 35 minutes, which means that the maximum rate of heat transfer is 20,140,000 B.T.U. per hour, with exit temperature difference between cooled mash and cold water only 58°. The rate of heat transfer is practically 685 B.T.U.

per square foot per hour per degree temperature difference, which is exceptionally high, more especially when the nature of the mash to be cooled is considered.

Twice every 24 hours the entire mash system, including the coolers, is sterilised with steam for one hour. The coolers are first flushed out with some 1,400 gallons of hot, sterile water, then blown out with high pressure steam, and sterilised for the remainder of the period under low pressure steam. Provision is made for sterilising the coils by tapping the mash outlet connection of the coolers for a ½" steam connection, and the inlet connection for a ½" drain.

The duty of the coolers is found gradually to fall off during the week's operation, owing principally to a slow accumulation of deposits on the surfaces, and to remedy this every Sunday as soon as the normal operations are concluded a solution of caustic soda (50 to 60 lbs. in 80 gals.) is pumped through the tubes. The soda is circulated through the tubes for the whole of the time available before starting operations again. Occasionally the soda is also pumped through the outer or water passages to keep the outer surfaces of the coils in good shape.

INOCULATING ARRANGEMENTS.

(See dwgs. A207 and A402.)

OUTLINE—The production of the inoculant is carried out three stages in the plant, from the laboratory flask to the ferme ter; in culture vessels, inoculators and seed tanks. The two form are located in the Culture Room on the fourth floor of the Distil tion Building, and the latter in the Seed Tank Room on the thi floor, below. (See album, pages 40 and 44.) There is thus grav flow from the culture vessels and inoculators to the seed tanks a to the fermenters, the latter being on the ground floor.

CULTURE VESSELS—The first stage in the production inoculant in the plant takes place in the culture vessels. These 5 gal. closed copper vessels with hemispherical jacketed botto and flanged domed covers (see album, page 41 and dwg. A17 The vessels have a hand operated stirring gear of simple form, a the covers are fitted with air and gas valve, filling valve, press vacuum gauge and thermometer. The jacket of the culture ve is so connected to the steam, water and drips headers behind and below the vessels that either steam may be applied to the jacket for cooking or water for cooling. The latter escapes through a valve at the bottom into a funnel in the drain system to enable the flow to be observed. The outlets from the vessels connect into a sloping 1" copper inoculating header through sweeping Y bends, and the header passes over the battery of inoculators, with branches into the covers. Each outlet is fitted with a drain valve and steam sterilising inlet. The inoculating line is provided with a sterile water and a steam connection at the upper end, and a double-valved, steam-locked drain at the lower or inoculator end.

There are six of the culture vessels arranged in a battery at such a height that the flow from them to the inoculators takes place under gravity.

OPERATION OF CULTURE VESSELS—The mash for the culture vessels is prepared in a 100 gal. open copper mash kettle. The ketttle has hemispherical steam jacketed bottom and mechanical stirring gear of peculiar design to prevent the mash adhering to the bottom of the kettle, and also to mix thoroughly the corn and water; this stirring gear rotates at 11 r.p.m.

The mash charge for a culture vessel is transferred from the mash kettle to the vessel by pail, and cooked by means of steam n the jacket, then cooled by circulating water through the jacket, with occasional stirring in both operations. Inoculant is poured from the glass flask into the vessel, and the fermentation proceeds ntil the proper stage of development is reached, when the inocu- nt is run through the previously sterilized inoculating line to the oculators.

INOCULATORS—The inoculators are 95 gal. closed copper nks with flanged domed cover and hemispherical steam jacketed ttom (see album, page 42 and dwg. No. B173). The tanks have belt driven propeller stirring gear (88 r.p.m.) with a jaw clutch r starting or stopping the propeller. The jackets are connected the steam and water headers similarly to the culture vessels, so t either steam or water may be put in the jackets. The covers e fitted with connection flanges for the inoculating inlet, ther- meter, pressure-vacuum gauge and air valve, and in addition e a screwed-cover hand hole. The filling connection is in the e of the tank. There is also in the side a sampling cock, and the tank is provided with a water gauge extending over the full depth from the outlet pipe to the side near the top.

There are six inoculators, which are arranged in a single row or battery, with various steam, water and air headers, etc., extending along the row. The vessels are filled from the mash kettle through a 2" W.I. sloping filling line, provided with a drain at the lower end. The steam is connected to the inoculators for sterilising, etc., through top gauge glass fitting, and also into the outlet pipe. The former connection keeps the gauge glass clear of mash, and enables pressure to be put on top of inoculant when emptying, while the latter enables the mash trapped in the outlet pipe to be boiled out.

The outlets pass into Y's in the 2" inoculating line to the seed tanks below, and this line is provided with a sterilising steam connection at the inoculator end, and with steam locked drains at the two ends in the Seed Tank Room.

Operation of Inoculators—The mash charge is run into the sterilised inoculator from the mashing kettle, cooked with steam in the jackets, and cooled by running water through the jackets. The stirring gear is rotated for both cooking and cooling operations. The inoculant is then run in from the culture vessels, and after fermentation has reached the proper point the inoculant produced is run to the seed tanks below under the action of gravity. When the vessel is empty steam is applied to force the mash ou of the pipe.

General Equipment of Culture Room—The steam drip from the jacket of the culture vessels and inoculators are collecte in a drip system leading to a steam trap on the floor below. Th slops and waste from all the vessels are collected in galvanized iro floor trays or pans under the inoculators and run from this to th sewer. Galvanized iron vapour hoods are placed over the inocula tors to carry away the steam and gases from the fermentatio through ducts to the roof. The power drive for the different sti ring gears is by means of a 3 h.p. 1,500 r.p.m. induction moto through rubber belting, countershafts and jaw clutches operated levers or rods.

Seed Tanks—There are sixteen seed tanks in the Se Tank Room below the Culture Room, arranged on four sides of rectangle (see dwg. A402). The central space is used as the oper ing area, and around the room behind the tanks a raised platform is built to give access to the top fittings of the tanks.

The seed tanks (see dwg. A172, and album, pages 43 and 44) are of copper, vertical cylindrical form, with dished bottom and flanged domed head. The tanks are 4' 6" in diameter by 6' 6" deep, with a capacity of 628 gals. The covers are provided with manhole and connections for an air valve, gas outlet and a pressure-vacuum gauge, while the sides are fitted with two thermometers, a water gauge covering the upper level and a sampling tap at the bottom. The filling and emptying is done through a single opening in the centre of the bottom, and the inoculant entrance is through a flange in the side near the top.

Cooling is carried out by means of a water cooling ring around the top of the tank, which discharges a sheet or curtain of water down the tank sides.

STIRRING GEAR—The stirring gear is of a more elaborate type than those previously described. The central shaft is belt driven at 32 r.p.m., and is supported in a step bearing at the bottom of the tank and one at the ceiling. The shaft carries a 10" diameter by 5' 0" pitch propeller at the bottom, set to throw the liquid downwards, while above the propeller two stationary baffles are riveted across the tank, one above the other, between which a single tapering blade attached to the shaft rotates. The propeller and revolving blade thoroughly mix the mash "head," while the stationary baffles prevent the mash as a whole from rotating. This arrangement was evolved after a considerable experiment, and has proved satisfactory under actual working. The time occupied in cooling was reduced by this arrangement from 3 to 1¼ hours.

SEED TANK PIPING—FILLING AND EMPTYING—The single opening in the bottom of these tanks is connected through a valve system to the 2" filling and emptying ring mains or headers extending around the room in front of the tanks on the floor (see dwg. A402 and album, page 43). The outlet pipe extends to the front of the tank through a gate valve, through a cross above the emptying header and into a tee above the filling header. A valve is placed between the cross and tee, and each of the latter is connected through a valve into a vertical Y in the respective mains. The other opening of the cross is connected to the steam for sterilising, and that of the tee provides a drain. This arrangement thus provides a steam lock at the outlet pipe between the four valves, preventing effectually contamination working back from either the outlet, filling or drain lines. The emptying main (inner) or fermenter inoculating main, is divided into two halves, the dead ends of which are fitted with steam sterilising connections, and which unite in a single 2" line to the cooled mash header from the coolers. The filling ring main (outer) is similarly divided, both branches supplied from the 3" seed tank charging line from the cookers, and in a similar way is fitted with steam connections at the two dead ends for blowing out.

INOCULATING—The inoculating line from the inoculators also supplies two branches of an inoculating ring main through gate valves, each half being provided with a steam locked drain. This enables each half of the main to be operated and sterilised independently.

STEAM—The steam supply of the tanks is from a ring main protected by safety valve from over pressure, and there are two branches to each tank, one to the top gauge glass fitting for blowing out the glass, and the other into the outlet pipe for the steam lock, cooking and boiling out mash in the outlet.

WATER—The cooling rings of the tanks are also supplied from a water ring main.

GAS—The gas generated during the fermentation is vented through a 1" main on top of the tank into a gas header leading to a water seal device, and thence through the wall to the outside. The gas seal (see dwg. A402), provides an antiseptic seal against contamination working back through the gas header, and maintains a pressure of 18" of water at the tank. There are four seals, one for each group of four tanks.

OPERATION—The tanks are usually sterilised in sections or groups under a steam pressure of 18" of water (outlet gas seal), the air valves and sampling taps being left slightly open in order that they may be sterilised also. The tanks are charged from the cookers with hot mash forced up by steam pressure in the cookers. The filling line is left practically full of mash between different chargings, but under steam pressure from the dead ends. About fifteen minutes are required to fill a tank. The steam lock in the tank inlet or outlet after filling is blown out with steam, and then left sealed under steam pressure.

Cooking is done by steam from the bottom connection until samples test sterile, then the mash is cooled to 98°. Throughout the cooking and cooling the stirring gear is kept revolving. When properly cooled, the inoculant is run in from the inoculators above, and the inoculating valve at the tank is closed just as the operator feels with his hand the steam temperature following the inoculant arrive at the valve. Any slight drips in the line are then blown out and the line again put under steam.

On completion of fermentation the charge is run through the inoculating line(previously under steam) to the fermenter charging main under gravity only. As soon as the tank is empty, steam is turned into the dead end of the inoculating line and follows the inoculant down, and in this case also as soon as the steam reaches the fermenter main the valve is closed and the drain opened, thus wasting a minimum of inoculant. It requires 15 to 20 minutes to run in a seed tank full, depending on the distance of the fermenter being inoculated from the coolers, which affects the back pressure. The inoculant is run in to the fermenter with the first cooker of mash.

GENERAL FITTINGS OF THE SEED TANK ROOM—The stirrer drive of the seed tanks is from a 5 H.P. 1,500 r.p.m. induction motor, driving through belts four countershafts from which drives to the tanks are taken by one-quarter turn belts and cord operated jaw clutches.

Steam from the tanks during sterilising and filling escapes through the air valve, and is caught in a vapour pipe which may be swung over the valve. The vapour pipes are connected to ducts leading to a fan below through a water condensing screen, and discharged to the outside. The condensed steam is carried to the sewer. The room itself is ventilated by a large vertical shaft from the ceiling to the roof. The seed tanks stand in a copper slop pan or tray on the floor to catch the waste, slops and the cooling water, and drains to the sewer.

STEAM AND WATER SUPPLY—The steam supply of the inoculating system is through a 2" line from the high pressure system (125 lbs.) through a Locke regulator, which reduces the pressure to a constant value of 12 lbs. on the system. This reduction in pressure is necessitated in order to protect the tanks, which are only capable of withstanding a moderate internal pressure.

The water used for cooling is from the municipal supply, because of the odours that are generated from the foul bay water when brought in contact with the hot tanks. The sterile water for flushing out the inoculating line to the inoculators is secured by condensing steam in a small reservoir.

FERMENTATION.

FERMENTER FILLING MAIN—The cooled mash header from the coolers, containing the mash venturi meter and inoculation connection from the seed tanks, connects into the top of a cross in the 4" fermenter filling ring main. On each side of the cross is a valve controlling the flow to either side of the main, and a 3" drain with 3/8" high pressure steam sealing connection into the valve is taken from the bottom of the cross (see dwg. A388). A recording thermometer is inserted in the header just before the entrance to the ring main. The thermometer chart not only gives a record of mash temperatures, but of length and temperature of the sterilising periods.

The fermenter mash filling main through which the cooled mash is pumped to the fermenters forms a closed circuit or loop about 180 ft. long and 25 ft. wide, with two short dead end branches at fermenters 20 and 22. (See dwg. A384.) The main is of 4" W.I. pipe, is provided with copper loop expansion bends where necessary, and is divided into sections by 4" gate valves. The division valve between fermenters 3 and 4 is provided with 1¼" steam connections on each side.

The two dead end branches of the main are provided with a double valve steam locked drain, the steam lock being also drained. At the end of the loop farthest from the inlet a system of valves is arranged, (see dwg. A388) with an air inlet, permitting air to be drawn in through a cotton-wool filter, steam sterilising connection and steam locked 2" drain. A pressure-vacuum gauge is also provided so that the operator after steaming out the line can watch until the pressure is just atmospheric before opening the air valve.

FERMENTER BRANCHES—From a tee or cross in the filling main, depending upon whether only one or two opposite fermenter connections are coming off, copper bends run horizontally, in order to cause no pockets in which mash can lie, to a 4" gate valve at the fermenter inlet flange (see dwg. A388 and album, pages 62 and 54). The latter is in the side of the fermenter, 4' 6" from the bottom, and the valve is controlled by extension spindle from the operating floor. The copper bends vary somewhat in form for the different fermenters, in some cases being simply horizontal offsets, while in others complete loop expansion bends. Their function is to take up any relative motion due to expansion or other cause between mash main and fermenter.

Into the expansion bends close to the valve a ½" steam line is brazed, supplying a nozzle inside the bend so shaped as to direct a jet of high pressure steam on the gate valve disc, preventing contamination of the fermenters by germs working back from the mash main.

FERMENTERS—The fermenting tanks employed are of the closed cylindrical type, of steel, with approximate capacities of 31,800 gals. (see album, pages 51, 52, 49, 61, and 53). They vary somewhat in dimensions and minor details, but have certain main characteristics which are common to all of the twenty-two in the plant. The dimensions are roughly 18' diameter by 20' high, with conical cover carrying certain fittings, and a comparatively flat bottom in most cases riveted to reinforcing I beams which rest on concrete footings, but in several cases rest directly on brick piers.

The fermenters each have a 4" inlet flange riveted in side at the front 4' 6" from the bottom, and a 4" outlet flange either in centre of bottom or at front of bottom, or in the improved later type fermenters a special cone outlet casting carrying a 4" flange. There is a 4" or 6" flange in the centre of the roof, and a 12" x 16" manhole in roof, and sometimes a second one in side at the bottom.

The fermenters are provided with recording thermometer, 4" air valve, and special 6" vacuum valve (both fitted with filter pads), and a 4" gas outlet pipe leads from the flange in the centre of the roof to the special "safety device" of the fermenter, and thence to the air. The tank is provided with top and bottom steam connections, manometer, and a sampling tap at top and bottom and midway between.

OUTLET PIPING—The outlet from the fermenter is arranged as follows (see dwg. A388) with a steam seal. On the outside of the outlet valve the outlet line divides in a Y, on the through branch of which is a 4" gate valved drain, and from the branch a short diagonal connection runs through a valve into a Y in one of the main beer system branches in the direction of the flow. Into the top of the first Y a ½" 15 lb. steam connection is tapped. When a tank is fermenting all three valves are closed and the steam is on between them, effectually preventing contamination working back from the beer system or drain.

Beer System—The outlets from all the fermenters are connected into a number of branches or headers of a 4" W.I. beer system (see dwg. A385). These branches, four in number, come together in a 6" cross header, from which the beer pumps draw (see dwg. A386). Three of the dead ends are provided with a 2" city water flushing out connection, and the other two with 2" drains.

Beer Pumps—There are two beer pumps, a 6 x 4 x 10 duplex steam pump, and a 4" single stage centrifugal pump, belt driven by a 6" x 6"-250 r.p.m. high speed steam engine (see album, page 64). Both these pumps draw from the 6" cross header of the beer system, and discharge into the same 5" W.I. discharge line. The pumps are provided with relief by-passes between discharge and suction. The main 5" discharge line proceeds across a pipe bridge to the finishing tubs in the Fermentation Department Annex, while there is in addition a 4" branch which passes upward in the Distillation Building to a beer still service tank on the third or operating floor for use in emergencies.

The position of the piping, fermenters and finishing tubs results in a siphon action in the beer line, and once the flow is started the pumps have little to do.

FERMENTER OPERATION.

Mash Line—After finishing the filling of a batch of fermenters, or "cooling," the whole mash main and all its branches to the fermenters is blown out by means of the small high pressure steam jets at the valves of each fermenter. This clears each of the fermenter branches. Sterile water is then pumped by the cooler pumps from the sterile water tanks through the cooler and out through the drain at the dead end beyond No. 22 fermenter. To accomplish this, the valve in the mash main south of the cross, where the line from the cooler enters, is closed, the north end being open. This operation clears all the thick sediment from the cooler pump, cooler connections, cooler, venturi meter, and mash main, as far as the drain. After blowing out this heavy mash the north valve is closed, the south one opened, and the sterile wash water pumped completely around the mash main and down the drain at the No. 22 fermenter dead end. This is done for the full capacity of the sterile water tank, about 1,400 gals., and takes probably fifteen minutes. When completed, all the drain valves are opened and the high pressure jets at each inlet valve again put on to blow out the branches, after which the drains are all closed, jets turned off, and the low pressure sterilising steam turned into the line. The sterilising steam connections are the two 1" on each side of a 4" valve between fermenters 3 and 4, the 1¼" at the east end, and by way of the inoculating line. The lines are sterilised for one hour twice daily, between the filling of each batch of fermenters. Before beginning to use the line again the line is drained of the condensed steam collected (with the steam on, of course).

STERILISING—After a fermenter has been emptied on completion of a fermentation the drain is closed, the pail of the safety device lowered, and the steam turned on to the washing down jets in the bottom of the tank (the upper two steam nozzles are used only in case of "foaming") with the air valve closed. The steam is blown in until the recording thermometer indicates 212° when the tank is put under pressure, the pail of the safety device being raised, and the lever of the latter also being raised (reducing opening to 1½" orifice). The pressure in the tank is brought up to whatever it will stand, without blowing water out of safety device seal, say 10 or 11 inches of water, as indicated by the manometer. The accumulated condensed steam is drained from the fermenter every three hours. The tank is "sterilised" at this pressure for at least six to eight hours, the whole operation occupying from ten to twelve hours.

Two of the fermenters are opened every other Sunday and the inside surfaces thoroughly hosed down. If the hose will not remove the coating the surfaces are scrubbed or brushed, but usually the coating comes off easily with the hose. After being opened for washing the fermenters are sterilised for eleven or twelve hours, cooled and allowed to stand for twelve hours. They are then sterilised again, cooled and allowed to stand for a second twelve hours, after which they are sterilised for the third time, cooled and filled.

COOLING—The pads of the air and vacuum valves from the previous fermentation are now removed and replaced by fresh ones. The steam is turned off and the tank allowed to cool naturally until pressure, indicated by the manometer, is ½-in. The air valve is then opened to eliminate chance of getting a vacuum, and the tank is allowed to cool until the recording thermometer shows 100°, when the tank is considered ready to fill. The average time taken to cool a tank is three hours.

FILLING—The mash is then turned into the tank from mash main, and as soon as a slight pressure is indicated on the manometer the air valve is closed. During the filling the pail of the safety device and the gate lever are both up. After mash has been entering fermenter for 15 minutes the temperature of the mash in the fermenter is taken by means of a sample from the bottom sampling cock. If the temperature is 98° the inoculant is turned into the mash line, and, depending on distance of fermenter from cooler (and therefore pressure on mash line), the inoculant takes a longer or shorter time to flow in, but requires an average of 15 minutes.

In filling fermenters if the rate of working the plant is, say, 10 fermenters per day, then the tanks will be filled in batches of five—that is, the mash from the cookers is pumped into five fermenters in succession, one cooker at a time (the inoculant going in with first cooker) into each fermenter. After each of the five tanks has received one cooker full the round is begun again and another cooker full pumped into each tank. This method has been found very successful. It permits the gradual growth of the culture, a stage at a time. Thus if the rate of cooling is 35 minutes per cooker, between the time of finishing putting a cooker into a tank until the next four have been similarly treated and the second cooker begins to be pumped into the tank there is a period of at least 140 minutes, or 2 hours 20 minutes, in which the inoculant or culture can develop in the 6,900 gals. of the first cooker. It then has a similar period to spread through the second cooker and so on for the full four cookers that go to each fermenter. This results in a stronger and safer fermentation, and is quite as easy to manipulate as the older method of filling a fermenter at one pumping. If only eight fermenters are being handled the filling is done in two batches of four each.

FERMENTATION—The fermentation takes from 24 to 30 hours from time of finishing filling, although one fermentation lasted 102 hours and gave the best yields of any. During the fermentation the air valve is closed, and at first both the pail of safety device and lever are raised. One hour after the fermenter is full, when the gas generated has built up a slight pressure, the pail of the safety device is lowered to uncover the orifice, and pressures on the manometer are then pressures on the orifice through which the gas flow is taking place, so that the manometer pressure is a measure of the rate of gas generation. After the manometer pressure becomes greater than 5 inches the lever is lowered, opening the 4" orifice and giving free vent to outside for the gas. When the rate of gas discharge has decreased towards the end of the fermentation until manometer shows only 0.1 inches, the lever is raised, again throttling escape of gas down to 1½" orifice.

FOAMING—If signs of incipient foaming are detected in a tub the cooling ring is applied, and if foaming still persists the beer pump (or usually pumps) is put on and the contents of the fermenter thrown over to the foaming or finishing tubs in Fermentation Department Annex. Ordinarily, the fermentation is practically complete before the fermenter is emptied.

EMPTYING—As soon as the pumps start to draw from the fermenter (i.e., when outlet valves are opened) the pail of the safety device is raised, the lever of it lowered, and the air valve opened. With both beer pumps working (duplex and centrifugal) a fermenter can be emptied in 50 minutes at the rate of 2700/50=540 gals. per minute, while the duplex alone can empty a tank in 1¼ hours at the rate of 27000/75=360 gals. per minute.

STEAM WASHING—If a tank has been emptied some time before it would normally be required for sterilisation in order to be filled at a certain time, a little steam is turned on, just enough to keep the tank warm, with air valve open, until it is time to sterilise.

BEER LINE—After a fermenter has been emptied, unless another fermenter is being emptied through the same line, the water is turned into the beer line and the latter washed out.

FOAMING AND FINISHING.

See Dwgs. A398 and A399.

INLET PIPING—The 5" W.I. beer line from beer pumps enters the Fermenter Department Annex and connects into 5" W.I. header over the five foaming or finishing tubs (see dwg. A398). 5" W.I. branches pass through the tub covers and end in elbows about 8 ft. from bottom of tub at the side, so placed that the beer is given a rotary motion around the tub on leaving the pipe.

FOAMING TUBS—There are five finishing tubs (formerly whiskey fermenting tubs Nos. 23 to 27) built of 2½" cypress staves 15' 9" deep, 25' 0" diameter inside at top, and 26' 0" diameter inside at bottom, with a capacity of 49,395 gals. (see album, page 65). Each tub is built on a circular concrete base, and has a dished copper bottom, from the centre of which a 3½" copper pipe passes radially through a channel in the concrete base. The tubs have been roofed with sheet iron conical roofs 24" high, from the apex of which a 24" diameter galvanized iron vent leads through the upper floor and roof to a 24" ventilator head of the stationary suction type. The tubs are fitted with a water flushing-down system on the tank bottom consisting of radiating perforated pipes which cause a rotary swirling flow of water on the bottom washing out the beer and "head" at the end of emptying.

EMPTYING PIPING—The original emptying line from the tubs is used consisting of the 3½" copper pipe from centre of the copper bottom, which connects through a 3½" screwed brass gate valve into a 5" copper header (at an angle of 45°) to the beer sump. The header is provided with a 2" washing out connection.

BEER SUMP—The beer sump is a concrete pit 15' 6" in diameter, 7' 3" deep, with a wooden cover above the level of the cellar floor and a bottom of wood (see photo 88 and Drawing A399). The sump was used in the distillery days, the beer from the fermenters draining into it from which it was withdrawn by supply pumps. It is provided with a stirring rake, mounted on a vertical timber shaft, driven from the main countershaft from the mill engine at about 5 r.p.m.

BEER PUMPS—Beer is drawn from the sump through a 6" cop- suction pipe, from which two branches pass through easy ds to two beer pumps (see album, page 66 and Drawing A399). e beer pump is 10 x 8 x 12 duplex steam pump (fitted with cop- air chamber) having a specially designed brass pumping end, the other a brass centrifugal pump made up of two single e, specially designed brass units. The two units are mounted t and left hand, on a single bed, and one shaft with the 9" meter pulley between through which the pump is belt-driven by rubber belt from an 11" x 11"-340 r.p.m. high speed steam en- e (Rites Governor) with 48" flywheels. The pumps are inter- nected with copper piping, so that they may be operated in er series or parallel. The east or both units of the centrifugal p and the duplex pump discharge through a 5" copper pipe and radius bends into a 5" copper flange jointed beer pipe run- diagonally across the fermenting cellar, and across the bridge he Distillation Department, a total distance of 250 ft.

DISTILLATION.

See Dwgs. A390-395.

BEER STILLS.

BEER STILL SUPPLY LINES—The 5 inch copper beer pipe passes the Distillation Building and enters through a 5 inch iron body valve a short beer still supply header under the beer stills. At west end of this header two 3 inch beer still feed lines from the er pass vertically upward on either side of a column through 3 inch gate control valves at the operating floor to two beer ers.

he discharge of a gear-driven reciprocating pump on the sec- loor just below beer stills drawing from the above-referred to still service tank (emergency), and the discharge of a triplex pump (formerly on whiskey distillation) which draws from eer sump through a 6" copper pipe, also connect into the beer header.

he two 3 inch W.I. beer still feed lines are provided just above ontrol valves with pressure gauges, protected by diaphragams the beer, and two 2 inch water connections for washing down tills, heaters, etc. A pressure gauge connected into one feed line below the valve indicates the pressure in the beer mains this floor. The three gauges are arranged on a gauge board c veniently placed on the column close to the control valves. (album, page 71.)

AUXILIARY BEER STILL SUPPLY SYSTEM—The 4 inch W.I. bra from the 5" discharge of the duplex beer pump in the Ferme tion Department passes upward into the top of a 7,107 gallon 1 dia. x 10 ft. deep copper beer still service tank carried on s and formerly used as a spirit weigh tank (see album, page The beer line, where it turns down into the tank, is provided a 1½ inch riser to roof for relieving air, and a 4" W.I. suction passes vertically downward to the suction of a 6 x 12 duplex p (No. 16) gear driven by a 6 x 10 single cylinder steam engine album, page 73). The pump and engine are on the second just below the beer still condensers. (See dwg. A391.) The 3 discharge line from this pump connects into the beer header, plying the stills as noted above. This arrangement was form used for the beer still feed, but is now retained only for us case of emergency.

BEER STILLS—The function of the beer still in the acetone p is to separate the acetone and butyl alcohol (and other alco etc.) from the remainder of the beer or residue of the grain after fermentation, known as the slop. In this plant there two 6 foot diameter by 20 feet (approximately) beer stills con ing ten plates each. Each still is provided with necessary heater and condenser. The stills are fully described under "S

The 3 inch feed lines enter the bottoms of the two heaters p at roof level from which hot beer lines pass into the two beer columns.

The vapours from each column pass over through the 10 vapour pipe to the top of the beer heater, from the bottom of the returns pass through a 3 inch copper reflux pipe to the sti the vapours to the top of the condensers. The distillate passe from the bottom of the latter to the double tail box, showin flow from both beer stills.

BEER STILL SLOP OUTLETS—The slop escapes from the b of each still through 6 inch copper slop seal into 6 inch c flanged-jointed slop main, which carries the slop to the sewe

. A391). The branches from the east and west stills pass the header with easy bends, and the slop header has a fall of t half an inch per foot, towards the outlet end with long radius ls to offer as little resistance to flow of slop as possible.

OPERATION OF BEER STILLS.

EER STILL FEED PUMPS—The duplex beer pump at the beer p in the Fermentation Department Annex, operates under a sure of 50 lbs. per square inch, and usually handles the beer at ate of from 10,000-16,000 gallons per hour. The centrifugal stage belt driven beer pump had only just been installed before ng down the plant, and had therefore never been usd.

ONDITION OF BEER—The pressure in the beer feed lines to the s below the control valves is usually about 25 lbs. per square and above the feed valves which are throttled slightly, 15 lbs. emperature of the beer as it leaves the fermenters is approxily 98°F. but it may be in the finishing tubs in the fermenting r for several hours, so that its temperature at the beer heater may be as low as 90° and it leaves the heater at about 130-140°. e east still a heating coil in the head of the still through which eer passes heats the feed to this still to a greater temperature the above.

EER STILL STEAM SUPPLY—The stills are heated by both live xhaust steam, provision for doing so being made in both stills. e regulation is by means of live steam and if the pressure in xhaust main is variable, the adjustment is rendered difficult. tills require a uniform steam pressure for good results, variain the pressure result in variation in the flow, and poorer tions.

PACITY OF STILLS—The stills working together normally hane tub of about 50,000 gallons of beer in from 4 to 4½ hours, still one fermenter of 27,000 gallons of beer in from 4½ to 5 . The stills thus work at a rate of from 5,500 to 6,200 gallons ur per still. Working continuously at ten fermenters a day, lls must handle 270,000 gallons per day of beer or 11,250 s per hour, making 5,625 gallons per hour per still.

PRESSURES IN STILLS—The pressure in the stills themselves, shown by the sensitive float pressure gauges, runs usually about lb. in the east still and 1½ lbs. in the west just below the four plate in each still. If the still becomes filled up this may rise to lbs. The reason for the difference in pressure of the two stills probably due to the method of supplying steam and the fact th there is one foot depth of slop in the bottom of the west still, wh the east, with the calandria (unused) has a depth of about 7 fe and further the east still has a heating coil in the top which t west has not, resulting in hotter feed to the former.

DISTILLATE PRODUCED—The distillate separated from slop in t beer still consists of a mixture of acetone, butyl alcohol, (and oth alcohols) and water. The distillate is known as A.B. (aceto butyl) and contains approximately 20-23% of acetone, 45-4 butyl, 3% ethyl alcohol, and the remainder of water. The qu tity of distillate produced is about 1,000 gallons per ferment charged with 24,000 pounds of corn. The A.B. flows from the box of the two beer stills under gravity only, through a 3 inch pipe across the court to the AB tank in the Tank Room for storage of crude acetone in process.

FIRST RECTIFICATION.

RECTIFIERS—The rectification of the acetone butyl, or AB tillate, from the beer stills is carried out in either or both of two rectifiers of the discontinuous type (see album, pages 72- Each rectifier consists of a copper kettle of 13,000 gallons capa fitted with spiral steam heating coil, a 60 inch diameter x 37 high 24 plate column, goose tank dephlegmator and tube type v cal cooling column. These are described in detail under "Stills

RECTIFIER CHARGING—The rectifier charge of 13,000 gallo drawn by means of a 6 x 8 x 12 single cylinder steam spirit pum the ground floor of the building, immediately north of the eas No. 2 rectifier, from the AB and A1 tanks in the crude ac storage room and discharged through a 3 inch W.I. pipe int end of a 4 inch W.I. rectifier supply header, from which 4 inch branches lead through 4 inch gate valves into the reflux lines, column to kettle just above their junction with the kettles.

RECTIFIER CHARGE—The rectifier charge is made up generally
f about 11,000 gallons of AB and about 2,000 gallons of an im-
ure acetone known as A1, the quantities depending on the percent-
ge of acetone in each. The time taken to pump in the 13,000 gal-
n charge varies from 1 to 1¼ hours. A little steam is turned on
e heating coil or "scroll" as soon as the latter is covered. It has
en found inadvisable to pump the charge on to the hot coils or
to a hot kettle.

RECTIFICATION—The steam pressure maintained on the coil is
nerally 30 lbs. and the charge is heated for about 10 hours before
e "first runnings" come over. The first part of this flow is largely
purities from the last run, and continues for a few minutes only,
obably from 30 to 40 gallons, and is directed from the tail box
either rectifier through two 2 inch stop cock controlled lines
o a single two inch W.I. pipe, which leads to an 881 gallon steel
ast Running Tank) on the floor below (see album, page 73). Of
30-40 gallons above, three or four gallons are an "oil" which
es to the top, and the rest water. When the tank has been filled,
water layer is run to the sewer and the "oil" run into drums
possible future use.

For the next 15 minutes to an hour, more generally 15 to 20
utes, a flow occurs of an impure acetone A1, washings from
various elements of the still, which is directed from the tail
es through a 3 inch W.I. line (paralleling the A.B. line) to the
tank in the Tank Room. The A1 contains 15-20% acetone, to-
er with butyl, ethyl alcohols, water and impurities. The qual-
of the distillate improves and that known as A2 follows the A1
s for 15-30 minutes. The A2 is 99% pure acetone and is directed
a third 3 inch line to two A2 tanks in the Tank Room. Fin-
the pure acetone or A3 part of the flow is reached, and lasts
t twelve hours at a rate of approximately 200 gallons per hour
rectifier (since rectifiers are never running on same liquid at
e time, they alternate in other words).

AUGING TANKS—The A3 is directed from either tail box into
of a set of four 100 gallon galvanised iron gauging or testing
s. (See album, page 76.) The A3 is run into one tank until
and then is directed into the next, that in the first meanwhile
subjected to the chemical tests, for purity. If it does not
the tests, it is directed from the gauging tank into the 3 inch

W.I. line into the A2 tanks, while, if it stands up, it is directed into either of two 2 inch W.I. pipe lines to the pure acetone tanks in the Shipping Department, or into a 1½ inch line passing to two acetone storage tanks in a small detached tank house.

As soon as the acetone fails to stand up to the test, the flow is directed to A2 tanks and then to the A1 tanks, just as during the beginning of the rectification, the flows lasting for about the same times.

A1 is followed by the distillate known as B1, a butyl constant boiling mixture 70-75% butyl and containing a very small percentage of acetone, which is directed from each tail box into two 2½ inch W.I. pipe lines (part copper where existing lines could be made use of) which pass to the east of two 13,431 gallon copper tanks in a small room partitioned off at north end of the pipe shop. This tank is known as B1 tank, the west as the B2 tank. The flow of B1 lasts probably 12 hours at a rate of from 500-600 gallons per hour—about 6,000 gallons from a charge.

Following the B1 at the end of the distillation is a short flow of LR distillate or "last running" an oil similar to the first runnings which is sent to the "Last Runnings Tank."

The residue chiefly water left in rectifier kettles is drained through the 4" copper drain from centre of bottom of kettle t sewer.

The average time occupied in running through a 13,000 gall charge, from time of starting to fill until end of last running, i about 40 hours.

SECOND RECTIFICATION.

A continuous acetone still (Badger) rated at 14,000 lbs. p 24 hours, is now run exclusively on acetone (A2). As by the pre ent method of working the two rectifiers handle the bulk of t acetone in the first rectification, this still is usually operated for week only or until all the A2 is used, and then is shut down f two or three weeks until another batch accumulates.

CONTINUOUS STILL—The still is of the modified Barbet ty and consists of a 54 inch diameter by 13 foot 16 plate exhausti column, 36 inch x 19' 6"-36 plate rectifying column, with 36 inch 4' 6"-6 plate auxiliary column, pre-heater, dephlegmator, cond ser, cooler, slop tester and various control appliances. See secti on Stills for detailed description, also album, pages 72, 74 and 77

STILL FEED—The A2 is diluted with water in either of the A2 tanks, in the Tank House until the strength is 25% acetone to 75% water. The diluted A2 is drawn from the A2 tanks by a 6 x 8 x 12 single cylinder steam still supply pump and elevated through a 2 inch W.I. line to a small 3 foot diameter x 3 foot deep steel constant level tank at roof level, through a regulating valve then back to upper floor through heater and down through a 2 inch pipe into the top of the exhausting column, and on through still. The constant level tank has a 3" W.I. overflow back to pump suction.

Considerable difficulty was experienced at first in operating this still, due to inexperienced operators or still men, and also due to its being forced beyond its capacity.

The charge for the second rectification contains a certain percentage of a dilute solution of soda. The arrangements for supplying this solution are as follows:

The soda solution is prepared in a 1,057 gallon open steel tank (formerly yeast tank) on the floor above the still operating floor. A 3" W.I. outlet from the bottom of the tank divides below the floor into a 2" line which passes across and into tops of A2 tanks in Tank Room. A 1" branch leading down and arranged to discharge soda into the second, fourth and sixth plates of No. 2 (east rectifier) and also discharges to sewer. The above arrangement is that formerly used when rectifier No. 2 was performing the final or second rectification.

CAPACITY—The still now operates satisfactorily, producing 50 to 68 gallons of pure acetone per hour and runs for hours absolutely without attention or adjustment. It has produced 66 gallons per hour steadily for days at a time, or at the rate of about 12,700 gallons per 24 hours.

DISTILLATES—From the tester of the continuous still (see Album, page 77) the distillate runs through a 1½" W.I. line to the three gauging vessels belonging to this still arranged similarly to those of the rectifiers.

ACETONE PIPING—The A3 header from the continuous still, gauging vessels and the A3 header from the rectifier gauging vessels are interconnected and arranged with valves so that the A3 distillate from either of the rectifier tail boxes or the continuous still tester can be directed into either of the 2" lines to two 4,500 gallon glass lined pure acetone storage tanks in the Shipping Room, or to the 3,000 gallon galvanised iron elevated auxiliary pure acetone tanks in the separate building. Similarly, the A2 from the rectifiers or continuous still may be directed into the A2 line to A2 tanks by properly adjusting the valves.

ACETONE STORAGE.

TANK ROOM FOR STORAGE OF CRUDE ACETONE IN PROCESS.

See Dwg. A398, A399 and album, page 78.

The AB, A1 and A2 distillates are stored in copper tanks in a tank room partitioned off from the Fermentation Department Annex. There are eight 11,000 gal. copper tanks 13' dia. x 14' high, provided with light copper cover ventilated with 4" dia. duct (small to prevent excessive evaporation losses). The tanks stand on concrete bases (formerly fermenting tub bases) and are fitted with 3½" drain and draw off connections at three points in the side to enable different layers to be drawn off when necessary.

Two tanks are employed for each distillate, AB, A1 and A2, and in the case of the former two—AB and A1—the two tanks are arranged with a 4" overflow between them 2' from the top.

The two A2 tanks are separate, one being used for diluting, and a 2" soda line enters the top of each.

The outlets from the tanks are 4" dia. in the side, 9" from the bottom, and from them a single 4" main leads back to the rectifiers and still supply pumps.

The remaining two tanks provide emergency storage for any liquid required.

PURE ACETONE STORAGE.

See Dwg. A400 and 401 and album, page 79.

TANKS—A 1½" W.I. A3 line from the gauging tanks leads a small steel frame galvanised iron covered building. This buil ing carries on a concrete floor some 10 ft. above grade two 3,00 gal. No. 12 gauge closed galvanised iron tanks, 9 ft. dia. x 7' average height. The two 1½" branches of the above 1½" supp line controlled by valves enter the tops of the tanks and 2" emptying lines from the fronts of the sloping bottoms (4" slope draining to the front) unite in a single 2" W.I. (galvanised) line passing into Shipping Department to the racking off taps.

The two 2" W.I. lines (A3) from the gauging tanks in the Distillation Department connect into the emptying lines of two 8' 6" dia. x 10' 0" horizontal glass-lined pure acetone storage tanks, 3,750 gal. capacity each. The tanks are made up of four 30" flanged sections bolted together, with domed heads. They rest with axes horizontal on heavy timber stands about seven feet above the floor in the Shipping Room.

The tanks are each fitted with a ⅝" x 8 ft. gauge glass tapped into ends, with chain operated fittings.

Vents—To prevent loss by evaporation of acetone from the tanks, a water sealed vent and vacuum valve is provided for each tank, which permits pressure developing in the tank to vent through water, which absorbs the acetone vapor. If the tanks were closed with no vent whatever, the vapor pressure and compression of air in the top of the tank would, as tank was filled, become so great as to prevent inflow of acetone from the gauging tanks. In emptying storage tanks, if a vacuum is developed, it is relieved by the vacuum gauge on the vent lines. The water sealing the vents can be drawn off occasionally in pails and returned to rectifiers for recovery of the acetone.

An alternative method of relieving pressure in tanks is also provided. A ½" W.I. pipe is run from top of each tank to the third floor of the Distillation Building (operating) where it is connected to a pressure gauge, a ½" swing check valve acting as a vacuum valve, and through a valve to a vent through the wall to the air. The pressure on the tanks is indicated by the gauges and can be watched by the stillmen and relieved when necessary through the vent. A vacuum is prevented by the check valves.

SHIPPING.

See Dwgs. A400 and A401 and album, pages 80 and 81.

Methods of Shipment—Pure acetone is shipped from the plant both railroad and water in steel drums of the usual type, holding me 660 lbs. or 80 gals. During the navigation season transportation is almost entirely by boat, the filled drums being carried by motor truck to the docks. When navigation is closed, the acetone is shipped by rail, the drums then being loaded directly from the Shipping Room into the box cars placed on a siding immediately south of the Shipping Room.

DRUM WASHING (INTERIOR)—The drums are thoroughly tested for leaks before being washed, by being plunged first in cold water and then in hot water where they are put under a pressure of 15 lbs. If leaks are detected, which it is possible to repair, they are handed over to the acetelyne welder for repairs. If they test tight, the drum is rolled along a skidway over a drum washing tank.

The drum washing tank consists of a galvanized iron trough 8' 6" long, 20" wide, 11" deep at one end and 13" at other, where a 2" drain is located. The tank is fitted with two rotatable ¾" wash nozzles, of perforated brass pipe, which may be inserted into the bunghole of the drum and supplied with either water or steam. Drums for butyl are washed with steam only. The tank has around the upper edge a frame 2 x 2 x ¼" angle, which acts as rails when the drum is rolled over the trough. As the drum is rolled over the tank, a nozzle is inserted in the bung hole and the drum first washed out with cold water and then blown out with steam until it is just hot enough to handle. It is then rolled over and drained into the tank and rolled down a skidway to the floor, where it is rinsed out with acetone.

DRUM CLEANING AND PAINTING—The drum cleaners then receive the drum and thoroughly brush and scrape the rust off th outside, and then paint the outside all over with black paint. Afte this the drum is stored until required for filling.

A drum cleaning machine has been used to some extent fo cleaning the rust off drums. In this machine the drum is rotate on rollers and steel brushes pressed against the outside and ends brushing off the rust as the drum is rotated. The machine is bel driven and is quite good for surface rust, but when the rust ha penetrated deeply, the hand cleaning has to be used.

The acetone washings from the drum are poured into a was drum, weighed, and the then rolled under the 1¼" suction pipe a small 3" x 2" x 3" duplex steam pump. An extension of th suction pipe is inserted in the bunghole and the pump draws was ings from the drum and discharges through a 1¼" pipe to the north A2 tank in the Tank Room for rectification.

DRUM FILLING—The drum filling or racking-off arrangements for acetone are as follows (see album, pages 79 and 81):

The three 2" lines from the pure acetone storage tanks project outward over the platform of a 1,200 lb. platform scale in the Shipping Room and connect through three 1½" gate valves into 1½" lever handled plug cock, by which the flow of acetone into the drum is regulated.

The properly cleaned drum is rolled up skidways to the platform of the scale, and its tare weight taken. It is then filled by inserting a short piece of W.I. pipe into the bung and screwing it into plug cock and opening valve in proper line and the regulating plug cock. A drum normally takes 660 lbs. of acetone, which leaves 4 to 4½" at the top for expansion. The gross weight and a sample of the acetone are taken when full. On one part of the sample tests are made for purity of product, and the remainder stored in cupboards as a record of the drum. The plugs are screwed home with a heavy 24 inch T wrench.

The drum is rolled down from the scale platform after filling and the weight stencilled on, after which it is ready for shipment.

The drums weigh on an average 160-170 lbs. net, and are filled with 660 lbs. acetone, making a gross weight of 820-830 lbs.

LOADING—The shipping door is in the south wall of the Shipping Room and opens directly on the siding which runs close o this wall of the building. For loading the acetone drums on ars, trucks or waggons, an elevated platform is built inside this oor at a slightly greater height than the level of the railroad car oor (see album, page 82). The drums are raised to this platform y means of a light fixed radius jib crane of steel, equipped with n electrically operated one ton chain lifting block. From the platform the drums are rolled across a short skid into the car and laced. After the first tier is completed in the car, a stand is laced in position on the platform, and from the stand the drums e rolled across a skid on top of the first tier.

For shipment by boat, the drums are loaded in the same way n motor trucks, on end, fourteen or fifteen to a load and carried the wharf.

Rate of Filling and Loading—The rate of filling with this equipment is ten drums an hour from the auxiliary outside storage tanks (greater head) and seven or eight per hour from the main storage tanks. A car can be loaded in about one hour with a gang of nine men.

NORMAL BUTYL ALCOHOL.

(a) Crude Butyl Storage and Salting.

Initial Storage and Separation—The butyl distillate as it comes from the tail boxes of the rectifiers in the first rectification is run under gravity through two 2½" pipe lines, part copper, part W.I., some 125 ft. long into the top the east one, B1, of two 13,431 gal. copper tanks, 14 ft. dia. x 14 ft. deep. The tanks were formerly spirit diluting tanks.

In B1 an aqueous layer of about one-third the depth settles out, which contains approximately 8% butyl. This aqueous (lower) layer is run off under gravity and static head through the original 2" dia. valve and a long ¾" W.I. pipe line 225 ft. long, to the brine line from the salting plant to the beer sump in the Fermenting Department Annex (refer back). From the sump the aqueous layer (and brine) is pumped back through distillation system and redistilled, or to storage for subsequent distilling.

The upper or butyl layer in B1 approximately 70 to 75% dry (i.e., 75% butyl) overflows from B1 into the west or B2 tank, through a 2" pipe running from 24" from top of B1 and entering B2 26" from bottom. The B2 is drawn from the second tank through two outlets, the old 2" from bottom and new 3" in side 5" from bottom, which unite in a 3" W.I. running along west wall o Fermenting Department at floor level to an 8 x 6 x 12 duplex steam pump at the south wall of the Distillation Department (See Dwg A391). This pump discharges the B2 through a 3" and 4" W.I line (the 4" section being an old molasses line) across court an shipping room roof and into the top of a 1,250,000 gal. outside stor age tank 95 ft. dia. x 30 ft. high of steel and roofed. The B2 i stored in this tank until required for salting and rectification fo shipment or conversion into methyl ethyl ketone. In the large tan a further settlement occurs, another aqueous layer settling ou which is pumped out from time to time and re-distilled.

SALTING PLANT.

See Dwgs. A400 and A401, and Album, Page 84.

FEED SYSTEM—There are two feed tanks for the salting plant, a 1,500 gal. 7' 6" dia. x 6' deep sloping bottom galvanized iron B2 tank and a 2,500 gal. open steel B1 tank. Both tanks are elevated about 6 ft. above the floor in order to give gravity feed to the salting plant.

There are two lines from the large outside butyl tank, a 4" from the bottom and a 2" from the top, both of which lead to the B2 tank and have a branch to the salting plant hopper. Flow is started in the 2" line by pump, after which it continues by siphoning.

A 4" W.I. line from the Trinity Stills is also arranged to deliver either the B1 fraction from the distillation to the B1 tank, or B2 to the B2 tank, while a 6 x 4 x 6 duplex pump at the salting plant s arranged to discharge salted butyl from the settling tanks hrough the same line to the still for rectifying.

Feed lines from the tanks are arranged to deliver the B1 or B2 to the salt drum hopper, where the liquid washes the salt fed into the hopper by scoop into the salt drum.

SALT DRUM HOPPER—The hopper is rectangular in form pering to a 3" circular section projecting through the hollow end urnal of the salt drum. The salt is scooped into this hopper by and and washed into the salt drum by the butyl.

SALT DRUM—The salt drum is a 20" dia. x 70" long cylin- ical chamber, with rolled riveted plate shell and cast heads pro- ded with hollow journals rotating in specially designed pillow ocks. The interior of the drum is divided longitudinally into ven chambers by six disks parallel to the heads, and transversely o four segments by four long blades or paddles extending the l length of the drum. Each disk has a 6" diameter hole in ntre through which the butyl, brine, and suspended salt flow m chamber to chamber, and a deflector by which the solid salt deflected through from chamber to chamber. The drum is belt ven at 45 r.p.m. through a countershaft by a 3 H.P. 750 r.p.m. uction motor (No. 6).

Operation—The operation of the drum is as follows:—The mixture of wet butyl and salt passes from the hopper into the first chamber and as the drum rotates the blades successively pick up the salt and let it slide off into the wet butyl, stirring the mixture thoroughly. Once during each revolution, a deflector opposite the rectangular slot cuts off a portion of the salt and guides it into the next chamber. The drum axis being horizontal, and the inlet opening 4" in diameter, while the holes in the disks are 6", the liquid flows from chamber to chamber through the 6" hole, and also through the rectangular slots when below the axis. In this way the salt and butyl pass on from chamber to chamber, being constantly agitated by the paddles, and the water in the mixture dissolving salt until, upon reaching the last chamber, when the drum is being properly operated, the water is thoroughly saturated with salt, and comparatively little undissolved salt is present. The rate of flow of the liquid through the drum, and the quantity of salt are under easy and direct control, the latter depending on the former. The mixture of 93% dry butyl and saturated salt solution, flows out through the 5" diameter outlet in the other hollow journal.

From the salting drum, the mixture flows into and through an observation chute in a broad shallow stream. In the chute the mixture may be momentarily arrested from time to time by means of a small flap gate, and examined through the glass windows to see that just a slight amount of crystal salt is coming through insuring thorough saturation of the water. In this way the amount of salt admitted to the drum, may be properly regulated to suit the rate of flow of butyl, so that the water is saturated and very little excess salt passes over.

The observation chute ends in a passage way leading into a settling tank. This passage way is so designed that the mixture of dry butyl and saturated salt solution in passing into the tank imparts to the whole body of liquid in the tank, a rotary motion. The object of the rotary motion is to obtain a low velocity and more time for the thorough or complete settling out of the suspended salt. The passage way is further so designed as to be readily accessible through the hinged observation window, for cleaning out accumulations of salt. A large proportion of the salt carried out of the drum in suspension, drops to the bottom of the settling tank and the liquid remaining (dry butyl and saturated salt solution) flows out through the elevated overflow. The salt that settles out drops to the cone-shaped bottom of the tank, and is drawn off occasionally through the salt valve into flat pans or pails and returned to the hopper.

The liquid proceeds from the overflow of the settling tank into the pump reservoir, where the rotary motion and elevated overflow are made use of to effect the complete separation of any remaining suspended salt.

A 7 x 5 x 7 duplex steam pump (17A) draws the salted butyl mixture through 1¼" W.I. pipe from overflow of pump reservoir, and discharges it through vertical 1" W.I. pipe into the main salted butyl (18,000 gal. formerly molasses tank) storage tank, about halfway up.

Butyl Brine Separation—In the 18,000 gal. steel tank (wooden cover) the butyl and brine immediately separate, the former rising to the top and latter settling to the bottom.

Salted Butyl Disposal—The salted butyl layer in the tank may be drawn off or overflow through either of two 2" connections tapped in side of tank, one near top and the other midway up, into a vertical header connecting at bottom into a pipe to a second, duplicate tank of 18,000 gal. capacity used for storing salted butyl, or to a line from the second tank to suction of the 6 x 4 x 6 pump (17B), which then pumps the salted butyl from either tank across o the Trinity Stills for rectification.

Disposal of Brine—The brine is drained off from bottom 2" ide connection of the first or separation tank, and runs through a " pipe to the line from B1 to beer sump. This brine is returned o sump for recovery of butyl in brine by distillation, or may be rained off through a centre main connection direct to sewer.

The plant is operated by one attendant and has handled as high s 600 gals, of wet butyl per hour, salting from 70-75% dryness up o 92-93% dryness.

(b) NORMAL BUTYL RECTIFICATION.

Salted Butyl Delivery Line—The 6 x 4 x 6 duplex steam mp draws the salted secondary butyl from either of the 18,000 l. steel storage tanks, and discharges it through a vertical 1½"

W.I. pipe to a 3" W.I. pipe, which passes over the roofs to the Stone Mill and Mashing Building where it connects up with an old 3" copper alcohol line from the whiskey beer still to the Trinity Street rectifying stills. The 3" copper line passes across Trinity Street into No. 1 Tank House. This line has a total length of some 550 ft., made up of 275 ft. of 3" W.I. and 275 ft. of old 3" copper line. The line is provided with a gate valve just before the Tank House is reached, from which an extension handle projects down through the roof of a small Tank Room. Just inside the wall of No. 1 Tank House the line divides into two branches, one passing vertically to the south one of three 5,000 gal. weigh tanks from which the salted butyl may be run by gravity to No. 11 Tank House for storage. The other branch passes into the top of the south of two copper still supply tanks through a 3" gate valve controlled from weighing room above.

STILL FEEDS—The still supply tanks are 9' 6" dia. x 15' 6" deep, 11,025 gals. capacity, elevated about 14 ft. above floor to give gravity feed to stills. They have light copper covers and stirring gears (hand operated and not now used) are connected by a 3½" overflow 9" from top, and the outlets connect into a single 3½" copper line, which leads to the stills. The two tanks have float gauges, the boards of which are on walls in tank room.

The 3½" copper still feed line passes through the three still compartments about 12 ft . above floor, and from it in each compartment a 3½" copper branch drops vertically downward into each still kettle through an angle control valve on kettle side or front. A 2" copper line enters the top of the still feed line (through a valve) in No. 1 Still compartment leading from the spirit tanks in No. 2 Tank House by which any distillate in any tank in No. 2 Tank House can be pumped into feed line, and so to any still for charging stills.

RECTIFYING STILLS—There are three rectifying stills in the Trinity Street Still House, which are of an early pattern and have been used in alcohol rectification. The stills have normal kettle capacities of No. 1—4,000 gal., Nos. 2 and 3—7,000 gals. each. (See section on Stills and album, pages 86 an 87). The stills are of the discontinuous type, No. 1 having a vertical copper kettle 10 ft. dia. x 9 ft. high, 60" dia. x 38' 6"-26 plate column, goose dephlegmator and three vertical Beemis type condensers 30" dia. x 12 ft. high and Nos. 2 and 3 each have a horizontal kettle 9 ft. dia. x 21 ft. long, 60" dia. x 42 ft., 26 plate column goose dephlegmator, and two vertical Beemis type condensers 31" dia. x 19' 10", all of copper construction throughout. There is in connection with the three stills a battery of two Beemis type fusel oil coolers 3' 0" x 15' 10".

The stills are placed in separate sections of the Gooderham & Worts Trinity Street Still House (see album, page 85), the compartments separated by brick walls. The three tail boxes and various controls of all three stills are on the operating floor of No. 2 Still compartment. Each still is here provided with a pressure gauge showing pressure on steam coils, one showing pressure on kettle itself, an extension handle on the control valve of the steam supply, the bay water supply to goose and bay water supply to condenser. The main steam and bay water gauges are also located here.

The various lines from the three tail boxes pass down through floor to different tanks in No. 2 Tank House in the rear—containing 16-9,000 gal. copper spirit tanks numbered 17-32. Up until just before the plant was closed down, these three stills had been used to handle all the rectifications for the M. E. K. plant, that is, normal butyl rectification, secondary butyl, M. E. K. and the various residues, first runnings, etc. In order to do this, the piping to and from the stills necessarily became complicated. With the completion of the two new stills in the Mill Street Still House for secondary butyl and M. E. K. rectifications the piping may be considerably simplified. The pipe lines are all, except where otherwise noted, of 2" W.I. with screwed fittings, galvanised pipe has been used to some extent.

RECTIFICATION OF NORMAL BUTYL ALCOHOL.

OPERATION—The rectifier charge for this rectification is 7,000 ls. of salted butyl which is run in from the two still supply tanks d the steam turned on. The steam is turned on freely at first til goose water becomes heated up and flow commences, after hich the water on the goose is reduced in temperature until a riod of five hours has elapsed from first turning on of steam. e water is cut off the goose then, and more steam supplied.

RUNNINGS—The first runnings of F. R. Fraction flows from vity, .815 at 70° F. at start to .840 at 70° F., after which the B1 fraction continues, at first clear, then milky, later clearing again, until gravity .810 at 70° F. when the distillate is B3, which continues to the end of the distillation. If the butyl is well salted, from a 7,000 gal. charge, approximately 50% or 3,500 gals. will be 99½% pure butyl or B3, 500 gals. F.R., 2,900 gals. B1 and from 50 to 100 gals. left as residue or "tails" in the kettle. A charge runs from 26 to 27 hours from time of finishing filling kettle, this time depends to some extent upon the skill of the operator in manipulating the steam on the coils and the water in the goose. It has been found better to regulate the flow entirely by the steam rather than water on the goose.

FR—The FR fraction from No. 3 Still is directed through a line to a hose connection over No. 26 tank, while that from Stills 2 and 1, if running on normal butyl, is carried from a header under the tail boxes to a hose connection between tanks 26 and 27. From the hose connection at the end of either line the FR is directed through a hose into tanks No. 29 and 30 until 7,000 gals. have accumulated for redistillation.

B1—The second fraction, B1, is directed from either tail box into a header running under them, from which a short line carries the B1 to the top of the east B1 tank. There are two B1 tanks, 10 ft. x 10 ft. x 6 ft. deep, 3,665 gals. of copper, elevated about 10 ft. above floor on timber stands. The tanks were formerly alcohol tanks No. 7 and 8, and they have been inter-connected below through 2" W.I. pipe and valve. From this under-connection between the valves a 2" suction line runs through a valve and th wall to the suction of a 6 x 4 x 6 duplex steam pump in No. 1 Stil Compartment. A discharge line from the pumps connects into th 3" copper line by which the salted butyl is delivered to the Trinit Stills on the street side of the valve in the latter line. By this arrangement the B1 is pumped back to the salting plant for re-saltin and subsequent rectification through the same line through whic the B2 or salted butyl is pumped over.

B3—R.N.B.—The 99½% dry normal butyl or B3 is carried fro a 3" header under the tail boxes of all three stills through a 3 W.I. line to No. 2 Tank House where it connects into a distributin system to fourteen of the sixteen tanks. These tanks are 14' 6 dia. x 9' 0", 9,154 gal. capacity, of copper, wooden-backed, copp cover with hand stirring gear. There is thus provided 128,000 gals. storage capacity for rectified normal butyl R.N.B. or B3.

RESIDUE "TAILS"—The residue or "tails" (50 to 100 gals.) left in the kettle after a run is completed, is withdrawn through a 1¼" header by a 3 x 2 x 4 duplex steam pump, and discharged through a ¾" line into the Tank Room where it may be run into drums, or into the FR or B1 tanks or No. 2 Tank House.

Ordinarily, the residue is discharged to an elevated rectangular 4,502 gallon steel tank 4' 0" above floor, from the bottom of which a short 4" W.I. pipe runs through valve into top of a second rectangular L.R. tank (wooden cover) on floor of 1,680 gals. capacity.

These tanks were formerly "oil" tanks Nos. 9 and 10. When the two tanks are full, the 6 x 4 x 6 duplex steam pump above draws the FR from the lower tank through a 2" W.I. suction pipe passing through cover to bottom, and discharges it along a 2" header in front of stills to either still for redistillation.

BUTYL ALCOHOL HANDLING EQUIPMENT—For handling the various alcohols and distillates, pumping from tank to tank, to and from stills, etc., there are permanently set up at the north side of the north row of tanks in No. 2 tank house, adjacent to tanks 24 and 25, two 6 x 6 x 9 duplex steam pumps (see album, page 89). These pumps are inter-connected on suction and discharge. The tank emptying lines are all extended under the tanks to the north side of the north row of tanks, and there provided with connections by which either of the two above pumps may be connected up to any tank by hose. The pump then draws the liquid from the tank and discharges into a header, from which six 2" pipe lines run. The pipe lines are arranged as follows:

(1) No. 11 Tank House—Used for discharging FR., FR1, FR2, FR3, etc., byproducts from the butyl, to this tank house where there are 10-13, 175 gal. copper tanks, for storage.

(2) Rectified Secondary Butyl—Tank No. 3. This line was used when secondary butyl was being rectified at Trinity Street stills, for discharging the R.S.B. pure secondary butyl through a " W.I. line, one of four parallel lines, back across Trinity Street the No. 3 (RSB) tank in the M.E.K. building.

(3) Normal Butyl to M.E.K.—No. 1—Rectified Normal Butyl NB, or B3, is pumped through this line back across Trinity

Street, through a second one of the four parallel lines to the RNB tank, No. 1 in the M.E.K. building

(4) Supply for Stills, 1, 2, 3—Through this line the charges are pumped into the three Trinity Street Stills from the tanks in No. 2 tank house. The line enters the still filling line through a valve in No. 2 still compartment (refer back).

(5) Supply to Weigh Scale. When rectified normal butyl is being shipped in tank cars, it is pumped through this line to the one weigh tank being used for butyl alcohol, weighed, after which it is run into the cars.

(6) Supply to No. 2 Tank House. This line, which runs into No. 1 tank house, where it connects up with an existing 2½" spirit line running back to the centre of No. 2 tank house, from which a hose is used to reach any tank. The line is made use of for transferring the contents of one tank to another.

In addition to the above, there is a third pump, a small duplex, near the other two, which discharges through a third one of the four parallel lines across Trinity Street, between Trinity Stills and M.E.K., to the secondary butyl salting plant in the M.E.K. building. The line was used for returning "weak runnings" from the secondary butyl rectification to the salting plant.

The fourth line across the street is used to deliver the salted secondary butyl to the stills or Nor 2 tank house.

DISTILLATION OF FR FRACTION—When a charge of 7,000 gals of the FR fraction has accumulated in the tanks Nos. 29 and 30 it is pumped by the above arrangement to the kettle of one of th stills and rectified.

On rectification 7,000 gals. of FR yield approximately 500 gals of a distillate FR 1, 4,500 gals. of a second fraction FR 2, and th balance about 3,000 gals. of B1. The latter is pumped back fo resalting and redistillation, while the two former are pumped t No. 11 tank house for storage.

(c) BUTYL ALCOHOL RACKING OFF AND SHIPPING.

Butyl alcohol is shipped both in drums and railroad tank car

DRUMS—For shipment in drums, the latter are filled fro the tanks (B3) in No. 2 tank house, making use of a set of calip scales (see album, page 89). A short length of hose is fasten over the spout of the tap on the end of the emptying line from the tank, which projects beyond the north end of platform on which tanks stand, and the hose inserted in the bung of the drum. The drum is suspended on caliper scales, and its tare weight taken and 660 lbs. of butyl run in, after which the plug is inserted, screwed home and the weight stencilled on the head. Butyl drums are loaded in the cars from an elevated loading platform connected with No. 2 tank house by long horizontal ways, along which the drum is rolled, and over a skid into the car (see album, pages 90 and 91).

TANK CAR—Tank cars are filled with butyl from the elevated weigh tank used in connection with the Trinity Stills. The butyl is drawn from the storage tank by the pumps in No. 2 tank house, elevated to the weigh tank and weighed. The weighed butyl is then run through a long 2½" W.I. pipe line to the above-mentioned loading platform, where a valve and long swivelling pipe is located. The latter is swung over the dome of the tank car, and the tank full run in.

There is in addition a 1½" branch connection located at the loading platform, so that drums can be filled here if necessary. The long 2½" W.I. pipe to the loading platform passes beyond to the No. 11 tank house.

POWER DEPARTMENT.

(See Album, Pages 17-21.)

BOILER HOUSES—In connection with the Plant, there are hree Boiler Houses, West, East, and Mill Boiler Houses.

WEST BOILER HOUSE—The West Boiler House (see album, ge 17 and dwg. A380) was formerly that of the General Distil- ry, it contains six Babcock & Wilcox water tube boilers, four of 5 h.p. each, and two of 250 h.p. each, a total of exactly 1,200 p. The boilers are fitted with Jones Underfeed Stokers, and oper- e under forced draft, and the flue gasses are carried away rough a smoke breeching 5' 6" x 6' 8" to an outside self-support- g steel stack 7' 0" dia. x 125 ft. high on a 12' 0" dia. base.

Boilers—The 250 h.p. boilers contain 120 tubes 4" dia. x 18' long, and have two 37" dia. x 21' 6" drums cross connected at the rear. The 175 h.p. boilers contain 80 tubes 4" dia. x 18' long and have a single drum 48 dia. x 21' 6" long.

Stokers—The stokers are of the Jones underfeed type, two to the 250 h.p. boilers, and one to each of the 175 h.p. boilers. The stoker hoppers are hand fired, and the feed mechanism operated from forced draft fan pulley.

The boilers operate at 125 lbs. pressure, and deliver steam through a 10" main to the building containing the Distillation and Fermentation Sections. A recording pressure gauge is placed in the steam main before it leaves the boiler room. The pressures as shown by the charts from this gauge vary considerably, from 100 to 120 lbs. per sq. inch.

Auxiliaries Room—There is a 19' 6" x 50' 6" Auxiliaries Room (see album, page 18) at the east end of the Boiler Room, partitioned off to protect the auxiliaries from dust. This room contains the feed water heaters, hot water drum, forced draft fans and engines, boiler feed pumps, auxiliary lighting plant, venturi boiler feed meter, and various gauges.

Feed Water Heater—Exhaust steam is returned through an 8" exhaust main to a 600 h.p. closed feed water heater, through which the boiler feed is pumped by the boiler feed pumps from the 6' x 6' feed water tank, into which are connected lines from different traps close by and an overflow from the sterile water tank in the Fermentation Department. The drum is supplied with either cold city water through a 2" branch, or hot water (160-180°) from the coolers.

The feed water fed to the boilers has an average temperature as shown by the recording gauge of from 180-200° F. when the coolers are running; when the coolers are off, during the sterilising period this drops to 130-150°. Temperatures of boiler feed as high as 222° have been recorded. The increase in power thus secured is obvious.

Boiler Feed Pumps—The boiler feed pumps are three in number, two duplicates are 9 x 5 x 10 outside packed duplex pumps, the other a 15 x 8 x 12-750 g.p.m. duplex steam pump.

BOILER FEED MEASUREMENT—The hot boiler feed is measured by 4" x 1¼" venturi meter, inserted in the 4" boiler feed line. The meter is provided with a recording and indicating instrument. The rate of boiler feed varies widely depending upon the demand for steam, number of stills running, pumps, etc. The general rate of feed runs from 40,000 to 70,000 lbs. per hour.

FORCED DRAFT—The boilers operate under forced draft from two fans, each belt driven by a 10 x 10, 60 h.p. high speed steam engine. An air flue has been built around the breeching behind the boilers, for a length of 56 ft. through which the fans draw, and through a 54" pipe, discharging into the forced draft duct under the boilers. This is found to result in the air being delivered to the boilers at a temperature up to 150° F. resulting in an appreciable increase in power developed.

EAST BOILER HOUSE—The east boiler house (see album, page 19) contains eight 100 h.p. horizontal return tubular boilers. Each boiler has a shell 66" dia. x 16 ft. long of ⅜" steel, and containing 54—4" x 16 ft. tubes. The boilers are good for 70 lbs. pressure only. The battery of boilers is provided with two fuel economizers, and with forced draft, from two fans, one normally employed driven by 20 h.p. 750 r.p.m. motor, the other steam engine driven. The flue gases are carried off in a brick stack.

The two boiler feed pumps (see album, page 20) are 9" x 5¼" x 10" duplex inside packed steam pumps, and are arranged to draw from rectangular 8 x 10 x 8 ft. deep (¾ plate) hot water tank above and discharge either through the economizer and to boiler feed header, or to header direct.

There is located in this boiler room an unused water softener consisting of a 12' dia. x 27' high steel tank filled with softener feeding devices, baffles, etc.

The boilers are equipped with Jones Underfeed Stokers hand ed.

MILL BOILER HOUSE—The boiler house of the Mill (see album ge 21) is not now used, although it is in proper condition for mediate use, should it be required. It contains four 100 h.p. rizontal return tubular boilers 66" dia. shell x 16' long, of ⅜" te, and with 54-4" dia. x 16 ft. tubes. These boilers are good 70 lbs. pressure only, and are fitted with Jones underfeed stokers. The boiler feed pump is a 9 x 5¼ x 10 inside packed duplex steam pump, there is a 12' dia. x 10' boiler feed water tank above, and the boilers are equipped with a fuel economizer. Forced draft is insured from a motor driven (15 h.p. 750 r.p.m.) fan, (30' dia. x 14" 6-blade impeller) and the stack is of brick.

OPERATION OF BOILERS—The boilers of the West Boiler House have for some time now been operating under a very heavy overload. Additional boiler capacity was urgently required, but the condition of the market precluded any chance of securing boilers with reasonable deliveries.

To operate continuously at the heavy overload great care had to be taken of the boilers. The boilers were blown down once every shift (three times a day) and one boiler was cleaned each week, and any necessary repairs to brickwork made. Formerly the tube cleaner was run through whenever cleaned, but since adopting the use of a boiler compound this has been necessary only on alternate cleanings.

In the east Boiler House also one boiler was always out for cleaning.

The effect of the attention paid to the steam generation was very effectively shown in the reduction on coal consumed. Thus, during the first year's operation the coal used was double, sometimes more than double the corn mashed. After the improvements in the boiler room, and in the management of the boiler rooms were carried out, this dropped steadily, until the coal used was less tha 80% of the corn mashed, even with over double the production o the early days.

The addition of the M.E.K. load has increased the coal consumption recently until it is now about equal to the corn mashed.

STEAM SYSTEM—The different boiler houses are interconnected by steam mains in order to permit of drawing stea from either one in case of repairs to the other. Much of this inte connecting piping has been installed in the last five years, and ha resulted in the system becoming an exceedingly complex, and i volved one due to the impossibility of any extended shut down t allow of a complete overhauling of the steam system. There a two pressures employed in the live steam system with to so extent two distinct systems, a high, and a low pressure system, b the two systems are interconnected at various points properly safeguarded by check valves to allow of steam from low being used in high where necessary.

HIGH PRESSURE SYSTEM—The West Boiler House since the boilers there are capable of working under 125 lbs. pressure supply a steam system working under that pressure, which takes care chiefly of the Fermentation and Distillation Departments. This line supplies the rectifiers (through reducing valves) beer stills (live steam) cooling water pumps, various spirit pumps, cooler pumps and high pressure steam for sterilising steam locks, etc. On this system are placed two Locke regulator systems, one of which supplies steam to the 15 lbs. pressure system for the cookers, mash line sterilising connections, etc., and the other the 12 lb. system for the seed tanks, inoculators and culture vessels.

A 4" line leads from the west end of the steam header in the west boiler house to the shipping department supplying the various pumps there, and the drum washing tanks and nozzles.

60-LB. STEAM SYSTEM—The boilers of the East Boiler House (and of the Mill Boiler House when in use) are good for 70 lbs. pressure only, and they are therefore connected in the so-called "60 lbs. system."

This 60 lbs. system from the East Boiler House supplies stills and pumps of the Trinity Still Building, the Mill engine, mashing equipment, mash pumps, digester, beer pumps, and connects into the high pressure system of the beer stills. The Mill Boilers connect into this 60-lb. system.

A branch from the 60-lb. system connects through a by-pass system with the M.E.K. plant steam manifold, and also connects through a check valve into the high pressure system at the beer stills. This enables the M.E.K. and the beer stills to be put on high or low pressure steam as required or as nature of loads demands.

A newly installed cross header from the East Boiler House to the West supplies the two stills and the four spirit pumps in the Mill Street Still Building and also the M.E.K. plant where it connects into the other 60 lb. line to the steam manifold.

EXHAUST STEAM SYSTEM—An exhaust system has been installed, which starting in the east boiler house picks up the exhausts from the boiler feed pumps, shop engine, follows the 60 lb. main through Trinity Still Building picking up exhausts of spirit pumps and then across to Mill and Mashing Building where all the exhausts are received (the main mill engine runs condensing) thence through Fermentation Department Annex where beer pump exhausts are connected in, and across to the Distillation Building. Here the exhausts from cooler pumps, spirit pumps, water pumps, etc., are received, and the header passes through machine shop to the exhaust feed water heater in the West Boiler House.

The exhausts from the M.E.K. are picked up in a 4" main which connects into the exhaust header near the beer stills.

The exhaust system is at several points connected through reducing valves to the high and low pressure systems, so that when plant shuts down or when no exhaust is available, live steam is admitted to the exhaust system.

The exhaust system pressure is 4 lbs. and from the system are supplied all the building heating systems, the mash tubs, and beer stills.

In connection with the continuous cooking system large quantities of exhaust steam were to be liberated and led through an 8" header into the exhaust steam system supplying the beer stills. There was arranged at this point one of the cross connections admitting live steam when exhaust fails.

Drips System—A drips system has also been installed in the plant. One section of the system 4" collects the drips from the traps on the coils of the Trinity Stills and returns them to the hot water tank in the east boiler house. A second system collects those of the mashing and milling departments. A third section, the principal one, collects drips from heating systems of men's quarters, offices, M.E.K. plant and Fermentation Department, discharging to a drips reservoir in floor under beer stills where they are cooled by water from the still condensers and discharged to the sewer.

Water Systems—There are two sources of water, one from the municipal mains from which potable water is secured and the other by means of pumps in the plant drawing non-potable water from the bay just south of the plant. The water in the bay is fouled by numerous sewer discharges and wastes from industrial plants. The water is supplied to the plant from the municipal mains from the Mill Street and Trinity Street mains.

A 4" supply main enters the north wall of the Fermentation Department from which branches lead to the coolers, to the hose connections on operating floor for washing down and cooling fermenters (non-potable water could not be used because of odors) to the seed tank and inoculating rooms, (also for cooling, etc.) to the beer line flushing out connections and to the feed water drum in the boiler room. A 2" branch supplies the constant level tank of the M.E.K. plant, which feeds through the city manifold the scrubber acid diluting, etc.

There is also a 4" supply entering the east boiler house for boiler feed purposes when the coolers are not working and a 2½ into the west boiler house, which is used only as an emergency supply for boiler feed.

Another 2" supply from Trinity St. supply the men's quarters and offices and there is a 2" line into the fire station for boiler feed.

HOT CITY WATER SYSTEM—The water from the coolers leaves at about 160 to 180° F. and is pumped by the two hot water pumps (see cooling) through the hot water system which supplies the boiler feed drum in west boiler house, the hot water storage tanks in mashing department, from which the mash tub hot water system is supplied, the hot diluting water for the lead still in the M.E.K. plant and the boiler feed water to the Mill, East and Fire Station Boilers.

Running at full capacity the coolers are capable of supplying all the hot boiler feed water and all the hot water for mashing required.

BAY WATER SYSTEM—Two 12 x 14 x 18 inside packed duplex steam pumps rated to handle 1,000 g.p.m. at 100 lbs. draw bay water through 14" suction pipes and discharge through two vertical 8" lines to an open 11' 2" dia. x 6"-5,300 gal. deep water tank at roof level of Distillation Building. From this tank bay water lines run to condensers of beer stills and the condensing columns and goose tanks of rectifiers in the Distillation Department. A 5" main runs parallel to the 60 lb. steam main, supplying through 4-2" lines the dephlegmators, condensers of the Mill Street stills with cooling water. A second main runs to the M.E.K. building supplying the bay water manifold.

The bay water tank is also arranged to be supplied from the fire system in case of accident to bay water pumps.

The Trinity Street Stills are supplied with cooling water from an 11' 9" x 10' 2" x 6' 9" steel tank on the roof which receives water from the fire pumps.

FIRE SYSTEM—A 22 x 20 x 11 x 15 High Pressure Tandem Compound Water inside packed duplex steam pump, and a 18 x 11 x 15 high pressure duplex steam inside packed pump are located in a small isolated fire protection pump house on the east side of Trinity Street. These pumps draw water from the bay, and supply a fire protection system of hydrants and hose connections which are described in the Architect's Report.

The boiler room of the fire pump station is equipped with two 85 h.p. Babcock and Wilcox boilers with 36" x 21' x 7/16" plate drums and 48-4" x 16' tubes. The boilers are good for 200 lbs. pressure and are hand fired. Steam is always kept up in one of the boilers and the other ready for instant use.

The boilers are supplied by a 6 x 3 x 7 single acting outside packed boiler feed pump, and the jet condenser of the tandem pump has a 6 x 10 x 12 pump.

COMPRESSED AIR SYSTEM—Compressed air is required in moderate quantities around the plant for various purposes, for moving acids in the M.E.K. plant, for acid agitation, for butylene handling, and for operating pneumatic tools used in the construction work that is continually going on.

The compressed air system is supplied by two air compressors in the "stone floor" which discharge into a 36" x 10' steel compressed air tank from which the 2" main of the compressed air system leads. The compressors are a 10 x 10 x 12 steam compressor and a 6 x 8 x 220 r.p.m. belt driven compressor. The latter is used only when there is an extra heavy demand for air.

COAL STORAGE AND HANDLING COAL SHED—The plant is equipped for burning slack coal which is received entirely by rail. The cars are unloaded by hand into horse drawn one-ton coal carts and taken to the coal shed or other coal storage.

The coal shed is of timber frame, corrugated iron covered construction 81 ' x 211' x 18' high (at eaves) with hip roof. A ramp is built up the north side of the building leading to elevated runways from which the coal is dumped in piles on the ground below, and afterwards the carts are simply drawn over the top of the pile. About an 18' depth of coal may be accumulated in this shed.

Auxiliary Storage—Due to great difficulty experienced in getting coal and in getting it delivered due to scarcity and freight congestion in the winter, which has resulted in plant shut downs. this year several auxiliary storage piles were accumulated. These auxiliary storages were built up in vacant land east and west of the coal shed, and both they and the coal sheds were provided with ample ventilating capacity. Some 14,000 tons had been accumulated when the plant was closed down.

Handling—From the various coal storages, the coal is loaded by hand into the horse drawn carts and carried to the different boiler houses, where it is dumped in front of the boilers. The carts take away the cinders on the return trip.

Due to the inconvenience of this method of coal handling and to the variation in size of coal supplied during war time, a coal crushing and loading plant was under consideration at time of closing of plant, consisting of track hopper, crusher, elevator, weigh bin and scales.

Piping Color Scheme—The great multiplicity of piping used for the conveying of the various fluids of the plant rendered a piping color scheme for the identification of the various pipe lines a necessity. Such a scheme was in course of application and was as follows:—

Steam—live—pink.
    exhaust—black.
Water—city—white.
    bay—light green.
Acid—red.
Mash—red.
Spirits (Acetone)—blue.
Inoculant—dark green.
Waste—brown.
Compressed air or gas—yellow.
Butyl alcohol—grey blue.
Butylene—grey blue—yellow bands.
B. H. S.—grey blue—red bands.
Secondary Butyl—grey blue—brown bands.
M. E. K.—grey blue—green bands.

REFERENCES.

More detailed descriptions and information regarding various elements of the plant are given in the following references:

REF. 1. MASH TUBS.

NEW TUBS—During the last 30 months the mash tubs have been giving considerable trouble owing to breakdowns of various kinds. The tubs previous to the taking over of the plants by the British Acetones had been idle for some time, and on being put into use again under the hard continuous working of the acetone plant rapidly developed leaks around the various pipe connections. The wood was continually rotting away at these spots with the consequent putting out of commission of the tub. These breakdowns have necessitated a great deal of overtime and Sunday work on the part of repair gangs. Finally, the tubs reached such a condition that rebuilding became imperative if a shutdown of the plant was to be avoided. It was decided that while the tubs were being rebuilt that they would be enlarged sufficiently to permit mashing a complete cooker of mash at once in order to eliminate the difficulty now experienced in dividing a mash between two cookers, 1½ mashes to a cooker. The work was originally laid out so that one tub would be taken out, the new supporting steel put in, new tub built in and connected up, the plant in the meantime operating on three tubs only. This latter could be done nicely with a little speeding up and use of live steam instead of exhaust to quicken boiling. With the closing down of the plant on the signing of the Armistice, the job was tackled as a whole, one tub having in the meantime been rebuilt. The old timber and steel supports and the mass of water, steam, mash, beer and other piping of the old distillery are being removed (see album, page 30). A new system of supporting steel has been laid out and fabricated (see section of report on Buildings), using as far as possible exis ing cast iron columns and wrought iron box girders, and is no being put in. The new mash tubs are built of cypress, and ar of the same diameter as the old but 6' 11" deep instead of 5' 6 The deepening was rendered desirable in changing the steel eliminate the great distance from bottom of girders in old constru tion to bottom of tubs. The old beams were latticed, making awkward to get at connections on tub bottoms. The original heating coils will be used again, as well as the present rake drive.

The piping to the mash tubs, steam and water, will be greatly simplified, as well as the mash piping between tubs and mash pump, in order to give a more free flow to the pump suction.

HEATING COILS—In the beginning of the work the mash was boiled up by simply injecting 60 lb. steam into the tubs through the sparger pipe, the coils not being used at all. This involved the use of a considerable quantity of live steam, since to raise say 4,000 gals. or 40,000 lbs. of water from 50° to 212° F. with 60 lb. steam (total heat 60 lb. steam=1181 B.T.U., heat of water at 212°=180 B.T.U., released heat=1001 B.T.U.) would require the condensation of 40,000/1001 x 162—6472 lbs. approximately 650 gals.

As the plant capacity began to increase and the boiler capacity to be crowded, the need for economy in steam became imperative. This was further the case owing to the price and difficulty of obtaining the necessary coal. Consequently, steps were taken to economise on the heat of the plant, one of which was the installation of an extensive exhaust steam collecting system. The exhaust steam thus collected was then used where possible in place of live steam, as in stills and mash tubs. Three of the four coils of the tubs (outer, inner and second) were connected to the exhaust steam system, leaving the sparger and third coil on the 60 lb. steam for use in emergencies. Although considerable difficulty was encountered at the beginning with the mash-men in overcoming their prejudices against the exhaust steam, they were gradually overcome and they now object to using the live steam. The use of the exhaust steam in the coils had another result in the thickening of the mash, owing to the great amount of condensed steam not entering the mash.

REF. 2. COOKERS.

(See Album, Pages 47 and 48. Dwg. A381.)

COOKER CONSTRUCTION—The cookers were originally four steel east tubs, 12 ft. diameter by 12 ft. deep, of 5/16" plate, with ngle-riveted lap joints. They were flat-bottomed, stood on timber ands 10 ft. high of 10" x 10" timber, and were fitted with a ght cover only.

To convert these into pressure cookers capable of withstanding a small pressure, 19" domed heads of 5/16" plate were riveted on and the bottoms reinforced by riveting to them six beams built up of two 12" channels at 20½ lb. back to back, between which at the ends plates were riveted which extend up and are riveted through angles to the tank sides. Thus reinforced the tanks were passed by the Government Inspector, and withstood a static test of 22½ lbs., and are normally operated with safety set at 15 lbs.

There are two outlets from each tank, the main one (recently put in) through a 5" flange bolted to the bottom 24" from side, and a second (originally the only one) through a special steel bowl casting riveted in the centre of the tank bottom, which provides a 4" outlet and also acts as a step-bearing for the stirring gear.

STIRRER—Through a special stuffing box and gland in the centre of the cover a 3" W.I. pipe extends to the bottom of the cooker, where it is fitted with a screwed cross which carries a bronze plug with a pin running in the bearing of the bowl casting, while the two side openings carry 4 ft. lengths of 1" pipe, from which close to the cross, 4 ft. side branches lead. This arrangement provides four arms at right angles, reaching to within 2 ft. of the tank sides and parallel to but 3" away from the tank bottom. Bolted to the central pipe about 12" above the bottom is a cone stirrer not now used.

To the top of the central pipe, about 2 feet above the tank top, is fitted a special stuffing box and gland, into which a 1½" steam pipe (on the 15 lb. system) is connected. The connection is provided with grease-cup lubrication, and is steadied by braces from the building steel (see album, page 47). Below this connectio gland is bolted a long bent handle, extending to beyond the cooke side, for rotating the central pipe and stirring arms by hand, whil below this is a worm wheel, formerly used for power stirring. A large cast iron bearing stand is bolted to the cover close to th central pipe, which also formed part of the power stirring arrangements formerly used.

FITTINGS—Each cooker cover is provided (see album, pages 47 48) with a 3" pop safety valve set for 15 lbs. from the exhaus of which a 3" vertical pipe leads to the outside. The elbow clo to the valve at the bottom of this vertical vent pipe is tapped an fitted with a short ¾ nipple to drain the vent and prevent a he of mash or water accumulating in the vent and putting a back pressure on the valve. A small galvanised iron funnel and 1" pipe carry the drip to the gutters on the ground floor. There is also a 2" bent nipple tapped into the cover of every cooker which is provided with a tee, on one branch of which is a 2" swing check valve (set to act as a vacuum valve) and a 2" brass gate (for blowing off), and from the latter a 2" line leads to the open air. Each cover has a 14" x 21" manhole, and a 30 lb. 5" dial pressure gauge is tapped into the cover.

A water gauge is mounted on the side of the cooker, the top fitting (brass) of which is tapped in 12" from the top. The gauge carries a 15" x 1½" O.D. glass. Into the top of the upper fitting a ½" high pressure steam line is tapped (see album, page 48). There is, beside the large glass a small ⅝" x 15" glass, which was formerly used. The top fitting of this gauge is 4" from the tank top. A ½" sampling or try cock is tapped into the north side of the cooker 4" from the bottom, where it can be reached from the runway.

Mash Outlet—The mash outlet from the cookers is through a 5" flange bolted to the tank bottom, from which a 5" W.I. pipe line drops vertically, to a 5" mash header running under the cookers. There is a 5" gate valve close to the tank bottom, and between the valve and the cooker in the outlet is tapped a ½" steam connection (high pressure steam) for sealing the valve against contamination and boiling up mash pocketed in outlet on top of valve, thus preventing settlement of mash.

This steam line and the one tapped into the bowl casting (see later) are both supplied by a single 1" line leading down from the operating floor where the control valve is located, and both this supply line and that leading to the water gauge glass are supplied a single line from the 125 lb. high pressure steam system.

Seed Tank Charging Outlet—The other outlet from the cookers through the bowl casting is used to draw off mash for charging the seed tanks. The bowl casting is of cast steel, carries the step bearing for the stirring shaft, and has tapped into its side ½" high pressure steam line, which by means of a long threaded nipple carries an elbow and short nipples so placed as to direct a of steam on the face of the valve, preventing contamination and also ensuring cooking and stirring of the pocket of mash in bowl casting and valve.

REF. 3. CONTINUOUS COOKING.

OUTLINE OF SYSTEM—A system of continuously cooking the mash as it comes from the mash tubs was designed, installed and tried out at Toronto on July 2, 1916. It provided for receiving the mash from the tubs, pumping it continuously without interruption through the mash line, and exploding it into a cooker, from which it flowed to a second, and thence to a third cooker, and was withdrawn from the third and pumped through the coolers continuously to the fermenters. A brief outline of the system follows; for a more detailed description, reference should be made to the Report of July, 1917.

The new mash line and digester (see Mashing) formed part of this system; the pressure on the digester was to be held around 50 or 60 lbs. per sq. in., which permitted a pressure at the cooker and of at least 45 lbs. on the mash. The mash line is of 5" pipe about 400 ft. long, and at 200 gals. per minute (12 fermenters day of the then 25,000 gals. each, the maximum output contem plates) this gave the mash about 1½ minutes' cooking under gradually decreasing pressure, which reached at the cooker end 4 lbs. with a temperature of 292°. The mash is not only subjecte to this pressure and temperature of steam, but is thoroughly churn ed up and agitated, securing good penetration of starch cells by th steam; a certain amount of cooking, and probably complete ster lisation. (See Report of July 14, 1917, Engineering Section—a pendix to Report on Continuous Cooking; also Report of Mr. B. Speakman.)

The mash at the cooker end passes through a specially design angle exploding valve combining an exploding and relief valve one. By means of this valve any desired back pressure may be ke on the mash line, regardless of cooker pressure or rate of workin and the mash passing through the valve has the pressure sudden dropped from 45 lb. down to 15 lb., 14 lb. or 12 lb., depending the pressure being used in the first cooker. The mash is then p jected vertically through a short length of pipe into the cook where it is sprayed uniformly over the top of the mass of mash the cooker by means of a spraying nozzle on the end of the p at the mash level, 10' 6" from the bottom.

The mash settles or flows gradually downward and across cooker, and enters a passage leading up the side of the coo farthest from the inlet nozzle. The passage is formed by rivet a sheet iron baffle to the side of the cooker, the bottom reaching to within 6" of the bottom, while the top projects above the level of the mash about 12" preventing mash flowing out of the cooker unless it passes up through the passage thus formed. The outlet from the cooker is through an 8" pipe 10' 6" from the bottom, behind the baffle, in which is an 8" gate valve. This pipe leads directly into the next or No. 3 cooker at the same level.

At the entrance of the 8" pipe to No. 3 Cooker it is fitted with a special deflecting baffle to spray the mash to either side of the ooker. It then settles and escapes into No. 2 cooker in the same way as into No. 3.

No. 3 cooker is the final cooker, and the outlet from this cooker s arranged by continuing the 5" outlet pipe from the bottom upard a distance of 9' 0". This pipe is surrounded by a 12" pipe et 6" above the bottom, permitting entrance of mash at bottom (similarly to the baffle passage in the other two cookers), and xtends 18" above the top of the 5" outlet pipe to prevent the ash flowing in from the top.

From the side of this cooker an 8" pipe connects with the fourth ank, similarly to the other connections, but the pipe projects inde Cooker No. 2 and carries an elbow and short nipple reaching ose to the roof. This later arrangement is to carry off the exust steam into the final tank used as an exhaust steam reservoir, d from which an 8" exhaust steam line connects with the plant haust steam system.

The cookers up to this time stood on individual heavy timber nds (see album, page 63). With the connecting up of the cookers th 8-inch pipe for the continuous cooking system, the shortness of ese large connections between the tanks (see album, page 48) dered the individual stands highly dangerous owing to the posility of a slight setttlement of one tank putting the connection der severe strain or even wrenching it off. For this reason the oden stands were replaced by a steel framework, so that the kers were carried on what amounted to a pair of long continuous ms extending under all four tanks (see section of Report on ldings), (see album, pages 61 and 62), supported on steel colns, knee braced and standing on heavy concrete footings.

During the trial the mash was projected into the first cooker h the velocity acquired as a result of the explosion and subsent vertical drop and sprayed over the surface. The pressure in the cooker was maintained at 15 lbs. and by throttling back slightly the valve between Cooker No. 4 and Cooker No. 3 the pressure in No. 3 was held at 12 lbs., allowing a slight drop in pressure. The steam released during the explosion in the exploding valves, and also during subsequent drops from cooker to cooker, coupled with the mash flow having to pass through the throttled 8" pipe, causes an appreciable velocity through the pipe between the cookers, and a good spraying action over the surface of the mash in each cooker. Similar action occurs between cookers No. 3 and No. 2, and the pressure is maintained in No. 2 at 9 lbs., while that in the exhaust steam reservoir is held at 4 lbs. Any settlement of a sludge or thick mash at the bottom of the tanks is prevented by occasionally at half-hour intervals say, stirring the mash by rotating the four steam stirring arms.

The flow of mash through the system is controlled entirely from the mash floor end. In the final cooker (No. 2 tank) is placed a float acting on an automatic pump control which regulates the speed of the cooler pump to suit that of the mash pump. Mash is thus pumped out at the same rate as it is fed in. This mechanical arrangement on trial was found to work perfectly.

The great advantage of the system, and one of the principal reasons for its introduction was the great saving in steam to be effected. In it all the steam thrown out of the mash during the drop in pressure from the 45 lbs. down to 5 lbs. is recovered and used in the exhaust steam system for beer still operation or mashing, etc. Thus at the rate of ten fermenters per day (or 270,000 gals. per day), which is 11,250 gals. per hour, or say, 110,000 lbs. per hour, the temperature drop (45 lbs. to 5 lbs.) is 281°-228° F. the heat liberated in the form of steam is 110,000 x 53=5,830,000 B.T.U., resulting in the evaporation of 5,830,000/1156=5043 lbs. of 5 lb. steam. At a time when the coal scarcity in Toronto was severe this was an extremely important consideration.

During the trial the rate of flow was 12,000 gals. per hour, and the mash thus had a period of 1½ hours' cooking under pressure varying from 15 lbs. down to 5 lbs., besides the sterilising, cooking and breaking up action of the digester, long mash pipe and subsequent explosion.

The system from a mechanical point of view worked perfectly; it was easy to control and manipulate, considerable latitude could be easily secured with the exploding valve and its various adjustments, while the levels were properly maintained and the pressures could be easily adjusted to a nicety by regulation of valves between cookers, and there was absolutely no danger of bursting the tanks owing to too high pressure. The possibility of under cooking through short-circuiting was reduced to a minimum.

Unfortunately, during the trial the pressure maintained in mash line was only 30 lbs., which gave insufficient explosion effect, besides lacking in penetrating power, and this, coupled with the use then for the first time of an apparently poorer grade of corn, resulted in the yield of acetone dropping slightly, apparently through the poorer corn and undercooking, although sterility was secured even in the first cooker. As at the time the prime need was for acetone in the largest possible quantities, it was not felt justifiable to experiment further, although undoubtedly the system would have operated satisfactorily even from a chemical point of view, had a higher steam pressure been put in the digester.

REF. NO. 4. DESCRIPTION OF PRESENT COOLERS.

See album, pages 58-63, and dwgs. A231, A389 and A403.

For details of construction, see Mr. Shaw's report.

Proposed Additional Cooler—During the period immediately preceding the closing down of the plant, the cooling capacity was gain becoming cramped. The rate of working was then ten fer-enters of 27,000 gallons of mash each, which allowing for the two ne-hour sterilising periods meant the cooling of 12,270 gallons of ash per hour. A fourth cooler of an improved type was there-ore under consideration.

It was proposed in this cooler to replace the outside water cir-its by the oval openings cast on the boxes instead of feet, which hen the passage was not required, would be blanked off by a ece of plate. At the ends where the water circuit passed be-ween the two boxes of a pair, an opening was to be made in the ate bolted between the boxes, through which the water could pass om chamber to chamber.

The end coil connection casting was to have been changed in der to provide it with a handhole for cleaning out the debris, om straws, chips, waste, etc., which comes through with the sh, enters the casting and becomes jambed in the entrance to one other of the coils.

REF. NO. 5. INOCULATING SYSTEM.

PRODUCTION OF INOCULANT—The growth of the culture in the plant proper takes place in three separate stages, and in as many tanks or vessels, before the fermenter is finally inoculated. The culture from the laboratory is poured into small 5 gal. culture vessels filled with about 3 gals. of mash. After the proper period of growth or fermentation, this 3 gals. mass of inoculant is fed through the piping into the 95 gal. inoculators, containing about 50 gals. of mash in proper condition. This 50 gals. of inoculant, after reaching the proper stage, is in turn used to inoculate 400 gals. of mash in the 625 gals. seed tanks, which forms the final step before the fermenter is reached. The 400 gals. of inoculant produced in the seed tanks inoculates 27,000 gals. of mash in the fermenters.

The whole system in the plant is a closed one; from the time the laboratory culture is poured into the culture vessel the inoculant flows from one closed vessel to another, through closed sterilised pipes, which when not in use are under steam pressure. The culture vessels, inoculators, and seed tanks are all of copper, provided with the necessary connections, fittings and instruments for securing sterility, watching the progress of the culture and the prevention of accidents.

UNDERLYING PRINCIPLES—In connection with the inoculating arrangements, there are several points or principles which underlie the whole design and layout, and which are essential to the proper working of the system. These points will be evident from the above description:

(a) The pipe lines and tanks not in use are at all times kept under steam pressure.

(b) On all mash and inoculating lines, provision is made for washing out with sterile water and steam after using, and afterwards keeping under steam pressure

(c) All drain lines are steam-locked as the only sure means of safe-guarding against contamination working back through leaky valves. It has been found unwise to rely on the tightness in a bacteriological way of any valve or cock.

(d) The transfer of inoculant and mash is by gravity assisted by steam pressure toward the end. Pumps are not used, although a rotary pump submerged in an anti-septic bath was tried in the the early days.

(e) The measurement of the gas generated has been completely abandoned as unnecessary and involving serious risks of contamination.

(f) Vacuum valves are not used due to the impossibility of securing such valves which are bacteriologically tight and that will operate on the very small vacua desired here. Instead, the air valve is used in conjunction with close observation of the pressure-vacuum gauge.

(g) The air valves are provided with a flange on which is placed a cotton wool filter when the flow is likely to be into the tanks, as when cooling, to prevent the entrance of foreign bacteria.

(h) The stuffing boxes where the stirrer shafts pass through the covers have glands fitted with a small funnel surrounding the shafts (see Dwgs. A171-2-3) into which antiseptic solution is poured to prevent contamination.

The production of the inoculant as outlined above is carried out n two rooms at the west end of the fourth and the third floor of the Fermentation Buildings. The upper room known as the Culture Room contains the six culture vessels and six inoculators, together with a 100 gal. mashing kettle, while the lower room, the Seed Tank Room, contains sixteen seed tanks.

MASH KETTLE—Mash for the culture vessels and the inoculat- rs is produced in the Culture Room in the 100 gal. mashing kettle (see album, page 40). The latter is an open vessel of 16 guage pper 38" diameter x 32" deep, with hemispherical steam jacketed ottom. It is carried on a pair of cast iron A frames, and is equip- ed with two paddles and a scraper carried on a central shaft, the addles rotating in a clockwise sense, while the scraper rotates ounterclockwise, carried on a sleeve. Both are belt driven through vel gears and pinion at 11 r.p.m.

The paddles mix the mash, while the scraper in addition to its ixing section prevents settlement of sludge and baking on the eam jacketed bottom. The outlet from the kettle is through a ntral pipe at the bottom, the opening into which is controlled by plug attached to the bottom of the central shaft, and controlled by ising or lowering the shaft by means of a lever. When the shaft raised, the paddles (on the central shaft) do not rotate, but the raper (on the sleeve) continues revolving.

The jacket is supplied at the top with low pressure steam, 12 lbs. per sq. in. through a 1" pipe, angle-valve controlled, and the drips escape from the bottom through a 1" line, in which are a check valve and globe valve, to the drips system.

Cold water is supplied to the kettle through a 1¼" pipe turned over the side, whilst the outlet for the mash is 2" and is arranged so that the mash may be fed to the inoculators or turned into a tray under the kettle, draining finally to the sewer, as when washing out kettle.

CULTURE VESSELS—The culture vessels (see Dwg. A171 and album, pages 40 and 41) have a nominal capacity of 5 gals., are made of 16 gauge copper, 13" diameter x 12" deep, with hemispherical steam jacketed bottom and flanged domed cover. They are provided with a 16" x 3" paddle stirring gear, driven by hand through bevel gears and horizontal handle. The covers are each provided with connection nipples for a 5" dial, 30 lb. 30 inch pressure vacuum gauge, a 250° mercury thermometer, a ½" gate valve for air inlet and gas outlet, a 1" filling valve (gate type), and a special stuffing box through which the stirring shaft passes. The stuffing box is special in that the gland is provided with a funnel around the shaft, in which antiseptic fluid may be poured to prevent contamination, and also takes a collar on the shaft and gear. Both valves carry nipples and a small funnel fitting into which in the case of the filling valve the copper funnel is fitted to receive the mash or inoculant.

There is a ½" sampling tap in the side of the vessel near the top and a 1" outlet at the bottom, while the jacket is provided with a ½" connection near the top for either steam inlet or cooling water outlet, a ⅜" connection near the bottom for condensed steam outlet, or cooling water inlet, and a pet cock drain at the bottom.

INOCULATORS—The inoculators (see Dwg. B173 and album pages 40 and 42) are of 16 gauge copper, 3 ft. diameter x 2' 7 deep, with hemispherical steam jacketed bottom and 6" dome flanged cover, with a capacity of 95 gals. The cover is provide with a special stuffing box, the gland of which is fitted with a funne for antiseptic solution with three screwed 1" flange connections fo 15 lb. 30 in. vacuum pressure gauge, a 260° F. mercury thermometer and inoculating connection, and connection for a 1½" bras air valve gate type, and in addition carries a 4" inside diamete screwed cover handhole fitted with rubber washers.

In the side of the tank 9" from the top is a 2" filling connection, 12" from the top a ½" test cock, and 3" from the top a ¾" water gauge connection.

The jacket which may be used for steam or water is fitted with 1" steam inlet, 1" steam return and water inlet, a ¾" water connection, and also a ⅜" air vent.

A 4' 6" length of 1 3/16" shafting projects through the cover carrying a 16"-5' pitch propeller about 9" from the bottom, set to throw the liquor upwards. The lower end of the shaft is rounded and fits into a foot rest in step bearing standing over the outlet on four feet. The stirring shaft is belt-driven at 88 r.p.m. by means of two six inch diameter metal pulleys and 2½" quarter turn belt from a countershaft behind the inoculators.

The outlet from the tank is 2" inside diameter in the centre of the hemispherical bottom.

SEED TANKS—The seed tanks (see Dwg. A172 and album, page 43) have a capacity of 628 gals., are built of 12 gauge copper, cylindrical in shape, 4' 6" in diameter, 6' 6" deep, with dished bottom and flanged domed cover. The cover is provided with an 11½" x 15" manhole, special 2" flange for an air valve, (2" brass gate valve, with 5½" diameter filter flange) 1" flange for gas connection, 1¼" flange for pressure gauge connection (either 5½" dial 30 in. 30 lb., or 30 in. 15 lb. pressure vacuum gauge), and an unused 1¼" flange, and in the centre with a stuffing box for 1 7/16" diameter shaft, fitted with antiseptic fluid funnel. Down one side are three ¾" connections, 19" apart, the upper two of which are used for the fittings for a 1" O.D. x 15" gauge glass, and the lower one for a bib cock. There are two ¾" diameter connections, one above the other, on the other side for 240° F. angle thermometers, the top one 15" from the top flange, and the other 3' 6" below top one. At the front of the tank 9" from the top flange is a 1½" diameter connection for the inoculating line, and there is a 2" outlet from the centre of the bottom used for filling, emptying and draining.

Just under the upper flange is a semi-circular cooling ring formed by riveting to the tank, along the top only, a shaped strip of 20 gauge copper. At the front of this ring is a ¾" cooling water connection through which the cooling water enters the passage and flows out under the bottom unriveted edge down the side of the tank in a curtain or sheet cooling the tank and its contents.

The seed tanks are carried on four cast iron legs, 16" high, to which is bolted a ring of 3" x ½" flat iron on edge, and inside this rests a ring of ½" square iron. In the recess formed by the two rings the seed tank rests, placing the pressure where it can be best resisted.

STIRRING GEAR—The stirring arrangements are rather complicated in the seed tanks in order to secure as rapid cooling as possible, to mix the "head" up with the rest of the liquor when emptying and to prevent incipient "foaming." The central 1 7/16" x 8' shaft runs in a step bearing at the bottom similar to that in the inoculator, and carries about 10" from the bottom a 16" diameter x 5' pitch propeller set to throw the liquor downwards. About 18" and 40" above the bottom two stationary baffles 12" wide of 16 gauge copper are riveted across the tank, one at 90° to the other, and between these an agitator is fastened to the shaft, consisting of a tapering blade of 16 gauge copper carried at an angle in a cast iron hub. The agitator and propellor, rotating at 32 r.p.m., thoroughly mix the beer and "head," while the stationary baffles prevent the mass as a whole rotating. In cooling, the single agitator reduced the time occupied in cooling from 3 hours to 1¼ hours with two agitators the period was further reduced to ½ hour, bu was too hard on the culture.

INOCULANT PUMP—Owing to difficulty in getting the inoculan out of the seed tanks and into the fermenter feed line in a previous inoculating layout, and trouble with the "head" in seed tank, power feed was tried out. A small 2" rotary driven pump wa connected into the inoculating line from the seed tank to fermente and belt driven so that it emptied a seed tank in 20 minutes, or the rate of 25 gals. per minute. Obviously, the great objection a pump is the suction or vacuum produced, and the difficulty securing tight glands. This difficulty was overcome in this ca by submerging the whole pump in a tank of anti-septic fluid. T direction of flow in the inoculating line was reversed so that t flow was from west to east, through the pump (or bypass arou pump) thence down through floor to fermenter feed line, where t inoculating line was provided with blow-off valve and drain, t steam sterilising inlet being at the other end. The use of the pu was abandoned when the whole inoculating layout and location w changed, although the pump had worked satisfactorily.

"HEAD"—Experiments were also carried out in the seed tanks with a view to breaking up the "head" and getting it mixed in with the rest of the inoculant, because it was found that the best part of the bacteria culture was in the "head" and unequal "seeding" resulted when the head was not got out, one fermenter working more rapidly than another. Various systems were tried of which the most successful was that now employed consisting of the rotating beater or agitator and propeller set to throw mash downward and thus draw "head" down, while stationary blades or baffles prevent rotation of the mass as a whole, or simply spinning. Originally, two beater blades were used, one above the upper fixed baffle and the present one between the two fixed baffles, but it was considered by the bacteriological department that the upper one interfered with the proper development of the fermentation, and it was therefore abandoned. In cooling, through superior circulation produced, the time was reduced with the two blades to ½ hour as against 1¼ hours with one blade, and 3 hours with none.

REF. 6. FERMENTERS.

See Dwgs. A382-387 and album, pages 46, 48-53.

DISADVANTAGES OF FERMENTERS—The design and construction f the new fermenters installed has been largely influenced by the pe of fermenters in the original plant, in order to conform to isting levels, buildings and piping. The fermenting tanks are, r this reason, subject to several grave disadvantages, which in an tirely new design could be wholly or partially eliminated. The st important disadvantage is the extreme difficulty of manipulat- g them, due to their weakness. The tanks without reinforced bot- ms (original alcohol fermenters) are only good for an internal essure of 1½ lbs. per square inch and the reinforced bottom tank r 3 lbs. A very small excess pressure causes the bottom of the mer tanks to bulge and raise the sides and top of the tank. This fect when considered in connection with vacua is even more ious. Since during the normal operation of the tank the possi- ity of producing a vacuum in the tank is always present, the dvantage of the weak tanks is obvious. A very slight vacuum sufficient to draw the bottoms of the dished bottom tanks up- rds into the tanks, breaking connections and straining the tanks dly.

Another resultant disadvantage of the weak tanks, is the length of time required to sterilise the tanks, when maximum steam pressure that it is possible to use is under half a pound per square inch. This means a long period of sterilisation, with the consequent reduction or restriction of the duty of the tank on actual productive parts of the process.

The flat bottom is a serious disadvantage from the point of view of emptying. The draining and flow of the outlet is slow, especially slow as the tank becomes nearly empty, the pressure causing the flow slight and the light gluey mass of the "head" begins to interfere. The swirling steam jets assist the emptying some, but undoubtedly the fermenter bottoms should be conical (this would give added strength also), with a good slope towards the outlet. (The fermenters built at Terre Haute were of this type and have worked well.)

Another disadvantage of less importance is the side inlet five feet from the bottom, which was inherited from the distilling days. This means that the mash and inoculant in its weakest state is projected through the air in the fermenter to the bottom of the tank and should there be any slight traces of contamination in the air of the fermenter gives it a better chance of overcoming the inoculant, while the latter is still weak. If the inlet and outlet on the other hand were both through the same opening in the bottom of the cone-bottomed tank (as in seed tanks), the culture would pass into tank directly into the mash and would have a better chance of getting properly started.

Fermenter Construction—The fermenters are cylindrical steel tanks, with a capacity of about 31,800 gals. There are twenty-two tanks, comprising fermenters of four different types, viz.: the original fermenters used in the distilling, those installed in the Fall of 1916, those built in the Spring of 1917, and those built in the Fall of 1917.

Type 1—Original Type—These were the tanks used in the fermentation of molasses, in the production of industrial alcohol (see album, page 49). They were 18 ft. in diameter, 20 ft. high on the straight, with slightly dished (6") bottom and no cover. The tanks were built of 5/16 plate with single riveted lap joints, were supported on brick piers and from the centre of the bottom a 4-inch emptying line ran through close nipple and elbow to the front of the tank. The 4-inch outlet from the tank was originally controlled by a plug fitting into it controlled by a long handle from the top of the tank. A set of four 1-inch perforated pipes radiated from a five-way fitting rested on the bottom of the tank, supplied with water through 1¼" line passing down inside of tank and out to the five-way fitting. This was used to wash out tank after emptying.

A conical roof of ¼ to 5/16 inch plate reinforced with angle rafters with 16-inch rise was flanged to these tanks since the fermentation has to take place in closed tanks. (Culture is anaerobic). To the cover at the apex was riveted a 6-inch screw pipe flange and the cover also was fitted with 12 x 16 inch manhole, two special 3-inch flanges side by side for safety valves, 4 inch flange for air valve and, in addition, was tapped for 1-inch thermometer gland and 1¼-inch steam pipe and 1¼-inch spring vacuum valve, which latter was later increased to two 1¼-inch vacuum valves and finally by 6-inch flanges for specially designed vacuum valves.

The 4-inch filling flange riveted on the side of the tank 4 feet 6 inches from the bottom at front was there in the distillery days, and it and the filling pipe originally were used for some time practically without alteration. Various holes were tapped in the sides of the tank. Three ½-inch for samplying cocks, two feet, ten feet and nineteen feet from top, five ¾-inch, five feet apart for water gauge extending full length, a 1¼-inch steam connection one foot from bottom and in the front just below the top a ½-inch manometer connection. A cooling ring of the 1¾-inch W.I. pipe encircled the tanks about three feet below the top carried on eight brackets, by means of which a curtain of water was sprayed on tank sides for cooling. The tanks when remodeled were subjected to a static test of 1½ lbs. per square inch.

The great disadvantage of these tanks was the small margin permissible in pressure variation. Thus, if the pressure became too great, the bottom of the tanks tended to take the spherical form bulged out raising tank bodily, while if a very slight vacuum was produced, the dished bottom of the tank was drawn up, breaking emptying connections and straining the tanks.

TYPE 2—1916 TYPE FERMENTER—(NOS. 20, 21 AND 22)—These tanks are 17 feet in dia. x 22 ft. 6" average height, are made of ¼" plate ½" cold driven, single riveted girth joints and double riveted longitudinal joints. The tanks have a conical cover flanged to shell and reinforced with ten 2½ x 2½ x 5/16 angle rafters, while the bottom is flat, with a 4-inch slope to the front, where the 4-inch outlet flange is riveted 8-inches from the side. The bottoms are riveted to the sides through 3 x 3 x 5/16 angles, and are strengthened by being riveted to six 12-inch I beams at 31½ lbs. running with slope carried on individual concrete pedestals. The fittings originally placed on the tank are the same as just described for the remodelled old fermenters, with the exception of the flange in centre of roof, which was made four inches instead of six and the location of the outlet flange.

These tanks, due to their reinforced bottoms, withstood a static test of 3 lbs. per sq. inch.

TYPE 2A—RECONSTRUCTED NO 1 FERMENTER—In the Fall of 1916 an explosion occurred in No. 1 Tank, which cut the tank in two near the bottom, threw the top section through the roof against the steel roof framing of building and generally played havoc with piping, etc.

The tank was immediately reconstructed by putting in a new lower belt of plate, replacing the ring cut by the explosion and a new flat bottom constructed and reinforced like those on the 1916 type (20 and 22) was riveted on. The dimensions of the tank when reconstructed were 18 ft. in diameter, a 20' 2" rear height and 20' 6" front height. The tank was subjected to a 3-lb. static test.

TYPE 3—THE SPRING 1917 TYPE—(NOS. 16-19)—These Fermenters are 18 ft. dia. x 19' 6" high at back and 20' 6" at front, of ¼" plate single riveted lap girth joints and double riveted longitudinal seams with cold driven rivets (see album, pages 51 and 61). The bottom is riveted to sides through a 3" x 3 x 5/16 angle bent to a circular shape, and is reinforced by means of the I beams as in previous types. The I beams in these fermenters rest on individual concrete piers a few inches above floor level. Owing to the great difficulty encountered in emptying the fermenters already in use, especially the last of the beer and "head," the greater slope was decided on for these new Fermenters, and, in addition, the outlet in the bottom at the front was now a special cone elbow casting 16 inches in diameter at top where riveted to tank and tapering and turning at right angles to a standard 4-inch flanged opening whose centre was 12 inches below tank bottom, in order to conform to existing piping. This construction considerably facilitated emptying the tanks. Also owing to difficulty experienced getting long-handled brushes, ladders, etc., into tanks through top manhole, because of its proximity to roof, a second 12 x 16 manhole was provided in these tanks in the side one foot from bottom 45 degrees from centre of front. A small oval shaped flanged casting was riveted to the covers of these tanks close to the centre of 4-inch flanges, with an oval opening about 3-inches x 6 inches, through which it was intended to insert a nozzle washing down device. The idea was later abandoned and the flanges covered with a cast-iron cover. These tanks were subjected to the 3-lb. per sq. inch static test.

TYPE 4—THE FALL OF 1917 TYPE—(NOS. 7-12)—The last six Fermenters were built in a building separate from Fermenting Department, a wall between the two being afterwards pierced by doorways (see album, page 53). The tanks were therefore hot riveted with steel rivets and the pitches were increased from 1½" and 2" in the single and double, riveted girth and longitudinal joints respectively to 1¾" and 2¼". The tanks are 18 feet diameter by 19' 6" rear and 20' 6" front height, provided with cone outlet casting at front and second manhole.

The tank bottoms are riveted to the I beams as before, but in this case the concrete footing instead of being in the form of individual pedestals or piers for each beam or a single heavy slab, took the form of two heavy reinforced beams or piers, some 12 feet apart, with axis at right angles to I beam axes. The tanks were not tapped for the gauge glass fittings nor for safety valve flanges. The roof rafters were ten 3 x 3 x 5/16" angles.

The tanks were subjected to a 3 lb. static pressure test.

FERMENTER FITTINGS—The Fermenters are now equipped with various fittings for the operation of the fermenter, including those for observing and checking the course of the fermentation; for performing certain operations on tank; for safeguarding the fermentation from contamination and protecting the tank from damage through undue pressure or vacuum (see album, pages 49, 51, and 53, and Dwg. A382).

The course of the fermentation is watched by means of temperature readings, acidity tests and samples and the rate of gas production during the early stages.

Temperature—Temperature of the mash is indicated in two ways, first by a recording thermometer with 40-220° F. range, of the mercury capillary type, supplied with fifteen foot capillary fitted with gland. The instrument is made by the Taylor Instrument Company. The gland of the capillary is tapped, (1" pipe thread) into the roof of the tank four feet three inches from the centre and the capillary passing through suspends the bulb about midway between top and bottom of the tank. The recording instrument is mounted at a convenient height (5 feet) on a vertical board (12 x 1½"), near the tank, the boards of all the tanks being arranged in parallel rows. Above the thermometer is the slide carrying the operation card and below it the manometer and file carrying the operation record of readings (see album, pages 52). The range of these thermometers is sufficient to permit of their being left in the tank during all operations, even steaming.

The other method of securing the temperature of the mash is by drawing a sample of mash at intervals in a metal vessel from the lowest sampling cock and taking the temperature of it, with ordinary brewery mercury dip thermometer. Temperatures thus taken show an average variation from the recording thermometer chart of 2 to 3 degrees higher or lower, which results from fact that samples are taken from near side of the tank, where radiation, proximity to other hot fermenters, etc., may seriously affect the temperature of the sample. Temperatures taken of samples from top, middle and bottom cocks shows a very slight variation in temperature in height of fermenter.

Acidity Tests—The tanks are each tapped for three ½-inch sampling cocks of the ordinary compression bib type, located two feet from top, halfway down and one foot from bottom. From these cocks samples are drawn for temperature measurements in a can, and for acidity tests in glass flasks.

Pressure—For indicating the pressure in the tank during various operations, a small glass U tube filled with colored water i employed. The tube is connected to the tank in the following way

A short ½ inch nipple is tapped into the tank and carries brass lever handled stop cock into which a second nipple is screwe carrying a $\frac{1}{2}$ inch cast iron cross set vertically. The lower outlet of the cross carries another nipple and a second lever handled stop cock. The opening opposite that leading to the tank is plugged and the fourth opening, that at the top, has a length of $\frac{1}{2}$ inch pipe about 12 in. long screwed into it, carrying a tee (or elbow), of which the upper opening is plugged, and the side outlet has screwed into it a plug into which a short $\frac{1}{4}$ inch copper tube is threaded. The rubber tubing is slipped over this copper tubing, and connects to the manometer which is quite close to the end of the copper tubs.

This arrangement was found advisable because of the difficulty encountered through the connections choking with mash. The construction as described allows the connections to be readily swabbed or blown out when convenient, without contamination.

The manometer is simply a $\frac{1}{4}$ inch glass U tube, with legs about 15 in. long and 3 in. apart, filled with colored water, with a scale marked on cross section paper, reading to one-tenths of an inch. This arrangement has been found quite satisfactory in practice.

AIR VALVE—The air valve is employed to permit of admission f air to the fermenter during certain operations. It consists of a our inch rising spindle gate valve, connecting through a short 4-nch nipple to the four-inch flange riveted to the roof of the tank ear the side, in order to be within reach of the operators. The alves have screwed into them on top short nipples, to which are razed copper funnels, 15 inches in diameter by about 7 inches deep, which fit loosely a removable one-eighth inch mesh copper gauze reen. The air filter of several thicknesses of cotton wool between eese cloth is tied over this funnel during time that valve is pened. Previous to cooling a tank, the funnels and valves are oroughly sponged out, with antiseptic solution and new filters tied . Under this action the former galvanised iron funnels disintegted rapidly and were replaced by the copper funnels now in use.

VACUUM VALVE—The vacuum valve employed is of special type, igned in the plant and constructed locally. The valve consists the body casting proper of brass some 5" long with hexagon top, eaded below this, on the outside with 7" standard pipe thread, by ich the valve is screwed into the 7" standard pipe flange riveted tank cover. The valve provides a 6 in. diameter opening through centre across which two arms are cast top and bottom, drilled in centre to act as guides for the valve spindle, a $\frac{3}{4}$ in. dia. steel rod, carrying at the lower end a 6½ in. O.D. brass valve disc with 45° cone seat, seating on a 1/16 in. wide seat turned on a lower end of body casting. The spindle projects above the upper guide some 4 in. and a short cross piece is driven through a hole drilled in it acting as a handle for grinding the valve in occasionally and testing valve's action between each fermentation.

A copper funnel 15 in. dia. x 5 in. deep with 2 in. straight section at the large diameter, is brazed into the top of the main body casting, and fitted into the larger diameter of the funnel is a removable copper screen of ⅛" mesh gauge. This being removable permits the easy examination of the valve, to see whether working properly, to regrind and to sterilise, when necessary, with antiseptic solution. A cotton wool filler is fitted on top of the screen, in the straight section of the funnel to prevent drawing in of foreign bacteria when valve operates.

The movement of the valve is resisted by a very light coil spring mounted around the spindle between the T handle and the upper guide. The spring is so designed that the valve operates on a vacuum of three inches of water.

The valves have been found thoroughly satisfactory in use, sensitive, readily accessible for cleaning and sterilising and proof against contamination of any kind. They are successful from both a bacteriological and a mechanical point of view, eliminating all danger of contamination from outside air and preventing absolutely danger of collapsing tank by too high a vacuum.

Safety Device—The function of this device is fourfold. It first of all acts as a safety relieving pressures exceeding the proper value, it acts as a gas meter through forcing the gas to pass through an orifice of definite size under a pressure indicated by the manometer it acts as a vaccum valve, and when gas discharge is large as a vent to the outside for these gases.

The device consists principally of a cast iron cross and a copper box (see Dwg. A60 and album, page 52). The cross is a special casting arranged to either screw into the 6" flange of the original fermenters or to bolt to the flange and close nipple screwed into the 4" flange of the new fermenters (the latter construction was used in order to keep a full 4" diameter outlet). The front flange of the cross is set at an angle so that the gas pipe bolted to it has an upward slant of 1 in. 10, in order that any liquid carried out in the gas may drain back into the fermenter. The other two openings of the cross are for cleaning operations, provided with hinged flanges, the upper one for cleaning the cross itself and the fermenter top in the immediate neighborhood of the outlet, and the back one to permit of the swabbing out of the gas pipe with a long swab. These cleaning-out operations have never been found necessary, the pipes and fittings being self-cleansing.

The device proper is in the form of a 6" square copper box about 46" long becoming circular at the top where it is flange-jointed (millboard gasket) to the 6" copper exhaust pipe, and with an open bottom. There is a dividing plate arranged extending lengthways in the box, which is shaped to eliminate all pockets and crevices around the flange for the gas pipe, which might possibly afford a hiding place for bacteria or make cleaning difficult. The dividing plate has cut in it a rectangular orifice with a notched upper edge permitting the easier discharge of gas and eliminating the sudden release of a large quantity that would occur under a flat edge, with the consequent surging. This orifice is equivalent in area to that of a 4" pipe, and the lower edge of the dividing plate is also notched. There is a gate controlled by a lever, which may be slipped in front of the orifice in the dividing plate which carries an 1½ in. circular orifice. The operating lever of this gate is bent as indicated, and moves in a closed sector (with thumb screw fastener) to catch any drip and keep the handle dry. Around the box a few inches below the water level, is riveted a perforated ring o dampen out surges and prevent liquid slopping over.

This box is arranged inside a 10" x 30" copper can into which he antiseptic water is poured from a pail or other container, hrough the larger lip, and overflows through the hooded overflow hich prevents the liquid level exceeding the proper value. The n is also provided with a second lip and bailing handle for empty- g and with a pair of roller handles. This can is suspended on sh cord carried over pulleys on the pipe frame and counterbal- nced by a cast weight. There are movable brackets on which the n is hung at different levels and the framework is arranged with rizontal arms on which the can may be rolled out of the way.

A large funnel underneath catches the overflow or froth and rries it through a 6" pipe to the drains in the floor below. The tion is as follows:

Steaming, Cooling and Filling a Fermenter—The can is at its upper level and the gate open, the device then acts as a safety valve relieving at 10" of water through a 4" pipe.

Fermenting—1st stage—The can is at the lower level and the gate closed, giving free gas discharge through an 1½" orifice, the pressure on which is measured by the manometer on the fermenter.

Fermenting—2nd stage—The can as in the first stage gate open, giving free discharge of the greater volume of gas now generated through a 4" pipe. The gate is opened after the pressure on the manometer shows 5 or 6 inches on the 1½" orifice.

Foaming—The can is further lowered until just sealing the end of the square box and the foam overflows the can and drips into the funnel. After foaming the can is cleaned out and replaced.

The devices were first made of galvanised iron and disintegrated rapidly. The copper ones are found to stand up well, except for the solder at the joints which disintegrates rapidly, and the iron operating handles which corrode rapidly.

Steam Connections—Each tank is provided with two 1¼-inch steam connections, supplied by 1¼-inch globe valve branch from high pressure steam main. One 1¼-inch connection passes through cover of tank close to side and extends down inside about two feet, where it is fitted with a tee, into which are screwed two one-inch nipples 9" long, fitted at the ends with 45° elbows and short nipples. These latter are set to throw two horizontal jets of steam across the top of the mash in the tank and were installed to break up the "head" when foaming commences, but have not been found very satisfactory in this respect.

The other 1¼-inch steam connection to the tank is made in the side 10 inches from the bottom, when it passes through and into centre of tank, and turns down into back of a five-way fitting, from which four arms of 1-inch pipe radiate, reaching to within six inches of tank side, where they are capped. The arms are drilled with three-sixteenth inch holes, 1½" apart, so as to direct jets of steam at 45° downward on bottom of tank.

The function of this set of jets is to clean out bottom of tank when emptying and afterwards to supply steam for sterilising and steam washing.

Cooling Rings—There are further provided several removable cooling rings, which can be removed from one tank to another as required. The rings are of one-inch copper tubing, be to form a ring of about 3 feet diameter, with one 6-inch gap in it, the ends of ring on either side being plugged, and connected opposite the gap, with a 1½ inch W.I. pipe, which acts as a handle and also supplied the cooling water through a hose connection at the other end. The ring is drilled with ⅛-inch holes 2½" apart.

The rings are used to apply cooling water to the tanks to prevent foaming. As soon as there is evidence that tank is beginning to foam, the cooling ring is placed around the cross on top of the tank and the cooling water turned on. This treatment has been partly effective.

Each fermenter is further supplied with necessary inlet and outlet valves described elsewhere and two 12" x 16" manholes, with two arches each, one in cover near side at front and the other in side 12 ins. from bottom at 45° to the front. These manholes are fitted with asbestos gaskets.

FITTINGS ONCE USED, NOW ABANDONED.

GAUGE GLASS—Originally gauge glass fittings were tapped nto the side of the tank every five feet, which were fitted with ¾ nch gauges connected together with brass connecting pieces to orm a continuous gauge glass from top to bottom of tank, behind hich and protecting it was a gauge board graduated in hundreds f gallons. Later this bottom fitting was fitted into an arrange-ent of piping tapped into the bottom of the tanks (similar to that escribed in connection with cooker gauge glasses) in order to in-icate lowest levels. The glasses, however, speedily became clogged ith mash and when connection was tapped into bottom, absolute- caked up, forcing the abandonment of the gauge glasses entirely d the use of the sampling cocks to determine approximately the vel of the mash in the tank.

COOLING RING—The 1¼" perforated cooling ring circling the nk and used in the distillery operations was tried in connection th acetone work, but was too powerful, cooling tank too rapidly, th resultant danger of vacuum and collapse, and was abandoned favour of the smaller copper movable cooling ring described pre-usly.

VACUUM VALVES—At the beginning, from lack of under-nding of the problem, a 1¼-inch stock pattern spring vacuum valve was tapped into the cover of each tank. The number was later increased to two. These, besides being hopelessly small for the work required of them, were erratic in action, and could not, even with especially fitted weak spring, he made to operate on the small vacuum required in the case of the Fermenters, especially of the old type with dished bottom. The result was that the Fermenter bottoms were in several instances drawn up through production of vacuum during cooling, breaking joints, deranging piping and interfering with operation of plant. Another very serious disadvantage of the ordinary vacuum valves was the impossibility of properly preventing contamination of the fermenter through air drawn in through the valves, or simply through the foreign bacteria working in over the seats of the valves. This defect of the valves was fatal from the point of view of this bacteriological process. A special vacuum valve was, therefore, designed to overcome these difficulties.

The vacuum valve proper as first designed is practically identical with that described previously (refer back), but differed in that it was dead weight balanced, while the valve now used is spring balanced. Thus, the movement of the valve was resisted by the flat end of a 24-inch lever pressing against the flat end of the valve stem. The lever was pivotted at the centre in a post tapped into the roof of the tank and carried on the other end a number of weights, sufficient to cause the valve to act at the proper vacuum. This arrangement was a decided improvement over the ordinary vacuum valve, and operated satisfactorily, except for a slight sticking occasionally due to the number of working joints, etc. Th valve was easily kept sterile and a serious source of contaminatio thus removed.

After a time it was decided to replace the dead weight balancing arrangement by a weak coil spring placed around spindle between the T handle and the upper guide. This arrangement is the one now in use and works perfectly, both from a bacteriologica and mechanical point of view, eliminating all danger of contamination through drawing in air and preventing damage to tanks b collapsing. The valve operates on 3 inches of water vacuum.

Safety Valves—Two 3-inch standard commercial iron bod spring loaded safety valves were first used on the tank placed si by side on the tank roof on 3-inch nipples and flanges, screwed in the flanges rivetted to the roof. From the valves 3-inch vent pipes led vertically through the roof to the outside air. These valves were subject to certain defects. The valves were very bad bacteriologically for same reasons that vacuum valves were, viz.: working back across the seat into the tank (even though valve apparently closed) of foreign bacteria. This was especially true in the safety valves, since, after having blown off, the vent and valve were thoroughly choked with mash or beer thrown out, that blown up the pipe and collected a mass of foreign bacteria from pipe sides and then on falling back to valve the bacteria developed rapidly and working across the valve seat contaminated the tank.

Further, it was a difficult matter to adjust the valves accurately to operate under a 1-lb. per sq.-inch pressure, which was desired.

The vent pipe after blowing off was left filled with mash, putting a static head of mash on top of the valve, preventing their relieving the pressure at the proper time. This was later overcome by draining the elbow at the bottom of the vertical vent pipe.

After several fermenters had been lost through contamination traced to the safety valves and experiments made with a crude apparatus had demonstrated its possibilities the water seal arrangement previously described (refer back) combining gas vent, gas measuring orifice and water seal was designed and installed. The irst ones were made of galvanised iron throughout, with swetted nd soldered joints, but the antiseptic solution (carbolic acid) oupled with the high temperature when bubbling through steam in oiling, the alternate immersion and removal of certain parts from he liquid and the nature of the gasses vented, caused the rapid estruction of the galvanised iron. The new ones were constructed f 20 gauge copper with rivetted and soldered joints and now stand p very well with the exception of the solder of the joints and the on gate lever which gradually is eaten away until it breaks or replaced.

AIR VALVES—The air valves used have always been of the inch gate pattern, but their location has been changed from time time. In the first place, when the gas collecting system was beg installed, the air valve was placed on the gas line leading to the s drums at the front of the tank where readily accesible. With e abandonment of the gas collecting system following the explon in No. 1 tank, the valves, now two in number, were placed on flanges on the tank covers. The number was afterwards again reduced to one. The funnels on these valves were first made of galvanized iron, but owing to rapid corrosion were later replaced by copper.

GAS VENTING SYSTEMS—The handling of the gas has from the beginning presented quite a problem, not only from the viewpoint of simply getting it away, but also from that of its measurement, the recovery of the acetone it contains and its possible use for power generation. Various proposals were made in the early days for the use of the gases—one proposal was to burn the gas, using the heat to save coal. Gas is discharged from a fermenter at rate of 5 c. ft. per lb. of meal, or 120,000 c. ft. per fermenter, of which approximately 50% is hydrogen and 50% carbon dioxide. Roughly, the heat content of the 60,000 c. ft. or 312 lbs. of hydrogen in the 120,000 c. ft. 7,248 lbs. of gas discharged in the fermentation of 24,000 lbs. of maize in 28,000 gals. of mash is 312 x 52920=26,501,000 B.T.U., representing 1893 lbs., or practically one ton of average quality coal. Without considering the cost of plant necessary to utilize this heat, the saving effected per fermenter with coal at $5.00 per ton equals only 1/10 cent per pound of total weight of acetone and butyl alcohol obtained per fermenter (approximately 1,700 and 3,700 lbs., respectively).

The great disadvantage of this proposal is the risk involved of explosion in connection with an explosive gas of this nature, either in connection with the pipes or burning arrangements, and it does not appear wise to run the risks involved to affect so small a saving.

WASHING DOWN SYSTEMS—(FERMENTER STERILITY)—The opinion was at one time held by the Bacteriological Department, as the result of frequent failures of fermentation, and examinations of the scale or coating forming on the inside surface of the fermenter tanks, that it was necessary to instal some device or system for washing down the inside of the fermenter after each fermentation. It was thought that the coating accumulating on the plates became so thick that foreign bacteria could lie safely in it and no be destroyed during sterilisation since the stream at such pressur could not penetrate sufficiently into the coating or scale. It wa further held that, even if the germs could be ultimately killed, th length of time devoted to sterilisation, in order to secure the necessary penetration, would be prohibitive, and it was on this accoun thought best to prevent scale forming by washing down the tank after each fermentation.

A scheme was therefore laid out and the new fermenters being built at the time (No. 16-19) were provided with a rectangular rounded flange, with a similar shaped opening through it, riveted to the cover. It was proposed to insert through this opening a rotateable nozzle, through which a powerful jet of sterile water (condensed steam) could be driven immediately, the tank was emptied against the roof of the tank at a small angle, the water then running down sides in a heavy deluge, carrying the soft coating, which had not had time to harden, to the bottom, where the swirling steam jets would wash it to centre and so out. With the application of the safety device, with its special cross at the centre, the design was altered to that of a permanently inserted nozzle, rotated by handle operated worm and gear, bolted to top flange of cross, totally enclosed against contamination. Whilst this system was being worked out, the Bacteriological Department were also investigating further and finally came to the conclusion, as the result of several long repeated runs without washing, that there was no danger of contamination arising in the coating, provided the fermenter was kept closed against outside contamination.

FOAMING—During fermentation there occurs at times the phenomenon of "foaming." Sometimes warning of what is about to happen is given through a slight rise of temperature indicated by the thermometer, at other times the first indication is the oozing out through the safety device and its pail of a slimy mass of gas bubbles and fermenting mash with which the whole gas space of the fermenter has become filled. The mass of thick slimy foam is forced out slowly at first but with increasing power until on many occasions the foam is forced up through the vent pipe and projected some distance above the end of the vent.

The "foaming" generally accompanies a particularly good fermentation, when good corn is being used. Recently when poor corn has been in use, practically no "foamings" have occurred.

POSSIBLE EXPLANATION OF PHENOMENON—The phenomenon of foaming is not understood. There is no known reason for the action of the fermenting mass, although it may reasonably be assumed that it is due partly to the sudden release of occluded gases in conjunction with a certain phase of the fermentation which sometimes occurs, the liquor assuming the colloidal state, and thus opposing the release of the gas.

Under such conditions it is probable that the gas generated in minute volumes at an infinite number of points is not able to collect in a large enough volume to rise until a certain stage has been reached. At this stage the surface tension of the liquid on the outside of the minute volumes of gas, having been sufficient to hold the gas at a pressure above that due to internal pressure, is upset and the imprisoned gas expands freely, collecting into larger bubbles. When this occurs at one point it instigates similar action throughout the whole of the mass. Under such conditions the volumes of the liquor will increase, tending finally to fill the whole tank, from which it is finally discharged at considerable pressure.

This explanation seems more probable than that there should be any sudden increase in the actual generation of gas, although in view of the obscurity attached to the action of the enzymes, it is possible that there may be an increased rate of starch decomposition occurring.

METHOD OF ELIMINATING OR COUNTERACTING—Various methods have been suggested, and some have been tried, for dealing with this trouble. Among them are the following:—

Circulating the Beer—A pipe system four inches in diameter was arranged in connection with a centrifugal pump capable of discharging fifteen to twenty thousand gallons per hour, and liquid was drawn from the bottom of the tank and discharged into the top of the tank above the level of the free surface of the liquid.

The idea was that such a circulation might do two things, viz.: mix up the head which at about this time collects on top of the liquor, and also give a discharge of the gas, which would then be freed from the liquid. This was tried, but without good results.

Steam Jets into the "Head"—Another means was to discharge steam at high pressure slightly above the top level of the liquid, or still higher, near the top of the tank. It has been found that this is partially successful, as in passing through the "head" or mass of foam, it evidently causes the liberation of a considerable amount of gas.

Water Cooling—The use of water cooling rings have also proved partially effective, if applied in time in arresting the foaming.

Steam Jets and Water Cooling—A combination of the steam jets and cooling ring is now used when indications point to a case of foaming in order to gain time to put the beer pump into operation. The steam jets blow the foam against the cold surface of the tank, partially checking the foaming and gaining valuable time to enable the beer pump to start drawing beer from the fermenter, thus lowering the level and giving more room for the foam.

The Use of Oil, etc.—Experiments have been made for the purpose of determining whether the use of oils, acetone or ether would have the effect of liberating the gas from the top surface of the fermenting mass. Any of these is found to be good in connection with what is termed frothing, i.e., formation of large gas bubbles, which sometimes occurs at an early stage of the fermentation; but the results are not good when tried on the real foam, which is characterized by the presence of as much as fifty per cent of the volume of the liquid in very minute gas bubbles.

The following method has been devised and applied to the fermenters for the prevention of foaming, and also to increase the yield of acetone from the fermenter.

Separate Finishing and Foaming Tubs—The yield of acetone has been found to be over ninety-five per cent. at from eighty to eighty-five per cent. of the time occupied until the yield ceases. Further, it has been demonstrated that the condition of the fermenting liquor is such that no foreign bugs can successfully compete with the B.Y. bacillus at this stage, which renders it possible to withdraw the fermenting liquor from the fermenting tank at a stage before complete yield of acetone is obtained and at about the time when foaming would occur or has just started in order to increase the duty of the tanks and prevent loss by foaming.

The present layout of beer piping and pumps was therefore installed, by use of which the tanks can be rapidly emptied, preventing loss of beer and attendant muss and disorder when a tank foams over. No interference was found to occur with the progress of the fermentation due to lack of complete sterility or to disturbance of the bacteria. In whiskey fermentation due to the form of the organism, any disturbance of the fermenting liquor immediately arrests fermentation. It was feared that the same would be true in this case, but apparently without cause, as the yield from tubs pumped across stand up just as well as fermenters not disturbed and pumped direct to beer still.

During the last months, when working on inferior corn, no "foamings" occurred, and as there was ample fermenting capacity, the fermenters were not generally thrown across to the foaming tubs until practically finished fermenting.

REF. NO. 7. BEER STILLS.

BEER STILL FEED—SINGLE PUMP SYSTEM—The original 6 ft. diameter x 41 ft. long beer still (see album, page 70) was supplied with beer for alcohol distillation by means of a steam engine gear driven duplex pump on the groud floor, to which the beer lines from the fermenters ran at floor level, and from which a discharge line ran to the top floor of building to the beer heater. The arrangement was made use of without change for the acetone distillation and worked satisfactorily until the plant capacity became too great and the pump could not feed the still fast enough.

DOUBLE PUMP SYSTEM—The feeding system was then altered, making use of two pumps and a still service tank. A 7 x 5 x 12 inch duplex steam pump was placed south of cooker No. 4 in the Fermenting Department capable of handling 8,000 gallons per hour at 80 strokes per minute. It drew beer from the fermenter beer main and delivered it through a 4-inch W.I. pipe line, which discharged through the cover of a 7,100 gallon copper beer still service tank on third floor. This line is now in place, connected into present beer system for use in cases of emergency (refer back). The tank was formerly a spirit weigh tank and drains through a 4-inch W.I. suction pipe, to the gear driven duplex pump on the third floor close to tank, just west of beer still condenser. The pump was a 6 x 12 duplex pump gear driven from a 6 x 10 single cylinder steam engine and discharged through a short 3 inch W.I. line into bottom of the beer heater. This arrangement gave close regulation of the rate of feed to the still since the controls were right on the operating floor and, in addition, the steam engine gear drive allowed of closer regulation than an ordinary steam pump. The two pumps increased the rate of working considerably and the use of a service tank was of some advantage in case of "foaming" as a portion of beer could be pumped out of the fermenter into the service tank. The tank was too small to be of much use in this respect, however, The operation of the beer still remained poor, due to irregularity or discontinuous operation, i.e., distilling one fermenter and then having to wait possibly some time for another, and due also to the lack of homogenity in the beer. The beer drawn from the fermenters varies considerably in density as the tub is emptied and finally when the head reaches the bottom, pumping is, difficult due to the slow rate of flow toward the tank outlet. When nothing but head is delivered to the still, it rapidly chokes the operation.

Foaming Tub System—For the above two reasons, and further and chiefly, as an attempt to deal with the question of foaming which at the time was giving a great deal of trouble, the use of the foaming or finishing tubs was decided upon, and in conjunction with them a 10 x 6 x 12 duplex steam pump capable of dealing with 11,700 gals. per hour at 75 strokes, was installed discharging through a 5" W.I. pipe line to the tops of the tubs through their cone covers.

Still Supply Pump—The beer was drawn from the tubs by a 10 x 6 x 12 duplex steam beer still supply pump in the Fermentation Department Annex, discharged through a 4" line across the court, into the header below the beer stills, from which the feed ines ran as now to the beer heaters. The service tank and gear driven pumps were dispensed with, the latter however was moved o the floor below, and again connected up to the service tank as escribed above for use in case of emergency. The still supply ump was fitted with a relief by-pass and automatic pressure control, so that the pump always maintained sufficient margin of pres-ure over that required to feed the stills, that the stillmen had some eway in regulating the beer stills. Later a duplicate pump was stalled discharging through a second line to the still header. A irly homogeneous beer was secured by drawing from two tubs once. Thus when one tub was nearly empty except for the head, e drain valve of second tub was opened and the pump started to aw fairly clear beer from the second full tub, and the clear beer ith the "head" and thick stuff coming from the nearly empty rmenter mingled, securing a certain degree of homogenity. The stem worked for some months fairly satisfactorily, although ouble was experienced with the regulation of the pump, due apparently to the beer clogging the delicate mechanism of the control, owing to the air becoming exhausted from the air chamber with resultant water hammer and also to trouble with the valves of the pump from the nature of fluid handled. The chief trouble arose from the corrosion of the interior of the pumps by the beer, which was extremely rapid, and quickly interfered with the proper operation of the pump.

CORROSION OF PUMPS—After one of the beer pumps had been in use for some time, it was taken down for repairs and was found to have been ruined by corrosion. The dividing walls between the various chambers had been in places practically eaten through. The pump was taken down and the steam end fitted with a new brass pumping end making it 10 x 8 x12, the bore of the beer and having been increased from 6" to 8". The pump was provided with forty large diameter (4") valves.

USE OF BEER SUMP—A further improvement in the system was the use of the beer sump in the south-east corner of the cellar to mix up the beer and head. The sump holding 8,000 gals. was fitted with stirring and mixing rake, and the existing 3½" copper emptying lines of the tubs drained through a 5" copper header directly into the sump. It was used in the whiskey distilling days for the same purpose, a plunger beer pump then drawing the beer from the sump and elevating it to the still supply tank. The 5" W.I. suction header of the two duplex beer pumps was extended to the beer sump and was fitted with a check valve (foot valve).

With this system, the beer and foam was run from the foaming tubs to the beer sump and was drawn from the sump by the two duplex beer pumps and discharged through two separate 4" W.I. lines to the beer header under the stills.

The brass-ended pump upon completion was placed in its present position just south of the beer sump, and has worked satisfactorily. There is no evidence of corrosion and the sump produces homogeneous beer, offering no difficulty in the stills.

PIPE CORROSION—The corrosion of the cast iron beer pump showed the risk of using W.I. pipes for the carrying of the beer and for this reason when the bronze end pump was set up at the beer sump, the suction piping was of 6" copper pipe and discharge from pump across to beer stills of 5" copper piping (existing).

Centrifugal Still Supply Pump—While the bronze end beer pump was being built, inquiries were made regarding the purchase of a brass centrifugal pump for the work. It was considered that the centrifugal would possess certain advantages over the duplex in smoothness of running, steadiness of flow, and freedom from fluctuations in pressure. The pump now installed was finally ordered, but no opportunity had been given to test out the arrangement before the plant was closed down on the signing of the Armistice.

Beer Stills—The General Distillery was equipped with a single 72" dia. x 41 long 19 plate beer still which was used without change for acetone work, and handled 6,000 gals. per hour of beer which was equivalent to a rate of operation of the plant of between five and six fermenters of 25,000 gals. each per day, allowing no margins. As soon as the rate of working of the plant commenced to approach this, the question of more beer still capacity became urgent.

It was found from observation of the working of the beer still that only about half the plates were doing effective work, in other words the liquor on the trays of the lower half of the still contained no trace of acetone or butyl. The decision was therefore made to cut the still in two, and with the addition of a new top and bottom section construct two stills of same diameter but with half the number of plates. This was done, and two 6' dia. x 10 plate stills were the result capable of handling 6,000-7,000 gals. per hour of beer each.

A detailed description of the old still and the two new ones is given in Appendix on Stills.

Slop Pipes—In the industrial alcohol distillation, the slop pipe from the beer still was 5" dia. copper piping leading to two "double effect" evaporators. When the plant was converted to manufacture acetone, this copper pipe was removed and a 5" W.I. slop line put in leading direct to sewer. This pipe, as the capacity of the plant became greater and greater and the beer still handled greater quantities of beer and discharged greater quantities of slop, gave a great deal of trouble through the rapidity with which the slop, at the high temperature at which it escaped from the still (220°) corroded, and disintegrated the iron pipe. After a time a galvanised iron pipe was tried and proved even less resistant to the corrosive action than the W.I. pipe. Finally, a 6" copper pipe was put in, when the old still was cut in two to form the present two beer stills, to carry away the slop from both stills, and so far this copper pipe has given no trouble. The pipe handles some 260,000-270,000 gals. of slop per day or at the rate of 10,800 to 11,250 gals. per hour or 180 to 188 gals. per min.

REF. NO. 8. RECTIFIERS.

Rectifiers and Alterations—The two 13,000 gal. rectifying stills of the General Distillery were employed for the rectification of the distillates in acetone production practically without any alterations except minor ones. These alterations are listed below, and the rectifiers are described in detail in the appendix on stills. The continuous acetone still, later added to the other two, is also described in the above-mentioned appendix.

The alterations or additions that were made in the rectifiers when taken over by the Government or subsequently may be summarized as follows:—

(a) Changing of bay water connection from goose tanks into reflux from goose to column for washing down column, to a city water connection.

(b) Placing of goose tank sampling lines running to pails on operating floor for reading temperature of goose.

(c) Soda connections into the east column on to trays 2, 4, and 6 from bottom, and also into kettles of both stills.

(d) Removal of fusel oil traps and cooler from reflux lines goose to columns.

(e) The insertion of a 3" copper line running from fusel oil trap of No. 1 rectifier through gate valves into the column on top of ninth and nineteenth plates, in order to speed up action of rectifier—was not successful, and now removed.

(f) Addition of various 1½" and 2" W.I. lines to existing lines from tail boxes of rectifiers.

Rectifier Arrangements—While the plant capacity was small the rectification of the A. B. distillate from the beer still was carried out in two stages, (a) first rectification in west or No. 1 recti fier, and (b) second rectification in east or No. 2 rectifier. The second rectification dealt with the A 2 fraction from the first rectification. In the second rectification the soda solution was run on the lower plates of the column.

The runnings from the first rectification were, in order, A 1, R2 (A2), A 1, B 1, and L.R. (last runnings), while from the second rectification were obtained A 1, A3 (acetone), A 1 and last runnings.

The plant capacity finally increased to a point where the two rectifiers were unable to handle the necessary rectifications on the above system of two rectifications with A3 from second one only, and it was decided to alter the system placing the two rectifiers on the first rectification and to place a contract for a continuous acetone still to deal with the second rectification. A contract was herefore let in May, 1917, for a modified Barbet continuous still apable of rectifying 10,000 lbs. per day, which was later increased o 14,000 lbs. per day. The still was installed but for some time ailed to operate properly, the quality of the acetone being very oor. In some cases A2 fed to the still came away poorer in quality han when pumped into the still. It was finally made to operate atisfactorily, although at a lower capacity than the higher of the bove figures. The auxiliary purifying column was apparently use- ss and was permanently disconnected.

While the continuous still was being adjusted, the Distillation epartment decided that it would be possible to produce pure ace- ne A3 in the first rectification. A trial charge was run through, e results of which were satisfactory and the method of distilla- on was changed to that at present in use, in which the bulk of e pure acetone results from the first rectification and the con- nuous still has very little to do, handling only the small amount A 2 resulting from the first rectification.

F. NO. 9. ACETONE STORAGE.

Formerly the crude acetone distillates were stored in light cop- r tanks in the distillery proper. These tanks were ones which d formed part of the equipment of the industrial alcohol plant. the plant capacity increased, and additional tanks and equip- nt were installed, the question of the storage of liquids in pro- s became acute, and as a result the present system of tanks was d out, in which the storage is an entirely separate section of the plant. There were several reasons for this change:—

1. The danger to employees and plant in case of an explosion of some of the other apparatus, or of fire causing a rupture of the tanks, resulting in the whole ground floor becoming instantly converted into a sea of flame, was a risk which could not be undertaken for a moment.

2. The cramped quarters in the building, lack of space, coupled with the construction work continually going on with the resultant carrying and handling of long pipes and beams and danger of puncturing the tanks with loss of distillate and danger of fire. The B1 tank was punctured by the end of a steel beam resulting in loss of a great deal of butyl.

3. The extreme lightness of the tanks which were only 16 o 18 gauge copper necessitated great care in handling them, in making new connections in them and rendered them extremely liabl to puncture by slight knock.

4. The cramped nature of the building resulted in the AB an A1 tanks being very close, two or three feet only, to the fermenters, particularly No. 19 and also No. 20. This was serious whe the fermenters were under steam, the heat radiated being grea To cool the distillate tanks at these times, the tanks were covere with heavy bagging wrapped around a perforated cooling pip around the top of tank, so that the water flowed down throug bagging keeping it saturated and both by the flow of water an evaporation of water cooling the tanks somewhat.

5. Additional storage capacity was required to provide a marg of safety, not then available, in case of emergencies. Only one ta of 14,341 gals. capacity was available for each of the distillates A A1, A2 and A3, which considering rate of production was insu cient.

The Tank Room in the Fermentation Department Annex w therefore built as it now exists to provide a storage capacity for t liquids in process of sufficient size to suit present and future nee in a separate building quite removed from fire and puncturing ri and of sufficient weight (12 gauge) to provide reasonable streng

Mixing of Distillates—The difference in specific gravity the various distillates and the impurities or other liquids t contain when in crude state, result in their tending to separ in storage into various layers or strata in the tanks. In charg a rectifier it is necessary to know the exact composition of the various portions of the charge to determine which samples are taken from the storage tanks. But if the liquids are lying in more or less separate layers in the tanks, unless a great number of separate samples are taken from an equal number of different depths, the resulting estimate of the composition of the distillate in the tank is likely to be in error. If the samples are taken at a number of different depths either from try cocks tapped into the side of the tank or by dipping or uncorking bottle at various depths and a fair estimate of the percentage composition of the distillate made, the pump will in withdrawing from the bottom draw away the heavier liquids first and unless the whole tank is mptied, the estimate made will not apply to the liquid charged to he rectifier.

For these reasons, the question of means of getting a homogen- ous liquid in the storage tanks received a great deal of attention. Different methods of stirring or mixing the liquids in the tank and reaking down the strata formation were devised and considered, s well as methods of withdrawing the liquid to the pump suction r for sampling simulatneously from all depths of the tank.

The method finally decided upon and about to be installed when e plant was closed down, was one of circulation. Thus the three side connections were provided on the tanks so that the liquid uld be withdrawn from the bottom of the tank by means of a mp and returned to the tank at the top or other side opening, culating the liquid and thus thoroughly mixing it up, prepara- y to taking the sample for estimation and the pumping of the rge into the rectifier.

J. H. PARKIN,
Mechanical Engineer.

proved:—
E. METCALFE SHAW,
Engineer-in-Chief.

LIST OF DRAWINGS.

PART I.

ACETONE SECTION OF REPORT.

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A 172	Seed Tank.
B 173	Inoculator.
A 207	Arrangement of Piping—Culture Room.
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7979	Continuous Acetone Still—Elevation.
7980	Continuous Acetone Still—Floor Plans.

BRITISH ACETONES, TORONTO, LIMITED

REPORT ON
PROPOSED METHYL ETHYL KETONE PLANT
AT
TORONTO

BY

EDWARD METCALFE SHAW, WH.SC., ASSOC. M. INST. C.E.

SEPTEMBER, 15, 1917. TORONTO, CANADA.

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PART I.

ECONOMIC CONSIDERATIONS.

PART I. (a).

PRODUCTION
of
BRITISH ACETONES, TORONTO, LIMITED.

This report will be found to deal with general matters of policy as well as the bare questions of plant installation and cost of operation.

It begins with figures now available, giving the exact yields and costs of Acetone and Butyl Alcohol. These figures are necessary since the question may have to be considered of producing more Acetone as against the conversion of Butyl into M.E.K.

E. M. S.

1. PRODUCTION OF BRITISH ACETONES, TORONTO, LIMITED.

Basis of Design—The plant of the British Acetones, Toronto, Limited, is at present (Sept. 15) operating at the rate of 2-43 fermenters a week. When the additions to the plant and quipment now being made are completed, this rate of working ill be increased to 72 fermenters a week or 12 fermenters per day a six-day week. In designing the proposed plant for the conver-ion of all or part of the butyl alcohol produced at Toronto as a by-roduct in the production of Acetone by the Weizmann process two izes were considered, one nominally a 50 gal. per hour plant, cap-ble of dealing with about one-third the butyl produced, the other 150 gal. per hour plant, capable of handling the entire output of utyl at 12 fermenters a day.

Present Production of British Acetones, Toronto—From r. A. Legg's figures given on another sheet it is shown that the ield of Acetone shipped and Butyl Alcohol 99% purity ready for conversion or sale and the yield of M.E.K. at 80% of the Butyl is as follows, per fermenter:—

TABLE 1—Yields of Acetone, Butyl, and M.E.K. per Fermenter

CORN.				ACETONE.			99% BUTYL ALCOHOL			M. E. K.		
Wet.		Dry.		Shipped.			Ready for conversion.			Ready for shipment.		
Lbs.	Tons	Lbs.	Tons	Lbs.	Tons	Gals.	Lbs.	Tons	Gals.	Lbs.	Tons	Gals.
18000	9	15480	7.74	1224	.612	153	2548	1.274	318	2038	1.02	255

(NOTE.—The short ton of 2,000 lbs. is used.)

TABLE 2—Weekly and Yearly Yields of Acetone, Butyl, and M.E.K. (12 Fermenters Daily)

	Corn (wet)	Acetone	Butyl Alcohol	M.E.K.	Total Solvent
Weekly(6 days)	648	44.06	91.728	73.38	117.44
Year (50 weeks)	32,440	2203	4586	3669	5872
Ratios........	14.7	1	2.08	1.664	2.664

COST OF PRODUCTION OF ACETONE AND BUTYL ALCOHOL

The chief factor entering into the cost of manufacture of the acetone and butyl alcohol by the Weizmann process, as carried out at Toronto is the cost of corn. Other costs are summarized under coal and labour and general expenses, including taxes and insurance. In addition to these, under ordinary circumstances, would be added the capital charges, depreciation, etc., but in the case of the British Acetones, Toronto, owing to the generosity of Messrs. Gooderham & Worts, this last item does not enter into the question. The entire cost of production then falls into the above three classifications, each of which is now considered in detail.

COST OF CORN—A fermenter charge at Toronto consists of 18,000 lbs. of wet corn meal. The corn at present being ground contains about 16% of moisture. During the milling process 10% of the original weight is removed as bran, and therefore the quan tity of corn necessary for an 18,000 lb. charge is 18,000 x 1/9 (18,000) = 20,000 lbs. The bran has at present a value of 60 cents a bushel, hence the net cost of the corn is:—

20,000/56 x – 2,000/56 y where x = value of corn and y the value of bran per bushel.

The price of the corn has varied considerably and the following table shows the cost of corn per fermenter for various periods. Messrs. Gooderham & Worts, when operations began, supplied the corn they had in stock at 91 cents per bushel. The price in pre-war times varied from 45 to 88 cents per bushel; in estimating the cost of acetone and butyl for one year after the war, the price of corn is taken at $1.00 per bushel, after which it is assumed the price will drop to about 60 cents per bushel.

TABLE 3—Cost of Corn per Fermenter

	Period	Price	Cost per Fermenter		
			Corn	Bran	Net
		$	$	$	$
1.	Bought and in use and will last until Oct. 15th..	1.88	671.43	21.43	650.00
2.	150,000 bushels already purchased, will last from Oct. 15th, to Dec. 1st....................	2.39	821.43	21.43	800.00
3.	Bought for December delivery, will last 6 to 12 months................................	1.27	453.37	21.43	431.94
4.	For one year after the war....................	1.00	357.14	21.43	335.71
5.	After one year, normal price..................	.60	214.28	21.43	192.85

The values of corn are in dollars per bushel of 56 lbs.

Cost of Coal—The coal used has relatively decreased with the increase in the number of fermenters per week, until for the week ending Sept. 4th with 45 fermenters distilled the weights of coal used and corn mashed were 774,200 and 774,000, respectively.

It will be found that with 72 fermenters weekly and with the economies now being introduced, the coal consumption, even in the winter, will be reduced below the corn used, and will probably fall to 75% to 80% of that quantity. For the present calculations the weights used of ground branless corn and coal are assumed equal.

The cost of coal now being used is $5.82, delivered to the boilers. There is 6,800 tons in stock, which by December 1st Col. Gooderham hopes to increase to 10,000, apart from the quantities used meanwhile. This quantity will carry on till next May, when it is probable that coal will be obtained at a price no higher than the present one. Hence, per fermenter 18,000 lbs. of ground branless corn—9 tons of coal at $5.82 will be used, and the cost per fermenter =$52.38. The normal pre-war time cost of coal delivered to the boilers was $3.25 per ton=$29.25 per fermenter.

Cost of Labour and General Expenses—The wage cost will only increase slightly whilst the fermenters increase from 42 to 72 per week, or 189 and 324 per month, as full shifts are now being worked and little extra labour will be involved under the present improved system of working. There will be an increase in cartage for hauling raw material and in connection with shipping. The present monthly labour costs are increased in connection with equipment by $1,800.

Operating the plant costs per month, at present, $8,775 for men and $1,625 for women. The men's labour will cost $9,450 in future, and women's $1,890. The cost of laboratory staff and operating, chemicals, etc., will remain at about the present amount of $1,070. Office expenses will remain at $400, and experts' cost about $1,600. It will be reasonable to charge half the experts' charges to operating expenses and a half to construction. When construction ceases, $800 per month will still be necessary under this head. Insurance $1,730 and Taxes $833, and General Factory expenses $3,833, complete the costs per month. The total cost of operation will be, therefore, per month, up to November 1st for 189 fermenters $19,066 or $100.90 per fermenter, and after November 1st for 324 fermenters per month $61.75 per fermenter. These figures are reckoned up to and from November 1st, though they will really be only approximately exact at some date prior to and after that time, because the transition will be gradual during two or three weeks.

SUMMARY OF COSTS OF ACETONE AND BUTYL ALCOHOL

Adding the costs of corn, coal, labor and general expenses determines the total cost per fermenter. This cost, together with the figures given in the section dealing with the production of Acetone and Butyl, make it possible to proceed with the determination of costs looking at the question from either of two viewpoints, either the point of view of an acetone factory purely and regarding Butyl as a by-product of more or less value or from the view point of a munition solvent factory producing both Acetone direct as a solvent and M.E.K. as a solvent, Butyl Alcohol being a half way stage.

In the former case the Butyl produced may be looked upon as a valueless by-product (as a munition solvent) and the whole cost of the fermenter borne by the acetone alone. If, as is the case, the butyl happens to be of value commercially for other work, and is sold, the revenue accruing from the sale may be applied to the reduction of the cost price of the acetone. The price at which some of that produced at Toronto has been sold varies from 21½c up to 35 cents per lb. 25 cents is taken here for the purpose of comparison.

In the latter case, the butyl alcohol stage is simply an intermediate stage between the raw material and the finished solvent and the butyl is therefore charged per pound, although unfinished as a solvent at the same cost as the finished acetone.

In the former case it is interesting to determine the price at which the butyl produced must be sold in order to secure the acetone for nothing, that is the revenue from the butyl covering the cost of production of the acetone and butyl.

All the preceeding results pertaining to Acetone and Butyl costs are set out in tabulated form in Table 4, following:—

EDWARD METCALFE SHAW.

TABLE No. 4

SUMMARY OF COSTS

Each fermenter produces in a finished state:

1224 lbs. Acetone

2548 lbs. Butyl—which may be converted into 2038 lbs. M.E.K.

	UNTIL :—	Fermenters per week.	Cost of Corn		Cost of Coal		Cost of Operation per Fermenter (dollars)	Total Cost per Fermenter (dollars)	Cost of Acetone and Butyl (cents per lb.)	Cost of Acetone Selling Butyl at 25c. per lb.	Price of Butyl for no Acetone cost
			Bushel	Fermenter	Ton	Fermenter					
			$ c.	$ c.	$ c.	$ c..	$ c.	$ c.	cents	cents	cents
1.	Oct. 15, 1917...	42	1.88	650.00	5.82	52.38	100.90	803.28	21.29	13.60	31.53
2.	Nov. 1, 1917...	42	2.30*	800.00	5.82	52.38	100.90	963.28	25.27	25.86	37.42
3.	Dec. 1, 1917....	72	2.30	800.00	5.82	52.38	61.75	914.13	24.23	22.66	35.88
4.	End of war.....	72	1.27	431.94	5.82	52.38	61.75	546.07	14.47	−7.41	21.43
5.	1 Year after war	72	1.00	335.71	4.50	40.50	61.75	437.96	11.61	−16.24	17.19
6.	Normal price...	72	.60	192.85	3.25	29.25	61.75	283.85	7.53	−28.83	11.14

* This is the highest cost reached during last year, but, although operating expenses have been higher per fermenter, corn (the big item) has kept down the total cost.

PART I. (b).

MEMORANDUM OF D. A. LEGG, A.I.C.

GROSS AND NET YIELDS OF ACETONE AND BUTYL ALCOHOL BASED ON RESULTS OBTAINED DURING THE PERIOD OF WORKING FROM DECEMBER 29, 1916, TO AUGUST 28, 1917.

From December 29th, 1916, to August 28th, 1917, the following are the amounts of dry corn meal used and the amounts of Acetone and Butyl Alcohol produced. The figures are based on weekly estimates.

Dry Corn Distilled	13,419,970 lbs.
Gross Acetone (Acetone in A.B.)	1,150,752 lbs.
Net Acetone (Acetone shipped)	1,062,148 lbs.
Dry Crude Butyl Alcohol (including Ethyl Alcohol)	2,464,984 lbs.
Real Butyl Alcohol, gross	2,277,445 lbs.
Rectified Butyl Alcohol (99% Butyl Alcohol)	2,208,432 lbs.

Notes—

(a) In calculating net acetone an allowance is made for acetone in process at beginning and end of period, deduction being made for average distillation losses.

(b) In calculating real Butyl Alcohol gross it is assumed that the Crude Butyl Alcohol averages 7.6% of ethyl alcohol.

(c) In calculating net Butyl Alcohol it is assumed that rectification losses from A.B. to final rectification are 4%.

Yields based on above figures are as follows:—

Acetone (gross)	8.57%
Acetone (net)	7.91%
Butyl Alcohol dry crude, gross (including ethyl alcohol)	18.37%
Real Butyl Alcohol, gross	17.0 %
Rectified Butyl Alcohol, net (99% Butyl Alcohol)	16.40%

Possible Output based on above figures—

Assuming 18,000 lbs. of wet corn per fermenter with a content moisture of 14%, the dry corn will be 15,480 lbs. per fermenter.

This gives the following weights of the two finished products per fermenter:—

Acetone (net)	1,224 lbs.
Rectified Butyl (net)	2,548 lbs.

	Acetone	Rectified Butyl Alcohol
At 6 fermenters per day for a week of 6 days, yield would be	44,064 lbs.	91,728 lbs.
at 8 fermenters per day, etc.	58,752 lbs.	122,304 lbs.
at 10 fermenters per day, etc.	73,440 lbs.	152,880 lbs.
at 12 fermenters per day, etc.	88,128 lbs.	183,456 lbs.

Estimated Yield of Methyl Ethyl Ketone.

Theoretically 100 parts by weight of n-butyl alcohol should give 97.3 parts by weight of methyl ethyl ketone. In this process, involving new types of plant and considerable number of distillations, it is somewhat difficult to estimate the yield on a large scale from laboratory and experimental plant results. On the small scale with a more or less improvised plant, the purifying, transference and leakage losses are considerable and vitiate the value of any direct comparison between amount of normal butyl fed in at first stage and amount of pure M.E.K. obtained finally. It is not justifiable to compare distillation losses with small columns with those of large stills as the latter always give much greater proportionate efficiency in purifying so that fewer distillations are required.

Judging from laboratory and experimental plant results and bearing in mind above considerations, I estimate that we should obtain an amount of pure M.E.K. equal to 80% of the butyl alcohol.

D. A. Legg,

12 Sept., 1917.

PART I. (c).

TOTAL PRODUCTION OF SOLVENT.

Total Production of Solvent.

The primary function of the British Acetones, Toronto, Limited, and of the proposed Methyl Ethyl Ketone Plant is the production of the greatest possible quantity of munition solvent. Bearing this in mind, the following tables have been prepared giving the actual and estimated production of acetone, butyl, methyl ethyl ketone and total solvent (acetone and M.E.K.) possible, up to certain dates, at Toronto under various conditions together with their value at current rates and the actual and estimated operating and equipment expenditures.

On the basis of Mr. D. A. Legg's figures after May 1, 1917, the Toronto plant will be turning out Acetone at the rate of 14,688 lbs. or 7.34 tons per day and butyl at the rate of 30,576 lbs. or 15.288 tons per day it being possible to convert the latter into 24456 lbs. or 12.278 tons of methyl ethyl ketone per day giving a total possible solvent production of 39044 lbs. or 19.52 tons per day.

The tables and figures are presented here in order to give the fullest information in condensed and quickly understood form so that the essential quantities and values involved in the proposed Methyl Ethyl Ketone Plant may appear in their proper relation to one another and enable a decision to be readily arrived at when considered in connection with the other determining factors.

PROPOSED M.E.K. PLANT

TABLE 5a—Acetone Production and Value

	Tons	Value at 19c. lb.
Acetone produced up to May 1 1917	253	$ 96,140
" " " Nov. 1, 1917	839	318,820
" " " May 1, 1918	1940	738,387
" " " Nov. 1, 1918	3032	1,155,960
" " " May 1, 1919	4144	1,574,720

TABLE 5b—Butyl Alcohol Production and Value

To whatever extent the conversion into M.E.K. is made, the unconverted butyl can be sold. The following table deals with the effect of such sales at 25 and 20 cents per lb.

	No Conversion	One-third Conversion	Full Conversion
Butyl alcohol sold or on stock May 1, 1917	658 tons	......	......
" " value at 25 cents per lb	$329,000	......	......
" " value at 20 cents per lb	263,200	......	......
Butyl alcohol sold or on stock Nov. 1, 1917	1833 tons	......	......
" " value at 25 cents per lb	$916,500	......	......
" " value at 20 cents per lb	733,200	......	......
utyl alcohol sold or on stock May 1, 1918	4363 tons	......	......
" " value at 25 cents per lb	$2,181,500	......	......
" " value at 20 cents per lb	1,745,200	......	......
utyl alcohol, weekly surplus from May 1, 1918	91.728 tons	61.15 tons	......
utyl alcohol, yearly surplus, from May 1, 1918 (50 weeks)	4586 tons	3057.5 tons	......
utyl alcohol sold or on stock Nov. 1, 1918	6656 tons	5892 tons	4363 tons
" " value at 25 cents per lb	$3,328,000	$2,946,000	$2,181,500
" " value at 20 cents per lb	2,662,400	2,356,800	1,745,200
utyl alcohol sold or on stock May 1, 1919	8949 tons	7420 tons	4363 tons
" " value at 25 cents per lb	$4,474,500	$3,710,000	$2,181,500
" " value at 20 cents per lb	3,579,600	2,968,000	1.745.200

NOTE.—As referred to here, Butyl Alcohol means 99% rectified butyl.

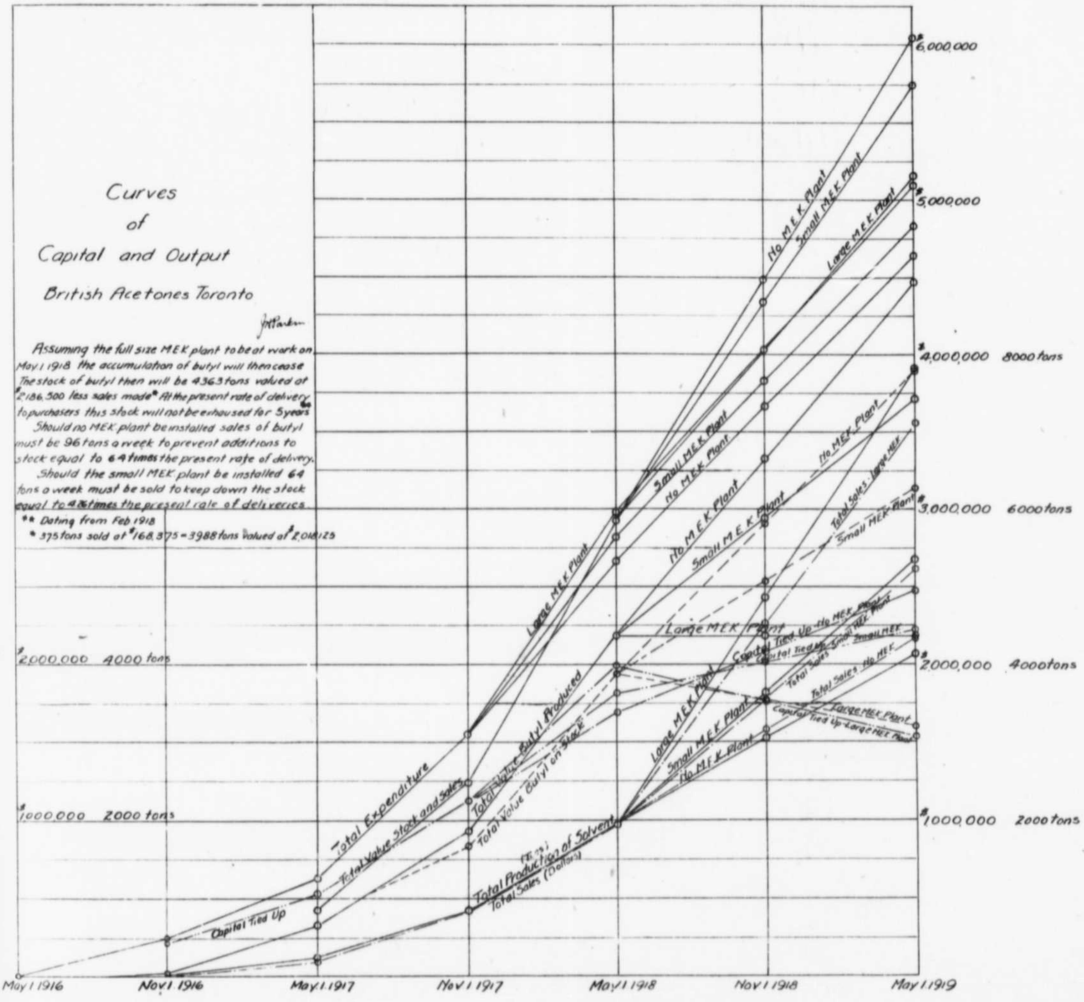
BRITISH ACETONES TORONTO, LIMITED

TABLE 5c—Operating and Equipment Costs

Operating	Acetone and Butyl Plant only	Cost, including M.E.K. Plant	
		Small Plant A	Larg Plant
Operating cost of production up to May 1, 1917..	$ 527,000	......	....
" " " " Nov. 1, 1917..	1,372,378	......	....
" " " " May 1, 1918..	2,503,827	......	....
" " " " Nov. 1, 1918..	3,486,753	$3,519,156	$3,553,
" " " " May 1, 1919..	4,469,679	4,534,482	4,603,
Equipment			
Equipment cost of Acetone Plant up to May 1, 1917	$112,666	......	....
Equipment cost, including the completion of the 12 fermenter a day plant, Nov. 1, 1917.......	173,666	......	....
Equipment cost up to May 1, 1918..............	173,666	$306,434	$48

cluding
. Plant

Large Plant
......
......
......
$3,553,
4,603,
......
......
$488,



Curves of Capital and Output

British Acetones Toronto

JHParker

Assuming the full size MEK plant to be at work on May 1 1918 the accumulation of butyl will then cease. The stock of butyl then will be 4363 tons valued at $2,186,500 less sales made* At the present rate of delivery to purchasers this stock will not be exhaused for 5 years**

Should no MEK plant be installed sales of butyl must be 96 tons a week to prevent additions to stock equal to 6.4 times the present rate of delivery.

Should the small MEK plant be installed 64 tons a week must be sold to keep down the stock equal to 4.36 times the present rate of deliveries.

** Dating from Feb 1918

* 375 tons sold at $168,375 = 3988 tons valued at $2,018,125

TABLE No. 6—SOLVENT DATA
PRODUCTION, EXPENDITURE, REVENUE, and UNIT COSTS

TABLE No. 6—SOLVENT DATA
PRODUCTION, EXPENDITURE, REVENUE, and UNIT COSTS

PERIOD ENDING	PRODUCTION (tons)				Total Expenditure Operation and Equipment	REVENUE				PROFIT	LOSS	Net cost per lb. (cents)	
	Butyl	Acetone	M. E. K.	Solvent		Butyl at 25 cents	Acetone at 19 cents	M.E.K. at 19 cents	Total			Acetone	Solvent
May 1, 1917	658	253	..	253	639,666	329,000	96,140	.....	425,140	.....	214,526	61.4	..
Nov. 1, 1917	1833	839	..	839	1,546,044	916,500	318,820	.....	1,235,320	.....	310,724	37.5	..
May 1, 1918													
No M.E.K. Plant	4363	1940	..	1940	2,677,493	2,186,500	738,387	.....	2,924,887	247,394	...	12.6	..
Small M.E.K. Plant A	4363	1940	..	1940	2,810,261	2,186,500	738,387	.....	2,924,887	114,626	...	16.0	..
Large M.E.K. Plant B1	4363	1940	..	1940	2,992,649	2,186,500	738,387	.....	2,924,887	.....	67,762	20.7	..
Nov. 1, 1918.													
No M.E.K. Plant	6656	3042	..	3042	3,660,419	3,328,000	1,155,960	.....	4,483,960	823,541	...	5.4	..
Small M.E.K. Plant A	5892	3042	612	3654	3,825,590	2,946,000	1,155,960	232,560	4,334,520	508,930	...	..	12.0
Large M.E.K. Plant B1	4363	3042	1835	4877	4,042,264	2,186,500	1,155,960	697,300	4,039,760	.....	2,504	..	19.0
May 1, 1919.													
No M.E.K. Plant	8949	4144	..	4144	4,643,363	4,474,500	1,574,720	.....	6,049,220	1,405,857	...	2.0	..
Small M.E.K. Plant A	7420	4144	1223	5367	4,840,916	3,710,000	1,574,720	465,120	5,749,840	908,934	...	..	10.5
Large M.E.K. Plant B1	4363	4144	3669	7813	5,091,874	2,186,500	1,574,720	1,394,600	5,155,820	63,946	...	..	18.6

NOTE.—After May 1, 1918, no capital expenditure on equipment should be required. All subsequent increase in the expenditure will be for operating the plant.

POINTS TO BE CONSIDERED.

M.E.K. *vs.* ACETONE—**Assuming that M.E.K. is** as efficient as Acetone the advantages as against producing elsewhere an equal quantity of Acetone by the Weizmann Process are:—

(1) The utilisation of further existing plant and premises placed at the disposal of the Imperial Authorities by Messrs. Gooderham & Worts.

(2) The further utilisation of the well organized and harmon-iously working staff at Toronto.

(3) Raising the quantity of solvent from 2203 to 5872 tons o solvent whilst saving the destruction of 54,459 tons of corn yearly which would be the extra amount necessary to add an equal amount of Acetone by the Weizmann process.

(4) Should the question of producing the Acetone by th Weizmann process in England be considered 54,459 tons of shipping must be provided instead of 3669 tons necessary for the finished product.

(5) If more Acetone is produced equal in quantity to the M.E.K the total quantity of Butyl Alcohol to be put on the market wi be increased by 7631 tons, or a total of 12,217 tons with a probabl reduction in the selling price which might seriously decrease th ratio of profit now made by the Butyl Alcohol sales.

QUERIES.

(1) Is the 3669 tons per year of M.E.K. as solvent needed?

(2) Can an equal amount of Acetone be produced or bought less time or for less money?

(3) Is it not better to produce 3669 tons of M.E.K. from But Alcohol than to consume an extra 54459 tons of food stuff (cor in the production of an equal quantity of Acetone, in addition the 36,000 tons consumed at present?

(4) Does the shipment of 54,459 tons of corn to England or conversion in Canada, affect the question?

(5) If extra expenditure on plant be incurred, how does it aff the question as regards—

(a) Its expenditure at Toronto.

(b) Its expenditure in England.

(c) Its value when peace is declared.

(6) $315,000 will provide the M.E.K. plant. It is better to spend this sum in producing means for producing further cordite solvent than run the risk of keeping that value or far more lying idle in the storage tank at Toronto in the form of Butyl.

EDWARD METCALFE SHAW.

PART 2

GENERAL DESCRIPTION.

BRITISH ACETONES TORONTO, LIMITED.

PROPOSED METHYL ETHYL KETONE PLANT AT TORONTO.

ALCOHOL—In conjunction with the production of Acetone at oronto by means of the Weizmann Culture there is also produced bout 2.1 times the quantity of 100% dry Butyl Alcohol.

The crude butyl alcohol as it comes from the second rectification asses to a setting tank from which the top layer averaging 75% ryness passes over into a second tank from which in turn it is umped into a large Butyl Storage tank. From the latter it is umped to the salting plant and salted, which removes a considrable part of the water and raises the dryness up to 90-92% this pumped to one of the three Trinity Street Gooderham and Worts ills. (No. 2-7,000 gal.) which can produce on the average 180 l. per hour of 99% Butyl Alcohol.

The net yield (yields based on the finished product) in per cent. dry corn being from December 29th, 1916, to August 28th, 1917. 91 Acetone and 16.40 Butyl alcohol (rectified) 99%. Each fernter batch uses 18,000 lbs. of corn (14% moisture average) and ,450 lbs. dry weight. Mr. Legg's figures for net yields of Acetone d Butyl Alcohol therefore give 1,224 lbs. and 2,548 lbs., respectly per fermenter. At 12 Fermenters per day the yield of Rectid Butyl is 30,576 lbs. This represents 3,715 gallons per 24 hours, 157 gallons per hour.

CAPACITY OF PLANT—The proposed M.E.K. plant is designed to vert 50 gals. per hr, of 99% dry rectified butyl alcohol, into tified pure M.E.K. The ultimate loss in the conversion as estited from experimental work done on 50 gallons of Butyl Alcohol should not exceed 20%. The plant design is based on experience obtained with the small experimental plant installed at Toronto.

PRINCIPLES OF DESIGN—The plans indicate a plant capable of handling 32% of the contemplated output of Butyl Alcohol. At the same time the question of a full sized plant has been considered and estimates are given showing the cost should the smaller plant be enlarged by additions subsequently in the same buildings. Some parts of the smaller plant are equal to the full capacity and the estimates indicate the increased cost if a full sized still and scrubber are installed at the onset.

The handling of the acid and to some extent the other liquids of the process is as far as possible carried out under the influence of gravity.

As far as possible, the units employed in each process have been grouped in sections to allow a direct flow through the plant, units such as catalysers requiring electric current, mixers requiring power and units requiring height, such as tanks, still and scrubber are separately grouped.

SIZE AND SHAPE OF BUILDING—Pending a decision as to the definite location of the plant, the shape and size of the building was rather indefinite, and under these circumstances it was decided that a square layout would allow a good arrangement and one permitting most easily rearrangement to suit location and size of property available. It was found that 50 ft. square was the least size possible to house a plant with a capacity of 50 gallons per hour allowing reasonable margins for possible future extensions, while a building 50 ft. x 75 ft. has been estimated for, as necessary for a 150 gal. per hour plant. The plant is arranged in four sections each 25 feet square, the lower right hand corner forming the Catalysing room, the upper right, the Sulphating and Salting Department, the upper left the Tank Still and Scrubbing Section and the lower left the Compressing and Cooling Portion. The left half of the building is 35 feet high to the roof and has floors placed 13 and 22 feet from the ground while the right half is 20 ft. high to the roofs.

The layout of the proposed plant will be described by tracing the passage of the liquid butyl alcohol through the various stages in the process until it emerges rectified M.E.K.

The conversion may be roughly divided into three stages, the first stage being that in which the normal butyl is converted into butylene, the second converting from butylene to secondary butyl alcohol and the third from secondary butyl into M.E.K.

FIRST STAGE.

The salted 90-92% dryness butyl alcohol is pumped to No. 2 G. and W. Still for rectification from which the rectified normal butyl is returned to a 2,500 gal. galvanised iron storage and feed tank placed 2 feet above floor level in the tank section of the plant. (This tank was formerly used for Acetone storage). From this tank the rectified butyl flows through about 60 ft. of 1½" W.I. pipe to the suction of a 3 x 2 x 3 brass fitted duplex pump which delivers it through a 1½" pipe to the bottom of a small 5.75 sq. ft. surface, evaporator of the copper wriggle coil type using steam at 100 lbs. pressure as the heating agent.

The Butyl Alcohol vapour is raised to about 250° F. in the evaporator, passes from the top of the evaporator to a preheater similar in design to the catalysers (see drg. 87). The preheater is a 72 inch electric heated one which raises the butyl alcohol vapour from 250° F. to above 800° F. The hot butyl vapour then enters either of two sets of two 48" Catalysers each, arranged in series.

CATALYSERS—The catalysers which it is proposed to use are hown in drawings 87 and 87A. Electrical heating by means of ichrome wire is proposed to supply the large amounts of endohermic heat required in the two catalytic reactions. The Catalysrs are cylindrical in form with an inside diameter of drum of 18" nd of two nominal lengths either 48" or 72". The units consist f a cover and inner tube (A)—bronze casting on which may be st or shrunk plates or trays as shown at the right hand side of rawing 87A or as at the left hand side of drawing 87A and in rawing 87. The portion (A) is bolted to an upper casting (B) so of bronze containing the 3" outlet connection provided with a ermometer pocket (F). The bottom casting (C) contains the 3" let opening also provided with a thermometer pocket (F) and the pper and lower castings are connected by the 18" dia. x ⅛" copper ate drum (E) which is brazed into each. The plates or trays on e inner tubes are spaced every two inches for a length of either

4 or 6 ft. and carry the catalyst. As already mentioned, there are two alternative constructions as shown in drawing 87A of which for several reasons it seems likely the construction in which the tube and trays are cast integral will be adopted. To permit of passage of the gas through the trays and Catalyst the trays are either drilled or slotted as shown.

HEATING—The heating is by means of electrical heating elements made up of nichrome ribbon wire placed in the inner tube and if found necessary further heating can easily be provided by nichrome wires surrounding the outer tube. The heating is graded so that more heat is supplied at the bottom than at the top. The exact arrangement of the heating equipment has been left to the General Electric Co. of Schenectady and quotations have been received. The subject is more fully considered on the report on the electrical heating.

CATALYST RENEWALS—The renewal of the Catalyser was a question that had to be taken care of as it cannot be definitely decided or determined how long the Catalyst in either stage will last. To enable the catalyst to be renewed, two batteries of two Catalysers each are provided in this stage so that while one battery is being renewed the other may be used. To renew the Catalyst the inner tube with its trays is drawn up, the edges of the trays are backed off or bevelled to facilitate this and to prevent jamming the Catalyst, and the old Catalyst removed by scraping or brushing. The inner portion is then lowered until the lowest tray is just below the flange of the upper casting.

Fresh Catalyst is packed in this tray. The whole inner portion is then lowered until the second tray is filled and so on until the whole Catalyser is full. A sheet metal shield is placed in position to prevent the Catalyst dropping from the tray into the outlet opening.

OPERATION—The gas entering the inlet passes up through the slots or holes in the first tray and is thereby heated, the tray being hot (800°-850° F.) from the conducted heat from the inner tube which in turn has been heated by the heating element; and the heated gas then passes into the 2" layer of hot Catalyst where some of it is converted. This process is repeated in the 24 sections of the first Catalyser and the 24 of the second, temperatures being, if possible, under automatic control. The switchboard containing electrical control and motors is located as shown.

BUTYLENE COOLING AND COMPRESSING—From the Catalysers the hot butylene gas with steam passes through the wall into a 100 sq. ft. Cooler to remove the catalytic water. A feed water heater is being employed for this with water as the cooling agent. The cool butylene gas then passes through a 2" W.I. pipe line to a 1,000 gal. gasometer of black iron and simple construction, located as shown. A small compressor draws the butylene from the gasometer through a 2" W.I. pipe line and compresses it to about 60 lbs. sq. in. or more discharging it through a 1½" line to a 30 sq. ft. cooler (feed water heater) to remove the heat of compression. The compressor to be used is a C O2 compressor with a small clearance and designed to take care of any possible liquification of the butylene. The high pressure coupled with the cooling will liquify the butylene which flows through a 1½" line to either of two measuring tanks.

MEASURING TANKS—The butylene measuring tanks are of 150 gals. capacity, of steel, tin coated inside, equipped with gauge glasses, manhole, etc., and constructed for an internal working pressure of 100 lbs. per sq. in.

SECOND STAGE.

ACID STORAGE, DILUTING AND COOLING—There is provided storage capacity for one car load of fresh concentrated acid in a steel 10,000 gal. tank at ground level just outside the building as indicated. The tank car or drum will be unloaded directly into this from which 1,000 gal. charges will be elevated by compressed air to the 5 ft. dia. x 10 ft. long diluting tank of lead lined steel. The concentrated acid is here diluted to 75% strength by water admitted through a perforated lead water inlet in the bottom, the heat generated being removed by means of water circulating through a lead cooling coil in the tank. The dilute acid then passes by gravity to a 5 ft. dia. x 10 ft. long lead lined cold dilute acid storage tank immediately below, which also acts as a recovered acid tank. The cold dilute acid flows under gravity from the latter tank to a small 150 gal. homogenous lead lined measuring tank located beside the butylene measuring tanks.

SULPHATING—From the measuring tanks the butylene and acid flow under gravity to either of two sulphating mixers. These mixers are of 50 gal. capacity, lead lined and equipped with special gland and stirring arrangements, the latter belt driven from the main drive. These are two mixers provided to give fairly continuous operation.

The butyl hydrogen sulphate before passing to the still is diluted with water in a third mixer into which it flows under gravity from the sulphating mixers. The water is supplied under gravity from an elevated supply tank. The diluted butyl hydrogen sulphate is then forced by compressed air through 1½" lead pipe to an elevated 1,500 gal. glass lined still supply tank.

LEAD LINED STILL—The butyl hydrogen sulphate flows under gravity from the still supply tank to the column of the lead lined still. The still consists essentially of a 5 ft. dia. x 8 ft. long lead lined steel kettle equipped with a lead steam coil, a 48" 12 plate lead lined column, a 15" copper dephlegmater and a 24 inch copper condenser. The secondary butyl issuing from the still through the regulating bottle flows under gravity through a 1½" W.I. pipe to a copper settling tank. From the bottom of the kettle a lead line leads to the acid recovery plant.

SALTING OF SECONDARY BUTYL—The secondary butyl from the still passes into a 13,000 gal. settling tank of copper, previously used as a wine tank and at present located in the fitter's shop. This tank is to be removed and equipped with gauge glasses vent, etc. The plan shows a new 1,500 gal. tank which it has been decided to replace with the existing 13,000 gal. tank. From this settling tank the top layer is drawn off through either of a number of outlets and passes through 1½" line under gravity to the salting plant, while the bottom layer is returned by a small duplex pump to the still supply tank for re-distillation.

The salting plant is similar to the one already successfully employed for the butyl salting at Toronto but with minor improvements. A full description of this plant has already been sent in and it is also contained in the General Report by Mr. E. M. Shaw. From the salt settling tank of the salting plant, in which any solid salt settles out, the secondary butyl, brine mixture flows under gravity to the top of a 2,500 gal. settling tank (formerly used for Acetone storage) in which the separation of the secondary butyl and the brine takes place. The top layer secondary butyl, is pumped by the small duplex pump beside the tank to the 4,000 gal. No. 1 Gooderham & Worts still for rectification.

THIRD STAGE.

CATALYSING—The rectified secondary butyl is returned and stored in an elevated 1,500 gal. glass lined tank from which it flows under gravity through a 1½" W.I. line to the suction of the small third stage feed pump in the catalysing room. The pump forces the secondary butyl through an evaporator similar to that in the first stage and the gaseous secondary butyl passes into either of two batteries of three 72 inch catalysers similar in design to the 48 inch ones of the first stage. The switchboard controlling the heating for these is located as shown.

M. E. K. SCRUBBING—From the Catalysers the gaseous, M. E. K. —hydrogen—unconverted secondary butyl mixture passes through a 50 sq. ft. elevated cooler (feed water heater) where the bulk of the M.E.K. is condensed and flows under gravity to the 1,000 gal. crude M.E.K. tank. The remaining gaseous mixture passes to the 20" dia. 15 plate cast iron scrubber which washes out the M. E. K. and unconverted secondary butyl which drop to the 4 ft. dia. x 8 ft. long steel kettle below while the permanent gases (hydrogen) escape to the atmosphere. The remaining M.E.K. in the wash is distilled from the kettle and condensed in a small 3 x 3 copper coil condenser and flows through the regulating bottle to the 1,000 gal. glass lined crude M.E.K. storage tank. The unconverted secondary butyl from the scrubber is returned to the secondary butyl storage (third stage supply tank).

M.E.K. RECTIFICATION—The crude M.E.K. is drawn from storage tank and pumped to the 7,000 gal. No. 3 Gooderham and Worts Still, which is to be modified for refluxing with soda. The M.E.K. requires two rectifications in this still after which it passes to the storage tanks in No. 2 Gooderham and Worts Tank House.

MISCELLANEOUS—Compressed air for handling the acid is supplied by an 11 x 11 x 12 Westinghouse locomotive type air compressor which delivers into a 500 gal. steel compressed air tank from which the air is drawn as required. Both compressor and tank are in stock on the premises. The drive for the three mixers and the salting drum is by belt through countershafts from a 15 H.P. low speed A.C. motor which is also in stock on the premises.

ACID RECOVERY SYSTEM—The large quantities of sulphuric acid used in this process rendered imperative the use of some form of recovery system not only because of the difficulty of securing acid in such large quantities and its cost, but also because of the serious problem of discarding the spent acid in such quantities. After a great deal of consideration and original research on the lines of Mr. Metcalfe Shaw's film evaporators owing to the difficulty of getting lead lined steel evaporating tubes and the serious doubts as to the life of lead lining the idea has for the time been rejected in favor of a standard acid tower concentrating plant as built by the Chemical Construction Company, Charlotte, N.C., U.S.A.

The Chemico Concentrator as built by this firm concentrates sulphuric acid of any strength up to 98% and produces a water white acid. For the small 50 gal. per hour M.E.K. plant it was decided that a small 20 ton per 24 hours plant would be required, in this case concentrating from 25% up to 75% only, while for the full size 150 gal. per hour plant two thirty ton plants will be necessary.

This type of Concentrator is quite well known and no extended description is necessary here. One or two extracts from the catalogue of the Chemical Construction Company will serve to give a general idea of the nature of the plant.

GENERAL DESCRIPTION—The capacity of the Chemico Concentrator ranges from ten to seventy tons of 66 degree Baume Acid per twenty-four hours. This apparatus consists of two principal units with auxiliary equipment. The first unit embodies the concentrating tower, concentrating flue and combustion chamber. The second unit consists of a filter and scrubbing tower. Auxiliary equipments, such as preliminary intermediate Storage Tanks; Acid Eggs for pumping the Acid; Exhaust fan for exhausting the steam and combustion gases; oil burning, natural or producer gas equipment for furnishing heat for evaporation; coolers for cooling the concentrated Acid; and Acid regulators and distributors.

CONSTRUCTION—The body of the Concentrating Tower, Flue, Combustion Chamber and Filter Tower, is constructed of acid-proof masonry well braced with steel framing. This eliminates the use of perishable and breakable metals. The Combustion Chamber and Flue are lined with Fire Brick. The masonry units are supported on concrete or brick foundations of suitable height above the ground line. Directly on top of the foundations masonry-lined lead pans are used, inside of which the footings of the masonry walls of their respective units are accommodated. The concentrating tower and the Filter Towers are packed with checkered Bricks, Quartz and other suitable packing. The coolers are constructed of lead with lead cooling coils. The gas and acid pipe lines are generally of lead. Storage tanks are usually constructed of wood, lined with sheet lead and regulus metal exhaust fans are used in case of acid fumes.

OPERATION—Hot combustion gases are furnished by combustion of fuel oil, natural or producer gas, which combustion originates in the front of the furnace flue. The hot gases from this chamber pass directly over a constantly agitated pool of acid. This exposes a large area of acid to the hot gases. The flue holds the above-mentioned pool of acid. This acid is agitated by forcing compressed air through a pipe running submerged in acid and lengthways of the flue. The air escapes through perforated holes in this pipe, causing a continuous agitation of the acid. All deposits of salt fall to the floor where they can be easily removed by suitable openings during operations. The gases after leaving the flue, pass in through the concentrating tower where they are met by a counter current of weak acid. This tower is suitably packed to furnish a large contact surface for the gas and acid. A preliminary concentration of the acid takes place in this tower. The weak acid to be concentrated is pumped into a overhead tank located on top of the concentrating tower. An acid regulator is located in this tank, which regulates the flow of acid from the tank to the distributing pan. The acid flows from the distributing pan to air-sealed lutes which are equally distributed over the upper surface of the tower top. With the use of this construction, the entrance of the acid is uniformly distributed over the upper surface of the concentrating tower packing.

Gases leaving the concentrating tower through a lead or stoneware flue, enter the filter and scrubbing towers where they are thoroughly washed of impurities. From these towers the gases consisting of combustion gases and steam, are released through the exhauster into the atmosphere at a temperature of 180 to 200 degrees Fahrenheit.

The Acid, after concentration, is drawn off through a well-constructed acid overflow into lead coolers where the concentrated acid is sufficiently cooled before being stored.

EDWARD METCALFE SHAW.

PART 3.

ELECTRIC HEATING EQUIPMENT.

GENERAL—In connection with the catalytic reactions in the first and third stages to be carried out in the 48" and 72" catalysers already described, a large amount of endothermic heat is required in each, coupled in the first stage with a quite high temperature and in the third with a somewhate lower temperature.

A very careful and extended consideration of the problem, the conditions to be met and the difficulties to be overcome, together with a large amount of research work with the small experimental plant with both gas and electric heating, finally led to the conclusion that electrical heating by means of nichrome wire possessed many advantages over any other method of heat supply and should therefore be adopted. Among the more important of these advantages are, the case of control, compactness, cleanliness, etc.

The following report or specification was drawn up (with names of substances omitted) giving the various conditions to be fulfilled by the heating equipment and the data available on which to work. This specification was submitted to practically all the large electrical firms in America for consideration, but it was found that the General Electric Co., of Schenectady, was the one with the necessary organization and equipment to deal with the problem and the only one, in fact, who cared to give a quotation on the work.

PRELIMINARY REPORT ON THE HEAT REQUIRED FOR THE PROPOSED M.E.K. PLANT.

DATA SUPPLIED:

CAPACITY—50 gal. per hour, 400 lbs. per hour.

1ST STAGE—Specific heat of normal butyl, ½ that of water.

Latent heat of normal butyl, 258 B.T.U.'s per lb., @ 212° F. Endothermic heat required, 345 B.T.U.'s per lb.

3RD STAGE—Specific heat of secondary butyl, ½ that of water. Latent heat of secondary butyl, 258 B.T.U.'s per lb, @ 212° F. Endothermic heat—190 B.T.U.'s per lb.

Temperature of Reaction—

1st stage	700 to 800 deg. F.
3rd stage	420 deg. F.

Preheating of Vapor before entering catalyser—

1ST STAGE—The liquid is to be vaporised by steam and the temperature of the vapors raised to approximately 250 deg. F. by that means. Before entering the catalyser these vapors may be heated to the reaction temperature, namely 800 deg. F. by an electric preheater.

3RD STAGE—In this stage the liquid is to be evaporated by steam and the vapors heated to approximately 250 deg. F. It is not desirable to preheat these vapors higher than this, owing to the danger of their being reconverted into butylene and water.

Heat Required for the Process—

Assuming no losses.

FIRST STAGE.

EVAPORATION—Heat required to raise temperature of the normal butyl from, say 60 deg. F. to 250 deg. F. and to evaporate it at that temperature=400 lbs. x spec. heat x rise in temperature+400 x latent heat=400 x ½ x 190+400 x 258= 35, 500+103, 200=138, 700 B.T.U.'s per hour which heat will be supplied by steam.

PREHEATING—Heat required to raise temperature of normal butyl vapor from 250° to 800 deg. F.=400 x ½ x (800-250)=110,000 B.T.U.'s per hour.

ENDOTHERMIC—Heat required by catalyser—400 x 345=138,000 B.T.U.'s per hour.

POWER REQUIRED FOR EVAPORATOR—138,700÷33479=4.15 Boiler Horse Power.

FOR ELECTRIC PREHEATER—110,000 x .293=32,230 watts.

FOR CATALYSERS—138,000 x .293=40,434 watts.

THIRD STAGE.

EVAPORATION—Heat required to raise temperature of the secondary butyl from, say 60° F. to 250° F. and to evaporate it at that temperature=400 lbs. x spec. heat x rise in temperature+400 x latent heat=35, 500+103, 200=137, 700 B.T.U.'s per hour, which heat will be supplied by steam.

ENDOTHERMIC—Heat required to raise temperature of vapor from 250° F. to 420 deg. F. and to supply the endothermic heat=400 x ½ (420-250)+400 x 190=34,000+76,000=110,000 B.T.U.'s per hour.

Power Required—

FOR EVAPORATOR—137,700 B.T.U.'s per hour=137,700÷33,479=4.15 Boiler Horse Power.

FOR CATALYSER—110,000 B.T.U.'s=110,000 x .293=32,230 watts.

Total heat required for whole plant

(Assuming no losses.)

Boiler Horse Power	8.3
Electrical energy	104,894 watts

=141 horse power.

Apparatus Required—

Stage 1. One 6 foot catalyser used as a preheater supplying 2 parallel batteries of two 4 foot catalysers in series.

Stage 3. Two batteries each of three 6 foot catalysers.

Heat required—Capacity 50 gals. per hour.

Theoretical Quantities Required for the Reaction—

(Assuming no losses).

For preheater	32,230 watts
For each battery of 2-4 foot catalysers	40.434 watts
For each battery of 2-6 foot catalysers	32,230 watts

PROPOSED M.E.K. PLANT

Conditions Required—

Preheater—since gas enters at the base at 250° F. and the same quantity leaves at the top at 800° F. provision must be made for a greater supply of heat at the bottom than at the top.

STAGE 1—We require a greater quantity of heat at the inlet of the gas to the 1st catalyser than at any other position, there being a gradual decrease in this quantity from the inlet to the outlet of the gas. For this reason it is advisable to break up the heating elements into three separate units for each catalyser or six separate units for the battery, the units being designed to deliver heat in the ratio of 10: 10: 8: 6: 4½: 3 to the catalyser shell. It must, however, be borne in mind that the temperature of the gas at all stages, must be held between the limits of 700 to 800° F., and that this must be automatically maintained, whether by pyrometers in the gas or in the tube operating on switches, for interrupting the current or changing the voltage across the heating element. These controlling devices, one for each coil, must be capable of adjustment and be controlled absolutely independent one from the other.

While the theoretical quantity of heat is 40,434 watts provision must be made to supply radiation losses. Further, due to the unknown uncertain elements, provision must be made, so that if one coil should be used but slightly, the added load thrown on the other elements may be supplied by them without too great a drop in temperature in the gas.

STAGE 3—The third stage is a slower process, and for this reason there does not seem to be any need for so close an adjustment of the temperature at all stages. It seems to be permissable therefore, to provide each six foot catalyser with only one coil, but for each battery of the three tubes the heat supplied by each coil progressing from the inlet to the outlet would vary in the ratio of 5: 4: 3. Temperature controls must be provided as with stage one, but the temperature of the gas must in this case be maintained between 400° and 500° F. It would be well in each of these coils, if wound in the form of a helix, to space the resistance wires closer at the bottom than at the top. Also the remarks in stage one on quantity of heat required above the theoretical quantity 32,230 watts will also apply.

Our visible current supply is at 12,500 volts 3 phase, 25 cycles, situated within 1,000 feet from the plant. We will therefore require transformers capable of supplying this load which will preferably be housed away from the plant near the transmission line and the transmission into the plant will be then at say, 2,200 volts, to be there stopped down to the desired voltage of approximately 110 v.

We are considering the advisability in generating our own current and would therefore appreciate a quotation on a generator of the above capacity and its accompanying switchboard.

In quoting prices, please arrange them so that a comparison may be made between the cost of transformers for stepping down from 12,500 to 110 volts and the cost of a generator for the latter voltage. Also state time for delivery from receipt of order.

PROPOSALS SUBMITTED.

The General Electric Company's Engineers after considering the question for a month, finally recommended a set of equipment to meet these requirements and a quotation was received from the Canadian General Electric based on this recommendation. The following is a description of the material recommended as described in the various communications received from the two firms. Reference should be made to the General Electric Drawings P-1828824, P-1828825 and M-1835576, blue prints of which accompany this report.

DESCRIPTION OF HEATER—The heaters are shown in assembly on drawings P-1828824 and 1828825. They consist essentially of a row of studs around a periphery on which grooved insulating spools are mounted. The resistance wire is to be wound around the cylinder and in the groove of the spools.

Other studs to carry the current will extend down through the centre of the heater and the ends of the respective heater coils will be connected thereto. Several diaphrams of Nichrome are provided which act as spacers and also to cut down convection currents. Further, a cylinder of thin sheet Nichrome is placed around the entire heater so as to prevent scale from the bronze casting of the catalyser shell from dropping into the coils of the resistors. There is to be one preheater which will consume 45KW and will have automatic temperature control. There will be two catalysers second stage, each of which will be electrically divided into three sections and the temperature automatically controlled in each of the 6 sections. There will be 3 catalysers third stage each of which will have the temperature automatically controlled.

CONTROL SYSTEM—The system of control involves the use of a Leeds and Northrup recorder-controller provided with 2 thermocouples one of which is placed adjacent to the resistor and the other in the air of the heating chamber. The controller is set to hold a high temperature on the resistor, say 1,800 F. until such time as the air thermocouples reaches a pre-determined temperature, say 1,200 F., when the control will automatically change over to hold this lower temperature to 1,200° F. on the resistor. This is accomplished by the 2 thermocouples above mentioned operating in conjunction with a rotating switch which is an integral part of the Leeds and Northrup controller. This instrument is provided with a pen and a roll of paper upon which a continuous chart is drawn showing the temperature maintained in the heating chamber. This controller is used to operate the relays on the control panels.

SPECIFICATIONS FOR SWITCHBOARD.

BRITISH ACETONES OF TORONRO, LIMITED.

The switchboard included in these specifications has not been esigned to match or line up with any existing installation as the ompany has no information that this is necessary.

It is understood that the Company can use its own discretion as o the location and arrangement of switchboard apparatus and nnections.

It is understood that the Company will not be required to sub-it drawings to Purchasers for approval before proceeding with rk in its own Factory.

Materials of panels will be Blue Vermont Marble.

Instruments will have dull black finish.

Panels will be mounted on pipe framework.

Switches will be provided with cardholders where necessary.

itchboard will Control—

1-12500/110 v. 150 (m) KW, 3-phase, 3-wire, 25 cycle, Step-wn Transformer.

The machine ratings given in these specifications indicate normal or continuous capacities. The symbol (M) when used in connection with any rating designates the overload upon which the specifications are based, and indicates that only momentary overloads are provided for.

Switchboard will Consist of—

1-12500 v. 150 (M) KW, 3-phase, 25 cycle, Transformer Primary Panel.

Item No. 1—

1-3-phase, 3-wire, 25 cycle, Transformer Panel.

Capacity—12500/110 v. 150 (M) KW.

Size—48 x 16 x 1½; 28 x 16 x 1½ on 76" supports.

EQUIPMENT.

1—5 amp. H-2 Ammeter with 10 amp. scale.

1—166.6 V. H-2 Voltmeter, with 20 KV scale.

1—3-way Ammeter Switch.

1—8-point Potential Receptacle with 4-point plug and holder.

Item No 1—

1—T.P.S.T. 1500 V. 300 amp. form K-12 automatic oil circuit breaker, mounted in cell with hand-operating mechanism, including slate, doors, structural steel, and fittings for cell for oil circuit breaker.

1—D.P. Inverse Time Limit Overload Relay (Plunger Type).

2—13200/100 V. 200 watt 25 cycle, Potential Transformers with fuses and oil.

2—10 amp. Current Transformers, 15,000 volts.

EDWARD METCALFE SHAW.

PART IV.

ESTIMATE OF COST
of
ERECTION AND OPERATION
of
PROPOSED METHYL ETHYL KETONE PLANT
at
TORONTO.

Estimates and data have been prepared for the erection either of two sizes of Methyl Ethyl Ketone Plant at Toront namely a 50 gal. per hour plant or a 150 gal. per hour plant, or the possible enlargement of the smaller one into the larger. The British Acetones, Toronto, Limited, when working at full capacity (12 fermenters a day) will produce 4,586 tons per year of rectified butyl alcohol. The larger of the proposed M.E.K. plant, working at its normal rate will convert only 4,320 tons of butyl, working six days a week for a 50 week year, while the small plant will deal with 1,440 tons per year. However, the small plant is expected to be quite capable of dealing with 60 gals. per hour and the yield of the large plant will be well over the estimated production of Butyl of the British Acetones. It is generally assumed in this report that the large and small M.E.K. plants deal with 100% and 33 1/3% of the butyl output. The normal capacities of the two plants in different units are as follows:—

Small Plant A—50 gals. per hour of Butyl Alcohol.
40 gals. per hour of Methyl Ethyl Ketone.
23.04 tons per week of Methyl Ethyl Ketone.
46,080 pounds per week of Methyl Ethyl Ketone.

Large Plant B—150 gals. per hour of Butyl Alcohol.
120 gals. per hour of Methyl Ethyl Ketone.
69.12 tons per week of Methyl Ethyl Ketone.
138,240 pounds per week of Methyl Ethyl Ketone.

Note:—In the above the "short ton" of 2,000 lbs. is employed nd the week is of 6 days or 144 hours.

Five possible methods of proceeding are provided for in the ollowing estimates, namely:—

(1) The building of a small 50 gal. plant A with no provision r enlargement.

(2) The building of a small 50 gal. Plant A1. containing certain rge units and arranged to facilitate enlarging to the full sized lant.

(3) The enlarging of the small plant A at some future date to full sized plant B.

(4) The enlarging of the small plant A1 to a full-sized plant B1.

(5) In addition to the above, of course there is the possibility building the full sized plant B1 immediately.

EDWARD METCALFE SHAW.

PART IV. (a).

ESTIMATE COST OF ERECTION.

Detailed Estimate of Cost.

The following is a detailed list of the quotations received on the various elements of the proposed 50 gal. per hour M.E.K. plant which it is necessary to purchase. The prices have all been quoted on or previous to Sept. 15th, 1917.

(21) *Acid Storage and Cooling*—Quoted by E. B. Badger & Sons, Co., consisting of a 10 x 20—10,000 gal. concentrated acid tank, a 5 x 10 lead lined mixing tank, equipped with cooling coil and a perforated water inlet (both the latter of lead), and a 5 x 10 lead lined cold 75% acid storage tank, which also is to act as a recovered acid tank.

Total approximate price $5,900.00

(23a) *Sulphating Mixers*—Quoted by E. B. Badger & Sons, Co., two—30 x 30—50 gal. lead lined with double stuffing box arrangement.

Approximate price, each $1,500 .... $3,000.00

(23b) *Diluting Mixer*—Quoted by E. B. Badger & Sons, Co., one—36 x 36—100 gal. mixer of simpler construction.

Approximate price $1,400.00

(25) *Lead Lined Still*—Quoted by E. B. Badger & Sons, Co., *Capacity* 50 *gals. per hour*, consisting of 5 x 8 lead lined steel kettle with lead coil, a 48"—12 plate lead lined column, a 15" copper dephlegmator, a 24" copper condenser, together with piping regulating bottle, accessories, etc., and a 3 x 3 closed top supply tank.

Approximate price $8,300.00

...... Similar still, but with a capacity of 150 gals. per hour.

Approximate price $19,500.00

(22a) *Measuring Tanks*—Quoted by E. B. Badger & Sons, Co., two—150 gal. 3 x 4 steel tanks, tinned and to withstand a working pressure of 100 lbs., fitted with gauge glass manhole, etc.

Approximate price, each $550 .... $1,100.00

(22b) *Measuring Tank*—Quoted by E. B. Badger & Sons, Co., one—150 gal. homogeneous lead lined tank.

Approximate price $400.00

(45) *Scrubber*—Quoted by E. B. Badger & Sons, Co., *Capacity sufficient for* 50 *gals. per hr. plant* comprising a 20" dia. 15 plate cast iron scrubber, a 4 x 8 steel kettle with coil, and a 3 x 3 copper coil condenser, complete with piping, fittings, etc.

Approximate price $2,000.00

Similar scrubber, but with a capacity sufficient for a 150 gal. per hour plant.

Approximate price $4,000.00

(70) *Acid Concentrating Plant*—Quoted by E. B. Badger & Sons, Co., 20 *ton plant, sufficient for a* 50 *gal. per hr. plant*, complete, ready for operation, and including acid pumping, storage, exhausters, coolers, oil burners, equipment, etc., but not including cost of building.

Approximate price delivered and
erected at Toronto $25,000.00

Similar equipment consisting of two—30 ton plants sufficient for a 150 gal, per hour plant.

Approximate price $30,000.00

CATALYSERS

(6) *Four Foot Unit—Separate Trays—*

Patterns	—Toronto Pattern Works	$ 145.00
Castings	—Queen City Foundry	675.00
Copper Plate	—Booth Coulter Co.	77.50
Machining and Assembling	—Sumbling Machine Co.	325.00
	Composite (Sumbling)	1,093.86
Catalyser Complete	—Booth Coulter Co.	2,000.00
	—Monarch Brass Co.	1,900.00
	E. B. Badger Co.	1,475.00
	F. Lepper & Son	1,440.00

(6) *Four Foot Unit—Trays Cast Integral—*

Patterns	—Toronto Pattern Works	180.00
Castings	—Queen City Foundry	540.00
Copper Plate	—Booth Coulter Co.	77.50

Machining and Assembling	—Sumbling Machine Co.	225.00	
	A. L. Torgis	150.00	
Catalyser Complete	—Booth Coulter Co.	1,550.00	
	—F. Lepper & Son	1,240.00	
	Composite Sumbling	862.95	
	Torgis	787.95	
Price assumed in the estimate			$1,000.00

(43) *Six Foot Unit—Separate Trays—*

Patterns	—Toronto Pattern Works	35.00*
Castings	—Queen City Foundry	855.00
Copper Plate	—Booth Coulter Co.	108.50
Machining and Assembling	—Sumbling Machine Co.	450.00
	Composite Sumbling	1,429.86
	Booth Coulter Co.	2,550.00
Catalyser Complete	—Monarch Brass Co.	2,400.00
	—E. B. Badger	1,810.00
	F. Lepper	1,550.00

(43) *Six Foot Unit—Trays Cast Integral—*

Patterns	—Toronto Pattern Works	45.00*	
Castings	—Queen City Foundry	698.00	
Copper Plate	—Booth Coulter Co.	108.50	
Machining and Assembling	—Sumbling Machine Co.	250.00	
	A. L. Torgis	150.00	
	Composite Sumbling	1,076.95	
Catalyser Complete	— Torgis	976.95	
	—Booth Coulter Co.	1,750.00	
	F. Lepper & Son	1,385.00	
Price asssumed in the estimate			$1,200.00

*These prices are those for the alterations of the 4 ft. unit patterns to enable them to be used for the 6 ft. units.

ELECTRICAL EQUIPMENT—Quoted by the General Electric Co., of Schenectady, consisting of the following as listed in their quotation of August 25th, 1917:—

(50) Item No. A: 1—Incoming line panel as per attached specifications. This panel is to control the 12,500 volt, 3 phase, 25 cycle transformer in item "B."

(51) Item No. B: 1—Type "H," 3 phase, 25 cycle transformer, self-cooled, rated:
150 KVA, 12,500 volt primary, 110 volt secondary, 50°, complete with oil.

(52) Item No. C: 1—High temperature heater for pre-heater, first stage, approximately 6 ft. 6 in., as per assembly drawing P-1828824.
(53) 2—High temperature heaters for catalyser, second stage, approximately 4 ft. 6 in. long, as per assembly drawing P-1828825.
(54) 3—High temperature heaters for catalyser, third stage, approximately 6 ft. 6 in. long, as per assembly drawing P-1828824.
(55) 1—Control panel, first stage.
(56) 2—Control panels, second stage.
(57) 1—Control panel, third stage.
(58) Item No. D: 10—Leeds & Northrup temperature controllers, including thermocouples.

The price for the above four items complete, f.o.b., Toronto, freight and duty paid—$22,650.00, Shipment on Item No. A, 4½ to 5 months; shipment on Item No. B, 4½ months; shipment on Items No. C and No. D, 5 months.

A supplementary estimate, September 8th, for two more 4' 6" heaters and three more 6' 6" heaters necessary for the arrangement of catalysers decided upon, was as follows:—

2—4' 6" high temperature heaters	$2,900.00
3—6' 6" high temperature heaters	8,400.00

Additional control equipment required, quoted Sept. 18:—

1—Extra Switches and Wiring	$560.00
9—Thermocouples .	130.00

This makes the total price of the electrical equipment for the heating of the catalysers in a 50 gal. per hour plant $34,640.00

The corresponding cost in a large 150 gal. per hour plant would probably be $103,920.00

(26) *Settling Tank*—13,000 gal. existing copper wine tank at present in fitting shop to be removed and fitted up as a measuring tank, with sight glasses, vent, inlet and outlet connections.

Approximate price of alterations $350.00

(8) *Gasometer*—Quoted by Wheeler and Bain. Simple in construction, of black iron.

Approximate price $700.00

(28b) *Salt Drum—*

		Present Price	Previous Price	Present Total
Drum proper	Toronto Iron Wks.	$116.00	$ 85.00	
Alterations to Patterns	Toronto Pattern Wks.	5.00		
Castings	Standard Fdy.	13.00		
Machining and Assembling	Sumbling Machine Co.	150.00	125.87	284.00
	F. Lepper & Son	103.00		224.00
	A. L. Torgis	75.00		209.00

Price assumed in the estimate $250.00

(28c) *Salt Drum Blocks—*

Alterations to Patterns	Toronto Pattern Wks.	$ 7.00		
Castings	Standard Fdy.	19.60		
Machining and Assembling	Sumbling Machine Co.	50.00	$37.81	$76.60
	F. Lepper & Son	35.00		42.00
	A. L. Torgis	22.00		48.00

Price assumed in the estimate $70.00

(28a) *Salt Drum Hopper*

		Present Price	Previous Price	Present Total
Alterations to Pattern				
Casting	Queen City Fdy.	$10.80		
Sheet Metal Part	Wheeler & Bain	13.75	$10.50	
Machining	Sumbling Machine Co.	12.50	3.13	$37.05
	F. Lepper & Son	15.00		28.75
	A. L. Torgis	1.00		25.55

Price assumed in the estimate $35.00

(4) *Evaporator—*
(42)

Alterations to Pattern	Toronto Pattern Wks.	$ 6.00		
Casting	Standard Fdy.	45.00	$34.20	
Copper Tubing	Booth Coulter C.B. Co.	10.00		
Machining, etc.	Sumbling Machine Co.	85.00	52.23	$146.00
	F. Lepper & Co.	95.00		111.00
	A. L. Torgis	35.00		96.00

Price assumed in the estimate $130.00

NOTE—Prices of F. Lepper & Son for Salt Drum, Bearings, Hopper and Evaporator include castings in each case.

(29) *Salt Settling Tank—*

Tank	Wheeler & Bain	$105.00	$92.00	$105.00
Salt Valve	Existing	....	....	....

Price assumed in the estimate $105.00

Coolers and Condensers (Feed Water Heaters employed)

(7) 1st stage catalytic water condenser—100 sq. ft. surface

Alberger	A. R. Williams Co.	$380.00	
	Fairbanks Morse Co.	420.00	
Price assumed in the estimate			$380.00

(10) 1st stage compression heat extractor—30 sq. ft. surface

Alberger	A. R. Williams Co.	$200.00	
	Fairbanks Morse Co.	180.00	
Price assumed in the estimate			$180.00

(44) 3rd stage catalytic gas cooler—50 sq. ft. surface

Alberger	A. R. Williams Co.	$250.00	
	Fairbanks Morse Co.	240.00	
Wainwright	A. R. Williams, second-hand	125.00	
Price assumed in the estimate			$240.00

(2,27) *Pumps—*

Various uses Smallest size duplex—

	Fairbanks Morse 3 x 2 x 4 iron fitted	$ 72.50 each
(30,41)	brass fitted	102.50 each
(47)	A. R. Williams Co. Martin 3 x 3 x 3 brass fitted.............	78.00 each
	Price assumed in the estimate	$78.00

(73) *Piping* required for various liquids and gases of process, steam exhaust, water and compressed air. The quantities are those estimated for inside the building only. The amount of piping required to and from the rectifiers depends on the location chosen for the building, which has not yet been decided upon. Quoted by General Fire Extinguisher Co. for iron pipe and fittings, Booth Coulter Copper & Brass Co. for copper pipe and Chemical Pump and Valve Co. for lead pipe and valves. August 15th, 1917.

Pipe

150 ft. of	½"	W.I.	pipe	@	$ 6.46	per	100	feet		$ 9.69
150 " "	¾"	"	"	@	8.17	"	"	"		12.16
100 " "	1 "	"	"	@	12.07	"	"	"		12.07
300 " "	1¼"	"	"	@	16.33	"	"	"		48.99
600 " "	1½"	"	"	@	19.53	"	"	"		117.18
400 " "	2 "	"	"	@	26.27	"	"	"		105.08
100 " "	2½"	"	"	@	43.88	"	"	"		43.88
100 " "	3 "	"	"	@	57.38	"	"	"		57.38
200 " "	4 "	"	"	@	85.02	"	"	"		170.04
100 " "	5 "	"	"	@	115.50	"	"	"		115.50
100 " "	6 "	"	"	@	145.90	"	"	"		145.90
				Total	for	W.I.	Pipe		....	$837.87

Fittings—Elbows						*Tees*				
Size	Quantity			Price		Quantity			Price	
½	2	doz.	@	$ .06	$1.44	1	doz.	@	$ .09	$ 1.08
¾	2	"	@	.08	1.92	1	"	@	.12	1.44
1	1	"	@	.10½	1.26	1	"	@	.15	1.80
1¼	2	"	@	.16	3.84	1	"	@	.23	2.76
1½	5	"	@	.20	12.00	1½	"	@	.29	5.22
2	3	"	@	.28	10.08	1	"	@	.41	4.92
2½	½	"	@	.50	3.00					
3	½	"	@	.60	3.60					
4		"	@	.96	....	1	"	@	1.75	21.00
5		"	@	1.60	....	½	"	@	2.40	14.40
6 1/12		"	@	2.20	2.20	½	"	@	3.20	19.20
	Total				$39.34		Total			$71.82
	Less 25%				29.51		Less 25%			53.87
							Total for fittings			$83.38

Valves—

			Type		Price
Size	Quantity		Globe	$ 1.60	$ 38.40
½	2	doz.	"	2.20	13.20
¾	½	"	"	2.80	16.80
1	½	"	"	4.00	48.00
1¼	1	"	Regrinding	4.00	24.00
1¼	½	"	Globe	5.50	66.00
1½	1	"	"	5.50	99.00
1½	1½	"	" (Brass)	8.75	157.00
2	½	"	Regrinding	8.75	105.00
2	1	"	Globe (iron)	12.00	....
2½	¼	"	less	16%	30.24
			Regrinding	22.00	198.00
3	¾	"	Globe (iron)	20.16	60.48
4	¼	"	" "	40.00	40.00
6	1/12	"			
			Total for valves		$896.12

Lead

150 ft. 1½" Chemical lead pipe and ¾ doz. lead valves $639.00

Copper

100 ft. 3" copper pipe @ 61c. per lb. $183.00

Miscellaneous

3	¾" Improved Float Steam Trap	@	$20.00	$60.00
2	1 " " " " "	@	27.50	55.00
5	1/3 pint Peerless Lubricator	@	7.00	35.00
			Total	$150.00

Total for piping for 50 gal. per hour plant	$2,789.37
Total for piping in a 150 gal. per hour plant, allowing 50% additional over that required for small plant	4,184.26

(75) *Power Transmission—*

Shafting—Quoted by Dodge Mfg. Co., August 15th, 1917—

20 ft.—1 15/16" cold rolled steel	$18.36

Pulleys

1 — 30" x 8" Wood split	12.00
1 — 12" x 5" " "	3.34
1 — 36" x 5" " "	10.58
4 pr. 6" x 4" fast and loose	24.48

Hangers

5 — 20" drop—15"/1-16 shaft hangers, Adjustable	29.70

Belting

150 ft.	2 "	single leather	@	$ .48	less	35%		$46.80
30 "	3½"	" "	@	.84	"	35%		16.48
50 "	4 "	" "	@	.96	"	35%		31.20
40 "	6 "	" "	@	1.44	"	35%		37.94
		Total for belting						$132.42

Total for Power Transmission for 50 gal. per hour plant	$230.88
Estimated cost for 150 gal. per hour plant, assuming 50% greater than in small plant	346.32

Buildings—Estimate of cost of M.E.K plant buildings for plant proper and for acid recovery plant, and for both sized plants in each, i.e., 50 gal. per hour plant and 150 gal. per hour plant. The main building is of brick, steel and concrete construction, and the acid recovery building of corrugated iron covered steel.

(60) (a) *Estimate for Main Building for* 50 *gal. per hour M.E.K. Plant,* 50 *feet x* 50 *feet—*

Steel	$2,700.00
Concrete	389.40
Brickwork	5,594.00
Footings	95.00
Excavation	90.00
Carpentry	1,800.00
Stairs, etc.	500.00
Windows	900.00
Electric Wiring	450.00
Heating	800.00
Machinery Supports	2,500.00
	$15,808.00

(b) *Estimate for Main Building for* 150 *gal. per hour M.E.K. Plant,*
feet x 75 *feet—*

Steel work	$3,240.00
Concrete Floors, 5 floor	467.00
Brickwork, Walls	6,354.00
Concrete, footings	110.00
Excavation	100.00
Carpentry Joist	1,500.00
Labour	750.00
Stairs, etc.	500.00
Windows	1,080.00
Electric Wiring	500.00
Heating	1,000.00
Plumbing	300.00
Machinery Supports, say:	2,500.00
T.C.—Door Estimate, say:	500.00
	$18,901.00

(61) (c) *Estimate for Acid Recovery Building for* 50 *gal. per hour plant*
one 20-*ton Chemico Concentrator,* 50 *ft. x* 47 *ft.*

Steel Frame	$3,220.00
16 Steel Sash	222.00
Glass	207.00
Erection	51.00
Sliding Doors and Erection	450.00
Corrugated Iron	750.00
Footings	350.00
Concrete Floor and Footings for Machines	650.00
Louvres	300.00
Electric Wiring	500.00
Drainage and Plumbing	420.00
12,000 Fuel Oil Storage Tank	1,550.00
	$8,670.00

(61) (d) *Estimate for Acid Recovery Building for* 150 *gal. per hour*
2-30 *ton Chemico Concentrators,* 40 *feet x* 76 *feet.*

Steel Frame	$6,900.00
24 Steel Sash	333.69
Glass, ¼" wired	311.04
Erecting Sash	77.76
Sliding Double Doors, Erection of same	450.00
Corrugated Iron	1,400.00
Footings	500.00
Concrete Floors and Footings for Machines	1,000.00
Louvres	480.00
Electric Wiring	600.00

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BRITISH ACETONES, TORONTO

PROPOSED M.E.K. PLANT AT TORONTO

Summary of Material Required and Price

Unit	Size Required	Unit to be Used	Size	Price Each	Remarks
First Stage—Butylene Stage					
Rectifier	50 g.p.h.	No 2 G. & W. Still	7000 gals.	Existing	180 g.p.h. on test.
Feed Tank		Acetone Tank	2500 gals.	Existing	Galvanized iron.
Duplex Pump	50 g.p.h.	Brass lined (3x2x3)	11 g.p.m.	78.00	Smallest size made.
Evaporator	"	Butyl Plant type	200 g.p.h.	Existing	Copper wriggle coil, 5.75 sq. ft.
Preheater	"	Electric type	72 inch	1200.00	Bronze.
Catalyser	"	Electric plate type	48 inch	1000.00	2 sets of 2 in series.
Condenser	100 sq. ft	Feed water heater	300 H.P.	380.00	Condense catalytic water
Gasometer		Simple type	1000 gals.	700.00	Black iron.
Compressor	30 c.f.m.	CO_2 Compressor		Existing	Small clearance.
Cooler	30 sq. ft.	Feed water heater	100 H.P.	180.00	Remove heat of comp.
Second Stage—Secondary Butyl Stage.					
Acid Equipment:					
Concentrated Acid Tank		10ft. dia. x 20ft. long	10000 gals.		
Diluting Tank		5ft. dia. x 10 ft. long	1500 gals.	5900.00	Lead fitted and lead lined
Cold 75% Acid T'k		5ft. dia.x 10ft. long	1500 gals.		
Measuring Tanks:					
Butylene		3 ft. dia. x 4 ft. long	150 gals.	550.00	Tinned & for 100 press
Dilute Acid		3 ft. dia. x 4 ft. long	150 gals.	400.00	Homogeneous lead lin'd
Mixers:					
Sulphating		30 in. x 30 in.	50 gals.	1500.00	" " "
Diluting		36 in. x 36 in.	100 gals.	1400.00	" " "
Still Feed Tank		Glass lined	1500 gals.	Existing	Brewery type.
Lead Lined Still	50 g.p.h.				
Kettle		5ft. dia.x8ft. deep steel.	50 g.p.h.		Lead lined, lead coil
Column		48 in.—12 plate			Lead lined.
Dephlegmator		15 in. copper		8300.00	
Condenser		24 in. copper			
Settling Tank		Copper, to be altered	13000 gals.	350.00	Cost for alterations.
Duplex Pump	50 g.p.h.	Brass fitted (3x2x3)	11 g.p.m.	78.00	Return'g bottom layer
Salting Plant	50 g.p.h.	Toronto type	600 g.p.h.		As used for Butyl Alcohol
Hopper				35.00	
Salt Drum				250.00	
Drum Bearings				70.00	
Salt Settling Tank			75 gals.	105.00	
Settling Tank		Acetone Tank	2500 gals.	Existing	9 ft. dia. x 7-6 high.
Duplex Pump	50 g.p.h.	Brass fitted (3x2x3)	11 g.p.m.	78.00	Rectifier supply.
Rectifier	50 g.p.h.	No. 1 G. & W. Still	4000 gals.	Existing	Sec. But. Rectification
Third Stage—M.E.K. Stage.					
Storage Tank		Glass lined	1500 gals.	Existing	Brewery type.
Duplex Pump		Brass lined (3x2x3)	11 g.p.m.	78.00	Third stage supply.
Evaporator	50 g.p.h.	Butyl Plant type	200 g.p.h.	130.00	Copper wriggle coil (5.75 sq. ft.
Catalysers	50 g.p.h.	Electric plate type	72 inch	1200.00	Two sets of 3 in series
Cooler	50 sq. ft.	Feed water heater	150 H.P.	240.00	Remove catalytic heat
Scrubber	50 g.p.h.		50 g.p.h.		
Scrubber proper		20 in. dia. x 15 plate			Cast iron.
Kettle		4 ft. dia. x 8 ft. long		2000.00	Steel.
Condenser		3 ft. x 3 ft			Copper coil.
Storage Tank		Glass lined	1000 gals.	Existing	7'6" dia. x 30" deep.
Duplex Pump	50 g.p.h.	Brass lined (3x2x3)	11 g.p.m.	87.00	Rectifier supply.
Rectifier	50 g.p.h.	No. 2 G. & W. Still	7000 gals.	Existing	M.E.K. Rectifications
Electrical Equipment					
Incoming Line Panel		12500v, 3 phase, 25 cycle			To control transformer
Transformer		12500v, 3 phase, 25 cycle			Self cooled.
Preheater Heater		6'-6" high temp'ture			
1st Stage Catalyser Heater		4'-6" " "			
3rd Stage Catalyser Heater		6'-6" " "		34,640 00	
Preheater Control Panel					
1st Stage Control Panel					
3rd Stage Control Panel					
Temperature Controls		Leeds & Northrup			Including thermo couples
Buildings:					
Main Building		Brick, steel & concrete	50 x 50.	15808.00	For small 50 g.p.h. pl't.
Acid Recovery		Corrugated iron&steel.	30 x 47	7120.00	For 20 ton acid tower
Miscellaneous:					
Acid Recovery Plant	20 ton	Tower type	20 ton	25000.00	Completely equipped.
Air Compressor		Westinghouse	11x11x12	Existing	Locomotive type.
Air Reservoir		Steel	500 gals.	"	
Piping		Pipe valves, fittings		2789.57	W.I., copper, lead.
Motor	7½H.P.		15 H.P.	Existing	General drive.
Power transmission		Shafting, hangers, pulleys		230.88	
Labor		10 men, 3 months		7500.00	Erection.

BRITISH ACETONES, TORONTO

PROPOSED M.E.K. PLANT AT TORONTO

Estimates of Cost

No.	Small Plant—50 g.p.h.			Additions Required for Large 150 g.p.h. Plant		
	No. of Units	Small Units throughout Plant A	With certain full size (150g) units Plant B	No. of Units	To small Plant A with small units only	To small Plant B with certain large units
1	1	....	....	..	....	....
2	1	....	....	..	....	....
3	1	78.00	78.00	..	....	....
4	1	....	....	..	....	....
5	1	1200.00	1200.00	2	2400.00	2400.00
6	4	4800.00	4800.00	8	9600.00	9600.00
7	1	380.00	380.00	2	760.00	760.00
8	1	700.00	700.00	..	....	....
9	1	....	....	1	532.00	532.00
10	1	180.00	180.00	2	360.00	360.00
21	..	....	....	..	....	....
21a	1	....	....	..	....	....
21b	1	5900.00	5900.00	..	....	....
21c	1	....	....	..	....	....
22	..	....	....	..	....	....
22a	2	1100.00	1100.00	..	....	....
22b	1	400.00	400.00	1	400.00	400.00
23	..	....	....	..	....	....
23a	2	3000.00	3000.00	1	1500.00	1500.00
23b	1	1400.00	1400.00	..	....	....
24	..	....	....	..	....	....
25	..	....	....	..	....	....
25a	1	....	....	..	....	....
25b	1	8300.00	19500.00	2	16600.00	....
25c	1	....	....	..	....	....
25d	1	....	....	..	....	....
26	1	350.00	350.00	..	....	....
27	1	78.00	78.00	..	....	....
28	..	....	....	..	....	....
28a	1	35.00	35.00	..	....	....
28b	1	250.00	250.00	..	....	....
28c	1	70.00	70.00	..	....	....
28d	1	105.00	105.00	..	....	....
29	1	....	....	..	....	....
30	1	78.00	78.00	..	....	....
31	1	....	....	1	17500.00	17500.00
40	1	....	....	..	....	....
41	1	78.00	78.00	..	....	....
42	1	130.00	130.00	..	....	....
43	6	7200.00	7200.00	12	14400.00	14400.00
44	1	240.00	240.00	2	480.00	480.00
45	..	....	....	..	....	....
45a	1	....	....	2	....	....
45b	1	2000.00	4000.00	2	4000.00	....
45c	1	....	....	2	....	....
46	1	....	....	..	....	....
47	1	78.00	78.00	..	....	....
48	1	....	....	..	....	....
50	1	....	....	2	....	....
51	1	....	....	2	....	....
52	1	....	....	2	....	....
53	4	....	....	8	....	....
54	6	34640.00	34640.00	12	69280.00	69280.00
55	1	....	....	2	....	....
56	2	....	....	4	....	....
57	1	....	....	2	....	....
58	19	....	....	38	....	....
60	1	15808.00	18901.00	..	4000.00	....
61	1	8670.00	14022.49	..	14022.49	....
70	1	25000.00	30000.00	1	55000.00	30000.00
71	1	....	....	..	....	....
72	1	....	....	..	....	....
73	..	2789.57	2789.57	..	4184.26	4184.26
74	1	....	....	..	....	....
79	..	230.88	230.88	..	346.32	346.32
76	..	7500.00	7500.00	..	5000.00	4000.00
Totals		132,768.45	159,413.94		220,365.07	155,742.58

Total for large 150 gal. per hour plant built from small plant containing small units only	$353,133.52
Total for large 150 gal. per hour plant built from small plant containing certain large units	315,156.52
Ultimate saving effected through starting with small plant containing certain large units	37,977.00

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Drainage and Plumbing	420.00
12,000 gal. fuel oil storage tank (piping existing)	1,550.00
	$14,022.49

(76) *Labour*—The estimate of the labour costs for the erection of the main M.E.K. Plant for the 50 gal. per hour output has been calculated on the basis of 10 men requiring 3 months at an average of $4.00 per day or a cost of approximately $7,500.00

For the enlargement of the small plant having certain large units originally installed in it to a larger 150 gal. per hour plant, the estimated labour charges are approximately estimated to be 4,000.00

EDWARD METCALFE SHAW.

PART 4 (b)

ESTIMATE OF COST OF OPERATION.

COST OF PRODUCTION OF METHYL ETHYL KETONE

The cost of the Methyl Ethyl Ketone as produced by the Weizmann-Legg Process will be made up of three general elements—

(a) The value of the butyl alcohol.

(b) The cost of the conversion.

(c) The amortization charges on the plant required for the conversion.

Each of the above elements is in turn dependent on many variable factors, the cost of the Butyl depending on the prices of corn, coal and labor, the cost of conversion on costs of coal, labor, electric power, catalyst, etc., and the amortization charges on the initial expenditure, the period of writing off, and possible enlargements. To prepare estimates of cost of the Methyl Ethyl Ketone for all these different combinations of these different factors would be both unwise and unnecessary so that in this report estimates are prepared covering only the most probable conditions of operation of the plant. The costs are primarily prepared for war conditions and on the assumption that the construction of the plant is authorized at an early date, erected in say six months and in full operation not later than May 1, 1918. For purposes of comparison normal peace time costs have also been prepared.

The cost of converting the butyl alcohol into methyl ethyl ketone is now considered in detail under the various headings above.

(a) VALUE OF BUTYL ALCOHOL.

The object of the British Acetones, Toronto, Limited, being to produce a munition solvent, butyl alcohol at present only has a use in reducing the cost of the acetone, since the butyl has a commercial value which is apparently at the present time at least 25 cents per pound.

By the Weizmann-Legg Process, Methyl Ethyl Ketone is produced from the butyl alcohol to the extent of at least 80% by weight, and the Methyl Ethyl Ketone is considered by some authorities to be of at least equal value to the acetone as a solvent.

In estimating a value to place upon the butyl as it comes from the acetone process to be converted into Methyl Ethyl Ketone, the most reasonable point of view to take is that up to the end of the acetone stage the acetone and butyl have each cost the same per pound to produce. The following figures are based on this assumption as it affords the fairest means of comparing the relative advantages of the different plans which have to be considered. As the basis of cost of M.E.K. apart from equipment expenditure depends on the cost of producing Butyl Alcohol it is interesting to see how this Butyl Cost is affected by the cost of corn, etc. Three periods are taken:

During the war, 14.7 cents per lb.
One year after war, 11.01 cents per lb.
Normal peace times, 7.53 cents per lb.

These prices are found by dividing the total cost of operation by the combined weights of Acetone and Butyl. Table 6 shows under what conditions capital has been put into the British Acetones and how and when it is paid off. The costs 11.01 and 7.53 will, if the British Acetones continues to manufacture after the war, be the actual costs of production since the whole of the capital put in by the Government will have been paid off.

It must be remembered, however, that these costs provide nothing for charges on account of the General Distillery, Gooderham & Worts property, nor for the services now being given gratis of the directors of the Company.

(b) OPERATING COSTS OF CONVERSION.

The following estimate of the operating costs of the Proposed Methyl Ethyl Ketone Plants at Toronto is based on the current war-time prices for material, power and labor. The prices for coal and labor are those being paid by the British Acetones, Toronto, Limited, at the present time, while prices for electric power, fuel, oil and sulphuric acid are based on quotations received from the Toronto Electric Light Company, Imperial Oil Company and Nichols Chemical Company, respectively.

Of the items making up the total cost for the catalyst, the prices for pumice and asbestos meal were quoted by Toronto firms (Stewart and Wood, and Eureka Mineral Wool, respectively) and those for alumina (Northern Aluminum Co.) and copper oxide (Mercks Chemical Co.) are those paid for the quantities used in the small experimental plant with suitable allowances for the greater quantities necessary for the large plant.

With regard to the normal or after the war prices, the normal prices of these, with the exception of the coal and some constituents of the catalyst, are unlikely to be lower. The normal price of coal is $3.25 per ton at the boilers compared with $5.82 at present, the price of pumice 8 cents per pound compared with a normal price of 6 cents, of asbestos meal 1.75 compared with 2.5 cents per lb., and with regard to alumina and copper oxide the former is unlikely to change due to the increased demand for aluminum and the before war price of the copper oxide was 60 cents per lb.

It should be noted that in the estimate a charge of catalyst for one battery of catalysers is assumed to last for three days without renewal, or that the two batteries of catalysers provided in each stage are good for one week. This is a minimum life for the catalyst and it is altogether likely that the actual life will considerably exceed this assumed value in which case the cost of conversion will be correspondingly reduced.

The detailed estimate of the Operating Costs of the conversion is given on the following table:

TABLE 7—TABLE OF OPERATING COSTS

	PLANT A			PLANT B		
	Per week	Per ton	Per pound	Per week	Per ton	Per pound
(1) LABOUR, 3 SHIFTS COMPRISING						
A. 8 men at $20, 1 Foreman at $25, 1 Chemist at $25	$630.00	$27.30	1.365	....	....	....
B. 12 men at $20, 1 Foreman at $25, 1 Chemist at $25	....	....	....	$870.00	$ 12.58	.629
(2) COAL AT $5.82 PER TON, SAY 6½ DAYS PER WEEK :						
A. Steam 1000 lbs. or 30 B.H.P. or 100 lbs. coal per hour	$45.37	$1.84	.092	....	....	....
B. Steam 3000 lbs. or 90 B.H.P. or 300 lbs. coal per hour	....	....	....	$135.11	$1.84	.092
(3) ELECTRIC POWER FOR CATALYSERS, ETC :						
A. 150 H.P. at $3.00 per H.P. month	$100.00	$4.34	.217	....	....	....
B. 450 H.P. at $3.00 per H.P. month	....	....	....	$300.00	$4.34	.217
(4) CATALYST—MINIMUM LIFE ONE WEEK COMPLETE CHARGE FOR :						
A. 4 FIRST STAGE CATALYSER :						
4 x 51½ lbs. asbestos meal = 206 lbs. at 2.5c	$ 5.15	....	....	....	....	....
4 x 51½ lbs. alumina = 206 lbs. at 10c.	20.60	....	....	....	....	....
6 THIRD STAGE CATALYSERS	....	$9.33	.466	....	....	....
6 x 154 lbs. pumice = 924 lbs. at 8c	73.92	....	....	....	....	....
6 x 19.25 lbs. copper oxide = 115½ lbs. at 100c	115.50	....	....	....	....	....

6 x 19.25 lbs. copper oxide = 115½ lbs. at 100c........	115.50	....	....	....	....	....

TABLE 5.—TABLE OF OPERATING COSTS—Continued

	PLANT A.			PLANT B.		
	Per week	Per ton	Per pound	Per week	Per ton	Per pound
B. 12 FIRST STAGE CATALYSERS :						
12 x 51½ lbs. asbestos meal = 618 lbs. at 2.5c..........	....	....	....	$15.45	....	....
12 x 51½ lbs. alumina........ = 618 lbs. at 10c	....	....	....	61.80	....	....
18 THIRD STAGE CATALYSERS...........................	....	....	....	....	$9.33	.466
18 x 154 lbs. pumice = 2772 lbs. at 8c............	....	....	....	$229.86	....	....
18 x 19.25 copper oxide = 345½ lbs. at 100c........	....	....	....	346.50	....	....
(5) OIL FUEL FOR ACID RECOVERY						
A. 254 gallons per 24 hours at 11 cents per gal.............	$195.58	$8.48	.424	....	....	....
B. 762 gallons per 24 hours at 11 cents per gal.............	....	....	....	$586.74	$8.50	.425
(6) GENERAL EXPENSES :						
A. 3 men (timekeeper and watchman at $20)..............	$60.00	$2.60	.130	60.	.87	.043
Sundries—oil, waste, light, etc......................	$50.00	$2.17	.108	70.	1.01	.050
(7) TOTALS—During War......................................	$1296.12	$56.06	2.802	$2667.46	$38.47	1.922
TOTALS—After War...	$1209.88	$52.47	2.623	$2408.74	$34.88	1.744

SUMMARY : (a) Present war time prices :

Cost of conversion at the 50 gal. per hour rate, 2.802 cts. per pound.
Cost of conversion at the 150 gal. per hour rate, 1.922 cts. per pound.

(b) Normal peace time prices :

Cost of conversion at the 50 gal. per hour rate, 2.623 cts per pound.
Cost of conversion at the 150 gal. per hour rate, 1.744 cts per pound.

(c) AMORTIZATION CHARGES.

In dealing with the amortization charges of the methyl ethyl ketone plant, the plant may be considered as a unit by itself, receiving the butyl alcohol from the British Acetones at cost price and the product methyl ethyl ketone bearing the amortization charges of the additional plant required. This method of dealing with the question has been adopted as offering the best means of judging of the financial aspect of the proposed process.

In the section of the report dealing with the general solvent question a different method has been adopted, namely, that of grouping the Acetone plant and proposed methyl ethyl ketone plant together as one solvent plant, and combining the amortization charges operating expenses, and output, etc., thus distributing the amortization charges of each over the output of both.

The detailed estimate of cost of erection of the various plants given in the preceding section together with the tabulated estimate in the large table at the end of the report given the total expenditures on buildings and equipment necessary. These totals do not include expenditures for existing plant or equipment in stock at Toronto. Messrs. Gooderham and Worts have placed at the disposal of the British Acetones a conveniently situated piece of ground 112 ft. x 106 ft. located a distance of 300 ft. behind the building where the raw butyl is rectified and stored, on the east side of Trinity St. (See drawing 62 of the General Report). They also provided ample boiler and storage tank capacity together with 2 7,000 gal. stills and 1-4,000 gal. still, ample for rectification purposes with the small M.E.K. Plant. These items are of considerable value, thus reducing the cost of the M.E.K. Plant appreciably and utilize almost the whole of the remaining plant on their premises.

The effect is shown in the Table No. 8 of writing off the amortization charges of the plants under consideration in either six or twelve months, working at their full rated output. The following are the conditions:

(1) Either of the small plants working at 50 gal. rate—amortization charges written off in 25 or 50 weeks.

(2) Additions to either of the small plants—large plant then working at 150 gal. rate—additional amortization charges written off in 25 weeks.

(3) Either of the small plants working at the 50 gal. rate—amortization charges written off in 25 weeks—then enlarged to full sized plant, working at 150 gal. rate—additional amortization charges written off in the remaining 25 weeks of the year.

(4) Large plant B1 erected at once, working at 150 gal. rate--amortization charges written off in 25 or 50 weeks.

In addition to the actual equipment expenditures covered in the estimate, there is also the expenditure for sulphuric acid which since it is recovered and used over and over again is really an amortization charge. Any slight loss of acid during the recovery process is taken care of under the General Operating Expenses. Its effect is also shown in the following table for either plant and for either period of writing off.

TABLE No. 8—TABLE OF AMORTIZATION CHARGES

Plant	Written off in 25 weeks			Written off in 50 weeks		
	Per week	Per ton	Per pound	Per week	Per ton	Per pound
Plant A. (Output	23.04 t	ons per	week.)			
132,768.45	5310.74	230.48	11.524	2655.37	115.24	5.762
1) Plant A1. (Output	23.04 t	ons per	week)			
159,413.94	6376.56	276.76	13.836	3188.28	138.38	6.919
Additions to A. (Out	put 69.12	tons pe	r week)			
220,365.07	8814.60	127.52	6.376	....	....	....
) Additions to A1. (Out	put 69.12	tons pe	r week)			
155,742.58	6229.70	90.12	4.506	....	....	....
Large Plant B. (Outpu	t 69.12 t	ons per	week)			
353,133.52	5310.74	230.48	11.524	8814.60	127.52	6.376
) Large Plant B1. (Outp	ut 69.12	tons pe	r week)			
315,156.52	6376.56	276.76	13.838	6229.70	90.12	4.506
) Total for Plant B1.	(Output	69.12 to	ns per w	eek)		
315,156.52	12060.62	182.36	9.118	6030.31	91.18	4.559
Sulphuric Acid, 1⅕ ce	nts per lb	. per carl	oad of	65,000	lbs. (3,6	00 gals.)
plus freight=$975.	+$78=	$1053.				
Small Plant. (Output	23.04 to	ns per w	eek)			
	42.12	1.828	0.091	21.06	0.914	0.0457
Large Plant. (Output	69.12 to	ns per w	eek.)			
	42.12	.609	0.030	21.06	0.304	0.0152

(d) TOTAL COST PER POUND OF METHYL ETHYL KETONE.

From the preceding detailed consideration of the elements entering into the cost of the methyl ethyl ketone produced by the Weizmann-Legg Process, the total cost under various conditions can now be determined. As the chief object is the production of solvent for war purposes the cost of the M.E.K. under war conditions is of immediate interest. For purposes of comparison or of permanent manufacture, the probable normal peace time prices are also of interest. As there is the possibility that peace may come before the plant is completed and as a midway condition between the former two, the cost under this third condition is also given. For each of these conditions above there are also three capital or amortization conditions, namely for periods of writing off of 25 and 50 weeks and for no capital charges.

The total cost of the Methyl Ethyl Ketone for the various above conditions and for the different plant arrangements is given in the following table. The table is arranged in three groups of three column each, the left, centre and right column of each group containing the costs for amortization periods of 25 and 50 weeks and for no capital charge respectively. The three groups are for different periods as follows:

Group 1—Is based on the assumption that the plant is authorized immediately and that the war lasts for one year after its completion, the butyl alcohol cost being that for the period Dec. 1 to the end of the war.

Group 2—Is based on the assumption that the war ends before the completion of the plant, but that the plant is proceeded with and operated in peace times and the butyl cost used is thus, that for the one year after the war period.

Group 3—Gives the cost of the production when the plant is erected and operated in normal peace times.

EDWARD METCALFE SHAW.

TABLE No. 9—TOTAL COST PER POUND OF METHYL ETHYL KETONE

Plant	During the War			One Year After the War Amortization During Peace			Normal Price As a Peace Proposition		
	Amortization Period		Free of Capital charges	Amortization Period		Free of Capital charges	Amortization Period		Free of Capital charges
	25 weeks	50 weeks		25 weeks	50 weeks		25 weeks	50 weeks	
1. Small Plant A.									
Butyl........	14.47	14.47	14.47	11.61	11.61	11.61	7.53	7.53	7.53
Conversion...	2.80	2.80	2.80	2.80	2.80	2.80	2.62	2.62	2.62
Amortization..	11.52	5.76	..	11.52	5.76	..	11.52	5.76	..
Acid.........	.09	.04	..	.09	.04	..	.09	.04	..
Total....	28.88	23.07	17.27	26.02	20.21	14.41	21.76	15.95	10.15
2 Small Plant A1.									
Butyl........	14.47	14.47	14.47	11.61	11.61	11.61	7.53	7.53	7.53
Conversion...	2.80	2.80	2.80	2.80	2.80	2.80	2.62	2.62	2.62
Amortization..	13.84	6.92	..	13.84	6.92	..	13.84	6.92	..
Acid.........	.09	.04	..	.09	.04	..	.09	.04	..
Total....	31.20	24.23	17.27	28.34	21.37	14.41	24.08	17.11	10.15
3. Large Plant B.	Small 50	gal. plan	t forfirst	25 week	s, large	150 gal.	plant fo	r second	25weeks
Butyl........	14.47	14.47	14.47	11.61	11.61	11.61	7.53	7.53	7.53
Conversion...	2.80	1.92	1.92	2.80	1.92	1.92	2.62	1.74	1.74
Amortization..	11.52	6.38	..	11.52	6.38	..	11.52	6.38	..
Acid.........	.09	.03	..	.09	.03	..	..09	.03	..
Total....	28.88	22.80	16.39	26.02	19.94	13.53	21.76	15.68	9.27
4. Large Plant B1.	Small 50	gal. plan	t forfirst	25 week	s, large	150 gal.	plant fo	r second	25weeks
Butyl........	14.47	14.47	14.47	11.61	11.61	11.61	7.53	7.53	7.53
Conversion...	2.80	1.92	1.92	2.80	1.92	1.92	2.62	1.74	1.74
Amortization..	13.84	4.51	..	13.84	4.51	..	13.84	4.51	..
Acid.........	.09	.03	..	.09	.03	..	.09	.03	..
Total....	31.20	20.93	16.39	28.34	18.07	13.53	24.08	13.81	9.27
Large Plant B1.	Erect	ed at	once.						
Butyl........	14.47	14.47	14.47	11.61	11.61	11.61	7.53	7.53	7.53
Conversion...	1.92	1.92	1.92	1.92	1.92	1.92	1.74	1.74	1.74
Amortization..	9.12	4.56	..	9.12	4.56	..	9.12	4.56	..
Acid.........	.03	.02	..	.03	.02	..	.03	.02	..
Total....	25.54	20.97	16.39	22.68	18.11	13.53	18.42	13.85	9.27

BRITISH ACETONES TORONTO, LIMITED

DRAWINGS AND TABLES.

	Number.
93—Estimate of Cost	1
91—General Plant of Plant	2
95—Block Plant of Property	3
87—Catalysers	4
87A—Catalyser Trays	5
M1835576—Control Panel	6
M18228824—72"Catalyser Heating Elements	7
P1828825—48" Catalyser Heating Elements	8

BRITISH ACETONES TORONTO, LIMITED.

REPORT ON M. E. K. PROCESS

By

D. ALLISTON LEGG.

Part 1—Chemical Considerations.
Part 2—Carrying Out the Process on a Large Scale.
Part 2—Existing Stills and Estimated Still Requirements for Handling 100 gallons per hour Acetone and 250 gallons per hour M.E.K.

Feb. 4th, 1918.

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PART 1.

CHEMICAL CONSIDERATIONS.

The process consists in the conversion of Normal Butyl Alcohol into Methyl Ethyl Ketone, and three main chemical reactions are involved:

(1) Conversion of n-butyl alcohol into butylenes.

(2) Conversion of butylene into secondary butyl alcohol.

(3) Conversion of secondary butyl alcohol into methyl ethyl ketone.

These reactions have been considered in previous reports, but results and conclusions to date may be further summarized.

Butyl Alcohol Used—The crude butyl alcohol as received from the acetone refining process contains from 70-75% of butyl alcohol and after salting treatment (see Acetone report) analyses approximately as follows:

N-Butyl Alcohol, 83-85% by weight.
Water, 8% by weight.
Ethyl Alcohol, 6-7% by weight.
Acetone, 0.7% by weight.
Sodium Chloride, 0.2% by weight.

This product is not suitable for conversion into M.E.K. and requires refining.

Refining the Butyl Alcohol—Using a discontinuous spirit still with 36 ft. column 5' in diameter, 7,000 gal. kettle, one can run through a 7,000 gallon charge of the salted butyl alcohol in about 36 hours or less and obtain roughly:

500 gals. first runnings (Acetone, ethyl alcohol, butyl alcohol and water. This can be redistilled.)

2,500 gals. B1 (Butyl alcohol constant boiling mixture returned to salting plant, and thence returned for redistillation.)

4,000 gals. B3 (Rectified butyl alcohol 99.5% n-butyl alcohol.)

This rectified butyl alcohol (B3) is suitable for conversion into M.E.K.

FIRST STAGE.

Conversion of n-butyl alcohol into butylenes.

$$CH_3CH_2CH_2CH_2OH \xrightarrow[\text{Heat}]{Al_2O_3} CH_3CH{=}CH\,CH_3 \text{ and } CH_3CH_2CH{=}CH_2$$

This consists in passing n-butyl alcohol vapours over dehydrating catalyst at suitable temperatures, separating the resultant butylenes from water, unchanged butyl alcohol and butyl ether.

THERMOCHEMISTRY—The reaction is endothermic and the following value was obtained from the calculated heats of formation of the reacting substances, for the endothermic heat required:

56.7 Kal per **Kg** of normal butyl alcohol, or

102 B.T.U.'s per lb. of butyl alcohol (previously given as 345 B.T.U.'s per lb.)

N.B.—The heats of formation of the substances were calculated from the heat values of linkages and radicles in carbon compounds given in Julius Thomson's work on thermochemistry and the results obtained differ considerably from the values given in previous M.E.K. report, which figures were based on text-book values for the heats of formation of the reacting substances. The above figures are, in my opinion, more reliable.

CATALYST—The most satisfactory catalyst which we have so far used is prepared as follows:

50 parts by weight of aluminum hydrate are mixed with 25 parts by weight of asbestos pulp (Johns-Manville Co.) made into stiff paste with water, rolled into lumps, dried and baked at 600-700° C. for 2 hours. The resultant mass is broken into pieces and presents a large active porous surface. The asbestos acts as a carrier which retains the alumina in a satisfactory way.

The chief cause of inactivation of the catalyst appears to be due to coating with carbon which, whilst preventing contact of the gases with catalyst, also induces side reactions. Carbonisation of catalyst appears to be caused chiefly by:

(a) Overheating, local or general.

(b) Presence of iron either as part of catalysers, or as constituent of catalyst.

(c) Presence of carbon (which acts as a carbonising catalyst).

(a) This can be avoided by having suitable heat distributing device in catalyser, and having satisfactory (preferably automatic) heat control on heating elements, these matters have been considered in previous reports.

(b) Bronze or copper catalysers are used. Some difficulty was experienced in obtaining asbestos with a minimum quantity of iron. Samples of asbestos from Quebec mines nearly all caused rapid carbonisation and contained from 1.6 to 3% iron. A sample of asbestos pulp obtained from Arizona mines (Johns-Manville Co.) and of very white appearance gave excellent results, there being no sign of degeneration after a prolonged run (6 days). On analysis, however, the sample was found to contain nearly as much iron as the Quebec samples, but it appears that in this case the iron is in combinations as silicate with the asbestos and is not infiltered or loosely combined iron as in the case of the Quebec material. Experience indicates that if the asbestos is grey in colour and on treating with strong HC1 immediately turns yellow, the sample will not be satisfactory, but if it is white in appearance, and on treatment with HC1 does not give an immediate yellow colour, the sample is satisfactory. The indications of these tests were of more value than a quantitative estimation of the iron.

As regards the aluminum hydrate, by far the most satisfactory grade used so far is Merck's aluminum hydrate, U.S.P. pure, but the aluminum hydrate obtained by the Aluminum Ore Co. of U.S.A. in their aluminum refining process is fairly satisfactory.

N.B.—Should it not be possible to obtain an asbestos with "inactive iron" it seems that the addition of about 30% of magnesia to the catalyst reduces the carbonising tendency of such asbestos, it also acts as good binding material and may be added with advantage in any case.

(c) One should avoid the presence of carbonisable material in the catalyst as this may char and cause further carbonisation.

ACTIVITY AND LIFE OF CATALYST—This varies considerably with each batch of catalyst, and besides being dependent on the factors previously mentioned and summarised below, seems to be dependent on certain other causes less easy to control.

The definite factors affecting activity and life of catalyst, so far recognized, are as follows:

(1) Presence of "active iron" in the asbestos, alumina, catalyser.

(2) Suitable carrier for the alumina (*i.e.*, one which does not allow the alumina to fall off, thus reducing the exposed surface.)

(3) Temperature and means of distributing the heat.

(4) Physical condition of, and percentage of water in the alumina (dependent on method of manufacture of the alumina hydrate and temperature at which it is baked).

(5) Presence of magnesia.

It would seem from the fact that variations in activity occur even when consecutive batches have been made up with above conditions as far as possible the same, that other factors are concerned. It may be, however, that variations in activity were due to unavoidable variation of some of these conditions.

TEMPERATURE AND VELOCITY OF REACTION (CF. CURVE)—Temperatures from 340°-500° C. (measured on gases) may be used, but the higher the temperatures the more rapid is the degeneration of the catalyst.

In laboratory experiments made with asbestos-alumina catalyst the rate of conversion was doubled with every 20° C. rise from 340° C. to 400° C. and increased by 1/3 with every 20° C. rise from 400-480° C. In practice a temperature of 400-440° C. seems the most satisfactory and allowances are being made for working at this temperature on large scale. At temperatures below 360° C. considerable amounts of butyl ether are formed (but this can also be converted into butylene) (cf. curve).

PERCENTAGE CONVERSION—In practice it does not seem advisable to convert more than 80-90% of the butyl during one passage through the catalysers, for it is found that to obtain a higher percentage conversion than this, the rate of feed has to be greatly reduced. Any unconverted butyl alcohol or butyl ether can be removed and returned with the feed to the catalysers.

VOLUME OF CATALYST, ETC.—The relative weights and volumes of the catalyst constituents wet and dried may be of some practical value and are roughly, as follows:

(a) *Aluminum hydrate*—1 cft. of the powder weighs approx. 70 lbs.

(b) *Asbestos pulp*—1 cft. of the pulp (lightly pressed) weighs approx. 10 lbs.

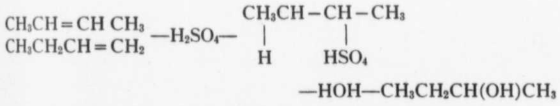
(c) *Catalyst* (stiff paste, consisting of 50 parts by weight of alumina, plus 25 parts by weight of asbestos pulp, plus 75 parts by weight of water)—1 cft. of this weighs approx. 80 lbs.

(d) *Catalyst* (as above, but baked at 600° C. and broken into lumps ½ x ¾")—1 cft. of this(lightly packed as in catalysers) corresponds to approx. 20 lbs. of aluminum hydrate and 10 lbs. of asbestos pulp.

GENERAL—Physical and chemical properties of Butyl Alcohol and substances connected with the process will be found in accompanying tables and blue prints.

STAGE 2.

Conversion of Butylene into Secondary Butyl Alcohol.



$$\begin{matrix} CH_3CH=CH\,CH_3 \\ CH_3CH_2CH=CH_2 \end{matrix} \text{—}H_2SO_4\text{—} \begin{matrix} CH_3CH-CH-CH_3 \\ |\qquad\quad | \\ H\qquad HSO_4 \end{matrix}$$

$$\text{—}HOH\text{—}CH_3CH_2CH(OH)CH_3$$

This has been dealt with in previous reports. Liquid butylenes are mixed with 75% by weight H2 S04 and the product hydrolysed by distilling with 1½ times its volume of water.

Cleanliness of acid and lead lined equipment is important, also freedom from iron as such impurities tend to induce polymerisation instead of absorption.

STRENGTH OF ACID—The acid used has been General Chemical Company's electrolyte acid of S.G. 1.84, this is diluted with water. Care must be taken that the strength of the acid does not much exceed 80% as in this event polymerisation will take place with considerably greater evolution of heat and consequent rise of pressure in the mixer. If the strength is much below 75% by weight absorption will be very slow or will not take place at all.

THERMOCHEMISTRY—The reacting liquids are mixed at ordinary temperatures as the reaction is exothermic, rise of temperature by about 60° C. will occur.

RECTIFICATION OF SEC. BUTYL ALCOHOL—Secondary butyl alcohol forms with water, a constant boiling mixture of maximum vapour pressure, B.P. about 86° C.

150 cc. of this mixture at 20° C. consisted of 142 cc. top layer and 8cc. bottom aqueous layer.

On hydrolising the butyl hydrogen sulphate and distilling, one obtains this mixture plus some excess of water plus some high and low boiling polymerised butylenes plus traces of butyl aldehyde plus traces of methyl ethyl ketone plus small amounts of higher alcohols. The mixture is separated and the top layer salted with sodium chloride. The salted mixture, on distillation in laboratory, gave somewhate similar results to those obtained in distillation, of salted, crude, normal butyl alcohol, splitting up into—

84° C. Head Products (low boiling polymerides, aldehyde and M.E.K.)

84-97° Intermediates (sec. butyl C.B. mixture, etc.)

87-101° "Product" (Refined secondary butyl alcohol).

101° Tail products (High boiling polymerides, higher alcohols, etc.)

The proportion of these constituents will very considerably, according to conditions of production of the butyl hydrogen sulphate.

The heads and intermediates are returned for salting and redistilled.

The "Product" may be used for conversion into M.E.K.

STAGE 3.

Conversion of Sec. Butyl Alcohol Into M.E.K.

$$CH_3CH_2CH(OH)CH_3 \xrightarrow[\text{heat}]{\text{Cu. catalyst}} CH_3CH_2CO\,CH_3$$

This has been previously considered and is carried out by passing secondary butyl vapours over copper catalyst at suitable temperatures.

THERMOCHEMISTRY—The reaction is endothermic and revised figures based on the calculated heats of formation of the reaction substances indicate approximately—

166 Kal. per Kg.

Or 300 B.T.U.'s per lb. of Sec. Butyl Alcohol.

N.B.—The heats of formation of the substances were calculated from the heat values of the atoms, linkages and radicles given in Julius Thomson's work on Thermochemistry. These values indicate a decidedly lower HF for secondary butyl alcohol than for the normal alcohol.

Previous figures given were based on text book values for HF of the compounds, but the figures given here are, in my opinion, more reliable.

CATALYST—This consists of copper reduced from copper oxide.

As mentioned previously considerable difficulty has been experienced in obtaining suitable material, the physical condition of the oxide being apparently of more importance than the chemical purity.

Of commercial samples so far tried, Merck's black copper oxide fine has proved satisfactory, but can not be obtained in large quantity. We have, however, obtained from Drakenfeld, of New York, a shipment of three tons of material which works fairly satisfactory. Other commercial grades (both powdered and granular) have been found unsatisfactory.

POWDERED OXIDE ON PUMICE—In practice, using the powdered oxide, one employs a mixture of 30 parts by weight of oxide to 90 parts by weight of pumice, any increase in the amount of oxide beyond this does not seem to give added advantage.

POISONING—It is noted that using the powdered oxide on pumice great variation in activity and life of catalyst occurs, but there is no evidence of poisoning due to objectionable substances (sulphur, etc.), in the secondary butyl alcohol. Experience indicates that the activity of the catalyst is dependent on the physical state of the oxide and reduced copper and that any degeneration which occurs is due to accumulation of films of high boiling oils or occlusion of gases produced in side reactions on the surface of the catalyst. Also decrease of efficiency is produced by the gradual falling off of the reduced copper from the carrier.

FUSED CRYSTALLINE COPPER OXIDE—The most satisfactory catalyst which we have so far used, consists of fused crystalline copper oxide (Cu0 Cu20). This we have prepared by oxidising copper foil at high temperature. The molten copper oxide may be cooled, broken into lumps and used in this form or may be impregnated in the molten state into alundum or other neutral refractory.

Though the use of fused solid copper oxide involves a greater weight of catalyst per unit, the life and activity are greater and more constant.

REGENERATION OF CATALYST—Experiments to date indicate that the copper catalyst, more especially the solid oxide can be restored to activity by reoxidation at moderate temperatures 400-500° C. If this works out satisfactorily in practice the fused oxide will present great advantage and as having once prepared original batch of catalyst we could periodically remove and reoxidise in a furnace. This could not be carried out satisfactorily with the powdered oxide on pumice.

MIXED CATALYST—Mixed nickel and copper and other mixed catalysts have been tried but no great advantage has been observed.

WEIGHT AND VOLUME OF CATALYST—*Pumice*—Lumps ½" size 1 cft. space requires 22 lbs. pumice.

Copper Oxide (powder)—1 cft. space in catalyser requires 7 lbs. of oxide.

Copper Oxide (fused crystaline in lumps ½" size)—1 cft. space in Catalyser requires about 140-150 lbs. of oxide.

TEMPERATURE AND VELOCITY OF REACTION—Temperatures from 200-300° C. (on gases) are permissable.

The velocity of conversion at given temperatures varies considerably with each batch of catalyst and with conditions of heat transfer. In laboratory experiments it has been found that from 200-240° C. the velocity increases threefold, from 240-260° C. it doubles, from 260-280° C. it increases by one half and from 280-300° C. by one third. Attached curves indicates results obtained with 90 grms. of pumice 30 grms. of copper oxide (Drakenfeld). This was packed in a 1" copper tube and the layer measured 2 ft. in length. It was heated in a 3 ft. electric tube furnace. Various measured rates of feed were delivered, at each temperature and rate of hydrogen measured from which rate of conversion and percentage conversion were calculated. On the curve amounts of secondary butyl converted per minute at 60% conversion are plotted against temperature. In practice the most satisfactory temperature seems to be about 260-280° C. bearing in mind that the higher the temperature the quicker is the degeneration of the catalyst.

PERCENTAGE CONVERSION—In practice (experimental plant) it has been found advisable not to convert more than 70-80% of the secondary butyl in one passage through the catalysers. The unconverted alcohol can be separated by distillation and returned to catalysers.

For a greater percentage conversion than 80% the actual amounts converted per unit of time is greatly reduced.

GENERAL—Attached will be found tables and curves covering the physical and chemical constants of the substances connected with this process. Some are experimental results, others have been calculated or obtained from the literature.

NOTE—(a) The vapour pressure of M.E.K. at any temperature important in connection with hydrogen scrubbing problem, etc.) may be calculated from the formula.

$1/T = .000575 \log P — .004483.$

T=Absolute temp. ° C.

P=Pressure in mm. of mercury.

(b) 1 litre of secondary butyl (21° C./15) gives on conversion 43 litres of hydrogen (S.T.P.)

i.e. 1 gallon of secondary butyl (70° F./60) gives on conversion 8.9 cft. of hydrogen (S.T.P.)

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PHYSICAL AND CHEMICAL CONSTANTS OF SUBSTANCES USED OR PRODUCED IN M.E.K. PROCESS

Substance	MW	BP°C	Density		Sp. Vol.	Sp. Ht.		Lat. Heat of Vaporization	H.F.P. gas at 15°C	Crit : T°C	Solubility in water
			Liquid	Vapor at 0° and 760 mm Air = 1	Calc. to 0°C 760 mm	Liquid	Vapor				
N-Butyl Alcohol $CH_3 CH_2 CH_2$ CH_2 CH	74.08	116-117°	0.8098 $\frac{-21^\circ}{15}$	2.56 (3.31 G.P.L.)	303	Approx. 0.5 at 10 °C	Me O.458 Et. O. 453	143	72K		1 in 8
Sec. Butyl Alcohol CH_3 CH_2 CH (OH)CH_3	74.08	99-100	0.8027 $\frac{-15^\circ}{15}$	2.56 (3.31 G.P.L.)	303	Approx. 0.5 at 10 °C	Me. O.458 Et. O. 453	136	77.7 K		1 in 29
Butylene $CH_3 CH_2 CH=$ CH_2 $CH_3 CH=$ CH CH_3	56.1	-5°C 1-2.5°C	0.635-13°C	1.94 (2.5 G.P.L,)	400	Iso-Amylene 0.5 at-10 to 40° C.	Amylene at 130°C. 1.0 Ethylene 10-200° C. 0.4	Amylene 75	9.8 K.	150°C	
Methy Ethyl Ketone CH_3 C H_2 CO CH_3	72.06	79-81	0.8075 $\frac{15}{15}$	2.49 (3.21 G.P.L.)	318	Acetone 0.506	Acetone 0.41	103.4	65.4 K.		1-26
Water H-OH	18	100°C	1.00	0.65 (0.80 G.P.L.)	1240	1.005	0.48 (130-250° C.	536.6	58 K		

PART 2.

THE PROCESS ON A LARGE SCALE.

The plant at above factory is designed to handle 250 gals. per hour (maximum figure) of butyl alcohol and the following indicates approximately the nature and function of the various units (sizes, weights, layout of these units will be found in the report from the Engineering Department.)

1ST STAGE.

RECTIFICATION OF BUTYL ALCOHOL—To deliver 250 gph. of rectified butyl alcohol will necessitate the use of the two Gooderham & Worts discontinuous spirit stills. These are spirit stills older type, each has a 7,000 gal. kettle, column 36' high and 5' in diameter. These each deliver on the average of 130 gals. per hour of rectified butyl alcohol.

PREPARATION OF CATALYST—A bread mixing device is being adopted for mixing the aluminum and asbestos with water and furnaces for drying and baking are under consideration.

CATALYSERS—Catalysers of the type indicated in previous report have been constructed, but some trouble has been experienced in avoiding porosity in the metal.

HEAT INTERCHANGE—Experiments are being made in this direction by Mr. Shaw and if satisfactory results are obtained these will be incorporated in the first stage system, in order to preheat the butyl vapours by means of the hot gases from the end of the catalysers.

THE PROCESS—The process in the first stage consists in passing the butyl alcohol through a wriggle evaporator and thence through a preheater (heat interchanger or electric preheater) raising the temperature of the vapours to 400-440° C., 750-820° F., at which temperature they will enter the electrically heated catalysers (how many of these will be required can only be determined by large scale experiments), the temperature in the catalysers being maintained at 750-820° F. The vapours and gases from the catalysers then pass through the heat interchanger (or a condenser), to partially cool, and then into another condenser cooled to the lowest possible water temperature. The unconvertd butyl alcohol, butyl ether and water removed in the process will be collected in a separating tank, fitted with gauge glasses, so that the aqueous layer may be withdrawn and the top layer returned to a boiler to remove the dissolved butylene, the residue being then returned to the evaporator and catalyser. The gaseous butylene passes from the condenser and separating tank to a gasometer, and from thence to a compressor, which compresses the butylene and delivers it via a cooler to either of two 150 gal. tinned butylene storage and charging tanks. Any permanent gases may be periodically vented from these tanks. The tanks are constructed to stand 100 lbs. working pressure, and are provided with gauge glasses, and a means of withdrawing any aqueous layer which may collect.

SECOND STAGE.

Acid Storage and Diluting System—A 10,000 gal. cast iron tank holds our stock of fresh acid (electrolyte acid sg. 1.84), this tank delivers to a lead lined diluting and cooling tank (6' x 7'). The latter delivers to a 6' x 7' lead lined 75% acid storage tank, and thence to the lead lined charging tank of 150 gal. capacity and fitted with gauge glasses. This acid will only be used at start and for making up losses incurred in the process and during re-concentration.

The Process—A charge of 25 gals. of the 75% acid and 25 gal. of the liquid butylene is forced into the sulphating mixers. These consist of lead lined tanks of 50 gals. capacity fitted with high speed propeller and constructed to stand 200 lbs. working pressure. These mixers (3 in number) receive from the acid charging tank and from either of the liquid butylene charging tanks and deliver to the butyl hydrogen sulphate storage and feed tank. They are provided with lead relief valves.

From the sulphating mixers on completion in a few minutes of the reaction the butyl hydrogen sulphate is elevated by air pressure to a 6' x 8' lead lined tank, fitted with gauge glasses, this acting as a reservoir between the mixers and the lead still. From this tank butyl hydrogen sulphate passes through a diluting mixer where it is diluted 1½ times its volume of water and from thence to the column of the continuous lead lined still. This still comprises a lead lined 72" diameter 12 plate column, and a 10' x 6' lead lined boiling kettle, working in conjunction with a copper dephlegmator and condenser. The liquor will enter this still at a temperature of approximately 60° C., and from the condenser we shall obtain say 300 to 350 gals. per hour of Secondary Butyl C.B. mixture. The C.B. mixture will pass to a copper or glass enameled storage tank fitted with gauge glasses and overflow. The aqueous layer from this separating tank will be returned to the still whilst the top layer will overflow to a storage tank and from thence be delivered to a continuous salting plant of the same type that is used in salting the normal butyl. In this salting process a small quantity of soda should be added to neutralize the traces of sulphurous acid which are present. The dilute acid from the exhausting column of the lead still will pass to either of two 30 ton per diem Chemico Concentrators, to be re-concentrated to 75% strength.

RECTIFICATION OF SECONDARY BUTYL ALCOHOL—The salted Sec-ndary Butyl Alcohol will be rectified in:

(a) A Gooderham & Worts discontinuous alcohol still. This till has a 36' x 5' column and kettle of 4,000 gals. and should de-iver on the average of 100 gals. per hour of rectified Secondary Butyl Alcohol.

(b) Another discontinuous still which is being constructed y Badger & Co., of Boston, to handle the remaining 150 gal. per our of Secondary Butyl. This comprises a 10' x 20' kettle, 60" x 4 plate column in conjunction with a copper dephlegmator and ndenser. It is expected that a charge of 4,000 gals. of the salted econdary Butyl will give 2,500-3,000 Secondary Butyl and 1,000-500 gals. of head products and constant boiling mixture. The tter will be separated, the top layer being returned to the salting ant and the bottom layer to the lead still.

THIRD STAGE.

PREPARATION OF CATALYST—(a) *Using powdered copper oxide d pumice*—A shallow steam jacketted copper pan is being de-ned into which the screened lump pumice (lumps about ½ x

¾) will be weighed and the weighed quantity of black powdered oxide added together with water. The mixture will be boiled and hand stirred so that on cooling the oxide adheres to the surface of the pumice. The copper pumice will be charged in a moist condition to the catalysers, and dried in situ.

(b) *Using fused crystalline copper oxide*—Experimental furnaces are being tested in order to obtain a suitable type which can be used continuously. To prepare this catalyst one needs a non-absorbent refractory, as otherwise the copper oxide formed permeates the furnace lining. So far alundum tubes coated with Johns-Manville No. 32 refractory cement have been found satisfactory. The furnace is heated electrically to about 1,000° C., and a stream of pre-heated air passed through the tube. The copper is fed in the form of foil, and oxidises almost immediately. The heat of reaction melting the oxide which runs down and can be withdrawn. The oxide obtained is broken into lumps about ½" for use.

CATALYSERS—Same type as for first stage and as previously reported. The number of units required can only be determined by large scale experiment as also the number in a battery and the heat which can be supplied in each unit.

THE PROCESS—Sec. Butyl Alcohol is vaporised in a wriggle evaporator and passed through an electric preheater (or a heat interchanger) and thence to catalysers electrically heated, internally and externally, so as to maintain a temperature of 260-280° C (500-536° F.) From the catalysers the M.E.K. vapour, hydrogen, etc., passes via heat interchanger to a condenser (water cooled) and thence to a separator to separate the liquid crude M.E.K. from th hydrogen.

HYDROGEN SCRUBBING SYSTEM—The hydrogen as it leaves th separator may contain about 10% of the total M.E.K., it is therefore taken through a 30 ft. x 40" water scrubbing tower. The rat of flow of hydrogen may be about 10,000 c. ft. per hour.

The scrubbing liquor passes to storage and thence via a pr heater to a continuous still, comprising an analysing and rectif ing column (the former 60" x 12 plate and latter 36" x 16 plate dephlegmator and condenser. The M.E.K. will distill off in th form of constant boiling mixture (B.P. 72° C.) and this will pa from the condenser to a sand filled separator. The aqueous lay will return to the still and the top layer overflow to a continuous calcium chloride salting tank. The salted material goes to storage and thence to the refining still whilst the calcium chloride solution is boiled to drive back any dissolved M.E.K. to continuous still, the residual concentrated solution being used for further salting.

REFINING THE CRUDE M.E.K.—The crude M.E.K. (70% M.E.K., 30% Sec. Butyl) has to be submitted to refining process. A still is being constructed by Badger & Sons, of Boston, which has been designed to deliver 125 gals. per hour of pure M.E.K. on the assumption that primary and secondary distillations will be required. Allowance is being made for treating the vapour from the column with solid caustic soda without allowing the return of the caustic to the column or kettle (it is a discontinuous still).

This caustic purifying arrangement can also be cut out if necessary at any time during a distillation. We decided that it was better to build a still of half capacity and re-duplicate after trial. Should a less pure ketone (for dope) be the main requirement, this single still may take care of the full output of 250 gal. per hour.

Comparison of laboratory distillations of acetone-butyl-ethyl-lcohol mixture from the Weizmann acetone process and M.E.K. Secondary butyl alcohol mixture from the M.E.K. process indicate hat it should, if anything, be easier on the large scale to obtain pure M.E.K. (suitable for cordite) than it is to obtain a pure cetone.

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PART III.

UMMARY OF EXISTING STILLS AND ESTIMATED STILL REQUIREMENTS FOR PRODUCING 100 GALS. PER HOUR OF ACETONE AND 250 GALS. PER HOUR OF M.E.K.

ACETONE PROCESS.

) 2 Beer Stills (Existing and in use).

Each 6 ft. in diameter with 10 plates, 60 boiling caps on each d working in conjunction with beer heater. Each still handles 00 gals. per hour of beer and delivers 600-700 gals. per hour A. B. containing 20-23% Acetone, 45-48% Butyl Alcohol.

(B) 2 Rectifiers (Existing and in use).

These are old charge spirit stills 37 ft. high x 5 ft. diameter with 24 plates, 7 boiling caps on each. The kettle has a capacity of 13,000 gals. A Goose dephlegmator is used. Each still handles on the average 4½ charges (13,000 gals.) per week. The charges consist of AB (from beer still) and A1 (intermediates from 1st rectification). They will deliver between them 100 gals. per hour of A2 (Acetone ready for final refining) and in addition take care of the refining of A2 to produce 50 gals. per hour of A3 (pure acetone).

(C) Badger-Barbet Continuous Refining Still.

This comprises a 13 ft. 16 plate exhausting column 5 ft. in diameter, and a 20 ft. 39 plate copper concentrating column 4 ft. in diameter. Small modern dephlegmator and also auxiliary purifying column (not needed). This handles A2 and delivers from 50-60 gals. per hour of A3 (pure Acetone).

(D) 2 Rectifiers (Existing and in use).

These are old spirit stills, they are 40 ft. high, 5 ft. diameter, have 26 plates with 3 boiling caps on each plate and work in conjunction with a goose dephlegmator. The kettles hold 7,000 gals. charge. They will each deliver 130 gals. per hour of rectified (99½%) butyl alcohol.

M.E.K. PROCESS.

(E) Lead Lined Continuous Still (constructed by Badger).

Lead lined 72" x 12 plate column with 10' x 6' boiling kettle and copper dephlegmator. Modern construction by Badger of Boston. This should handle 1,000-1,250 gals. per hour feed liquor and delivers from 300-350 gals. per hour of secondary butyl alcohol CB mixture and some water.

(F) Rectifier (Existing).

This, an old spirit still has a 4,000 gals. kettle and 40' x 5' column with 26 plates and 3 boiling caps on each. A goose is used, copper construction. It should deliver 100 gals. per hour of rectified secondary butyl alcohol.

(G) Rectifier (Badger type and now under construction).

10' x 20' kettle, 60" x 24 plate cast iron column in conjunction with copper dephlegmator, modern type. This should deliver 150 gals. per hour of rectified Sec. Butyl Alcohol.

(H) Continuous Still for Handling Hydrogen Scrubbing Liquor (Under construction by Badger).

This comprises exhausting column 60" diameter with 12 plates and rectifying column 30" diameter with 12 plates and should take care of the M.E.K. contained in 10,000 c. ft. per hour of hydrogen. It will handle a very dilute liquor and concentrate to the strength of CB mixture of which it may deliver about 30 gals. per hour. It works in conjunction with a decanter and calcium chloride salter.

(K) Discontinuous Badger Still (Under construction).

Details not at present known.

To handle crude M.E.K. and redistil 1st M.E.K. distillate so as to produce 150 gals. per hour of pure M.E.K.

(L) Discontinuous Badger Still.

Duplicate of (K), not to be constructed till (K) tested, but of same estimated capacity, or of capacity indicated by trial of K.

FEB. 4TH, 1918. D. A. LEGG.

SUPPLEMENT TO M.E.K. REPORT, BY D. A. LEGG DATED FEBRUARY 4TH, 1918.

ACETONE AND BUTYL ALCOHOL DISTILLATION AND RECTIFICATION.

The methods used in distilling and rectifying Acetone and Butyl Alcohol have been described in previous reports.

Attached will be found a blue print* indicating diagrametically nd approximately to scale the arrangement of the plant at British Acetones.

The plant as indicated will handle crude liquors sufficient to roduce continuously from 90-100 gals. per hour of pure Acetone nd from 220-250 gals. per hour of Rectified Butyl Alcohol, this eing our estimated output from 12 fermenters per diem (72 per eek). The flow of liquors and nature thereof is indicated.

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*This print is very similar to the Acetone Flow Sheet which is bound at e back of this report, and has therefore not been reproduced.

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FURTHER REPORT ON M.E.K. PROCESS AS CARRIED OUT

AT

BRITISH ACETONES, TORONTO, LIMITED.

DECEMBER 5TH, 1918.

D. ALLISTON LEGG.

Mr.

Sir:–

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STAGE I.
CH_3C

Norma

BRITISH ACETONES, TORONTO, LIMITED,

Toronto, Ont., Dec. 5th, 1918.

Mr. N. W. Pirrie,
Director of Explosives,
Imperial Munitions Board,
Ottawa, Ontario.

Sir:—

In submitting a final report on the methyl ethyl ketone process as carried out at British Acetones, Toronto, Limited, I beg to state hat this is intended to supplement my previous report, February th, 1918.

I have not, therefore, dealt with matters entered into this report, but have merely given a short account of the process as carried out from September to November 11th, touching on some of he chemical and mechanical considerations which arose during the peration.

I have not attempted to estimate the yield of M.E.K. which ight have been obtained as this was affected by many causes hich are not an essential concomitant of the process which were o a considerable extent eliminated towards the end of the period f working. An estimation of the yield is also vitiated by the fact hat large amounts of the material were in process and distributed various distillation fractions.

In tendering the accompanying report, I wish to express my eep personal regret that we were not able to produce the Pure .E.K. at an earlier date, but the experiment has, in my opinion, hown that M.E.K. of great purity can be produced on a large scale this method in sufficient quantity to justify the use of the ethod in times of Acetone shortage.

For reference, in connection with the report, the following note the essential reaction of the 3 stages is inserted:—

AGE I.

$$CH_3CH_2CH_2CH_2OH\text{—Kaolin}(340\text{-}350°\ C.)\text{—}\begin{matrix}CH_3CH=CH-CH_3\\CH_3CH_2=CH=CH_2\end{matrix}$$

Normal Butyl Alcohol——————————1 and 2 Butene

STAGE II.

$CH_3CH=CH-CH_3$—H_2SO_4(70-75% W/W)—$CH_3CH-CH-CH_3$
$CH_3CH_2=CH=CH_2$ $\quad$ H HSO_4

—HOH—$CH_3CH_2CH(OH)CH_3$
Secondary Butyl Alcohol

STAGE III.

$CH_3CH_2CH(OH)CH_3$—Cu(250-300° C.)—$CH_3CH_2CO\,CH_3$
Secondary Butyl Alcohol—————————Methyl Ethyl Ketone

I am, Sir,
Your obedient servant,
D. ALLISTON LEGG.

FURTHER REPORT ON M.E.K. PROCESS AS CARRIED OUT
AT
BRITISH ACETONES TORONTO, LIMITED.

1st Stage **(Butyl Alcohol to Butylene).**

Owing to the great difficulty experienced in obtaining gas tight casting, for the catalysing vessels and to other mechanical troubles, no extended run was possible between June 4th and September 17th.

On September 17th a 1st stage run was commenced with two batteries containing 3 units per battery.

Brief Description of 1st Stage Equipment and Process.

The process was carried out as follows:—

The rectified normal butyl alcohol was pumped by a variable stroke pump from a guaging vessel to a liquid preheater which utilised the gases from the catalysers after they had passed through the gas interchanger. The warm butyl alcohol then passed from a steam evaporator to the gas interchanger where it met the hot gases direct from the catalysers. The vaporized and preheated butyl alcohol was then split up into two portions, passing through two venturi meters to control the quantity to each of the two batteries. The catalysers were heated electrically by heaters elsewhere and previously described. The reaction temperature was observed on thermometers placed in the vapor pipes between each catalyser. From the catalysers the butylene, water and unconverted butyl alcohol vapors were passed through the heat interchanging systems referred to above and thence to a final cooler and separator. From the separator the gas passed to a gasometer, which by its rise and fall automatically controlled a steam driven "ammonia type" compressor. The compressed butylene was passed through a cooler to any of three graduated liquid butylene storage and charging tanks. The unconverted butyl alcohol and "catalytic water" was pumped to a storage tank whence the former rising as a layer could be separated and returned to the catalysers.

Any water which came through the compressor with the butylene in the form of vapor could be periodically drawn off from the liquid butylene tanks.

FIRST STAGE RUN COMMENCED SEPT. 17TH, 12 NOON, CONCLUDED SEPT. 28TH, 10.30 A.M.

Catalyst—Canadian China Clay baked at 600° C. and broken into lumps about ½ x ¾".

It was endeavored to obtain at least 80% conversion on 30 gals. per hour per battery, starting at lowest possible temperature.

Note on Percentage Conversion.

On account of the slowing down involved it does not seem advisable to convert more than 80-90% of the butyl alcohol in one passage through the catalysers, but rather to convert about this amount and return the rest after cooling and separation.

Summarized Log of Run.

Date and time		Gals of Butyl	Liquid Butylene Formed	Approx. % conversion	Approx. Temp. ° F.	Remarks.
17/9	6pm-12mt.	690	653	94.7	650	
18/9	12mt.-12mt.	1440	1222	84.8	650	
19/9	12mt.-12mt.	1542	1222	79.2	650-675	Temp. raised at 6 p.m.
20/9	12mt.-12mt.	1029	794	77.2	675	Leak. No. 2, Batt. out
21/9	12mt.-12mt.	1440	1196	83.0	675-720	
22/9	12mt.-12mt.	1440	1197	83.0	720	
23/9	12mt.-12mt.	1415	1113	78.8	740	Compressor out 50 min.
24/9	12mt.-12mt.	1430	1206	84.3	740-750	
25/9	12mt.-12mt.	1440	1162	76.7	750-760	
26/9	12mt.-12mt.	1440	1179	81.5	760-780	
27/9	12mt.-12mt.	1415	1128	80.0	780-800	Battery No. 1 out at 11 a.m.
28/9	12mt.-10.30a.m.	300	218	67.5	800	

Total Butyl Alcohol used	14,846 gals.
Total liquid butylene obtained	12,344 gals.
Average per cent. conversion	83.2
Total time of run	10 days 16½ hrs.

Leakages on heat interchanging system and catalysers necessitated shutting down on September 28th. The run might otherwise have continued for a few days, though the advisability of running at temperatures exceeding 800° F. is doubtful.

1st Stage Commenced October ***19th,*** *5p.m.*

The period between September 21st and October 19th was occupied in making considerable repairs on catalysers, interchanging system and some alterations and repairs on the second stage equipment.

On October 19th a fresh run was commenced with two batteries packed with fresh catalyst. After running at 650° F. for 19 hours on the rectified butyl alcohol and for 10 hours on "unconverted butyl" a shut down was necessitated by the collapse of the lead lining of the sulphator. A new sulphator was installed with a 3-bladed propeller running at slow speed 350 r.p.m. instead of the old type 2-bladed propeller which ran at 900 r.p.m. The run was recommenced with same catalyst on October 24th.

Summarized log of run, Oct. ***19th,*** *to Nov.* ***16th***—

Date and Time		Gals Butyl	Liquid Butylene	Approx. % conversion.	Approx. Temp. °F.	Remarks
19/10	5 p.m. to					
20/10	10 p.m.	1740	1334	76.8	650	
24/10	7.30 p.m. to					
	8 a.m.	743	525	70.8		
25/10	8 a.m.-8 a.m.	1440	1184	82.3	650-670	
26/10	8 a.m.-8 a.m.	1500	1235	82.5	670-680	
27/10	8 a.m.-8 a.m.	1440	1151	80.0	680	
28/10	8 a.m.-8 a.m.	1440	1197	83.3	690	
29/10	8 a.m.-8 a.m.	1440	1239	86.0	690	
30/10	8 a.m.-8 a.m.	1440	1232	85.6	690	
31/10	8 a.m.-8 a.m.	1440	1248	86.8	695	
1/11	8 a.m.-8 a.m.	1420	1107	77.0	695-710	Shut down ½ hr.
2/11	8 a.m.-8 a.m.	1440	1167	81.0	710	
/11	8 a.m.-8 a.m.	1365	1201	88.0	725	
/11	8 a.m.-8 a.m.	1440	1223	85.0	725	
/11	8 a m.-8 a.m.	1440	1211	84.0	725	Shut down sulphator trouble.
/11	8 a.m.-6.25 a.m.	1350	1077	80.0	735-740	
/11	12 noon to					
	8 a.m.	300	203	67.6	750	
/11	8 a.m.-8 a.m.	770	513	66.8	750	No. 2 Batt. out repairs. No. 1 on unconverted Butyl.

Date and	Time	Gals. Butyl	Liquid Butylene Formed	Approx. % conversion	Approx. Temp. °F.	Remarks
9/11	8 a.m.-8 a.m.	720	527	78.2	750	
10/11	8 a.m.-8 a.m.					
11/11	8 a.m. to					
13/11	8 a.m.	645	480	74.5	750	
13/11		720	618	86.0	770	
14/11		1390	1014	73.0	650-780	No. 2 Battery in at 2 p.m.
15/11		1333	961	72.0		
16/11		180	80	44.5	650/780	Official shut down.

Total Butyl Alcohol passed	24,466 gals.
Unconverted Butyl Alcohol returned	3,470 gals.
	27,936
Liquid Butylene formed=	22,189 gals.
Average % conversion=	About 80%
Total length of run	21 days 22 hours (526 hrs.)

Purity of butylene throughout, over 99.5% olefine.

Notes—

(a) The apparent fall off in activity of catalyst between November 8th to November 13th was partly due to the running of considerable amounts of "unconverted butyl alcohol." This includes butyl, ether, dissolved butylene and some water, and does not give quite so good a percentage conversion on passing as the straight butyl alcohol.

(b) The temperature at which the butyl alcohol vapor entered the 1st catalyser was as a result of the heat interchanging system usually about half that of the emergent gases, considerable losses taking place in the interconnecting pipes of the interchangers, even though these were heavily lagged.

Chemical Considerations and Conclusions.

(a) The results of the operations carried out between September 17th and November 19th indicate that bronze catalysers ar satisfactory from a chemical point of view, the purity of the butylene being always high (over 99.5%).

(b) The most satisfactory catalyst used was Canadian Chin Clay made into paste, dried, baked at 600° C. and broken int lumps about ½ x ¾" in size.

(c) The minimum working temperature measured on gases at start of the process is about 650° F. and by gradually raising the temperature to 800° F. a life of about 3 weeks is obtained, during which at least 24 gals. per hour of liquid butylene can be obtained from a battery of three catalysers.

(d) Any undue rise of temperature in the catalysers will shorten the life of the catalyst, but not to the same extent as in the third stage.

(e) The return of unconverted butyl, butyl ether, etc., though giving a lower yield at the time does not exert any detrimental effect on the catalyst.

(f) Chemical losses in this stage are comparatively small, provided the unconverted material is returned and the "catalytic water" distilled to recover dissolved butyl alcohol (2-3%).

Mechanical Considerations and Conclusions.

(a) The present type of catalyser is satisfactory provided it can be made definitely non-porous and that suitable means of jointing between inner and outer shell can be devised. The small copper ing gasket gave satisfactory results as a temporary expedient ut gave trouble by distorting the flanges of the catalysers, thus endering the later making of joints more difficult.

(b) The heat interchanging system, owing to the large amount f interconnecting piping, which involved loss of heat and leakages, ould with advantage, be replaced by a system in which a separate terchanger, evaporator and pump is used for each battery. This as the advantage, that a break down in the interchanger does not ut down all the batteries at once, that positive amounts of butyl n be fed to each battery, and that pipe radiation losses would e less.

(c) With the present heat interchanging system it was not ssible to run more than 30 gals. per hour per battery but with eater preheating and less resistance in interchanging system, 35 ls. per hour would be possible.

urces of Loss.

(a) "Catalytic water." This contained about 2-4% of butyl ohol and no means had, up to the time of closing, (owing to pres- e of other work) been provided for handling this. This would y, however, represent about 1% of the normal butyl feed.

(b) Formation of but-aldehyde. Almost negligible.

(c) Leakages. Serious at first but gradually eliminated.

(d) Mechanical troubles involving venting to air for a period. On a few occasions this was necessary, but loss in this way did not amount to much.

2ND STAGE (BUTYLENE TO SECONDARY BUTYL ALCOHOL)

Sulphation.

The sulphator as provided on September 17th was the same one previously described but with a somewhat larger two bladed propeller. After short service the lead lining on the propeller gave way and one of the smaller type was installed with the addition of a step bearing to prevent whipping of the shaft. The chief objection to the sulphator in this form was the high speed (900 r.p.m.) necessary to bring about efficient mixing. A new sulphator which had arrived was therefore fitted up with a larger 3 bladed propeller possessing greater lifting power. The central lead cylinder was also fitted with spiral vanes in order to prevent swirling action. This type was found to give very satisfactory results at 350 instead of 900 r.p.m. as with the old type.

Capacity of Sulphating Units.

A charge of 65 gals. of acid and 65 gals. of butylene was used practically throughout the manufacturing period and it was found that 2 such charges could be completed in one hour, so that the capacity of one sulphator is approximately 130 gals. per hour (butylene).

Amount Sulphated.

Between September 17th and November 16th 34,533 gals. o liquid butylene were sulphated.

Lead Valves on Sulphator.

Considerable losses were caused by unsuitable lead valves a bottom of the sulphator, through leakages on them the acid laye would be blown up to the B.H.S. feed tank before completion o the sulphation. These valves were replaced by an angle typ valve which give greater satisfaction. Further reference to th will be made in section dealing with yield and losses.

SULPHATOR PRESSURE CURVES.

During the operation of the sulphator, readings of the pressure were taken every two minutes, and were very valuable in indicating any variation in the conditions either chemical of mechanical.

No. 1 *and* 2.

The first two of these indicate the difference in rate of absorption of the butylene when working with 72% and 74% acid, when the most efficient mixing was not provided. It will be seen that with the 74% acid the reaction was much more rapid.

No. 3 *and* 4.

These illustrate the difference in rate of reaction when 72 and 74% acid is used, but with more efficient mixing.

On comparing No. 1 and 2 with No. 3 and 4, the superiority of the slow speed, large bladed propeller, is indicated.

No. 5.

This indicates that the reaction is considerably slower when the acid is less than 70%.

Hydrolysis of B.H.S. in Lead Still.

On completion of sulphation indicated by drop of pressure in the sulphator the B.H.S. was elevated by air pressure to either of two acid proof tanks, holding 1,500 and 2,500 gals. From either of these tanks the B.H.S. was run by gravity into a lead lined constant level tank and from thence into a diluting mixer above the lead still where it met a stream of warm water from a constant level water tank. Owing to the liberation of a certain amount of gas (SO2-butylene) in the diluting mixer it was found necessary to provide a vent in the diluting mixer and this eliminated to a considerable extent, trouble which had been experienced in regulating the constant feeds of water and B.H.S. The feed entered the 2 plate lead lined column through the usual seal which was provided with a sampling cock by means of which the S.G. of the feed could be determined and hence the proportions of B.H.S. and water regulated.

The still was capable of handling about 400-500 gals. per hour of B.H.S. when diluted with twice its volume of water.

In discontinuous practice it has only been found necessary to use 1½ times the volume of water as compared with B.H.S. but in the continuous still at least twice the volume is necessary as otherwise the hydrolysis is not sufficiently rapid and the unhydrolysed compound may escape with the slop. This is referred to later.

Trouble was experienced on several occasions owing to the eating out of defective lead pipes and valves.

Considerable trouble was also experienced at one time owing to the accumulation of crystalene deposits of aluminum and sodium sulphates which were derived from the recovery concentrating towers and were thrown out on mixing of the recovered acid with butylene.

These deposits caused blockages in the pipe lines and valve seats and were finally eliminated by the installation of a water flushing system.

Control of still was based on the vapor temperature on the condenser-dephlegmator pipe, this being recorded by a disc type recording thermometer, the best results were obtained by keeping this temperature at 185° F. (or 90° C.). The secondary butyl C.B. mixture was run from the tester to a separating tank whence the top layer flowed to the salting plant and the bottom layer was pumped back to the lead still water feed tank.

The top layer was salted in a continuous salter with a small quantity of strong caustic being also run in to neutralize the SO_2 present.

The salted Sec. Butyl was pumped to Trinity Street still for rectification. The acid slop from the lead still ran by gravity to dilute acid storage tanks to be reconcentrated.

Altogether about 70,000 gals. of B.H.S. were passed through the lead still from September 17th to November 10th.

The appended recording thermometer charts are ones taken from the vapour temperatures at the dephlegmator.

Chemical Consideration and Conclusions.

(a) The appended sulphator pressure curves, which are typical of several hundred obtained will indicate that satisfactory results can be obtained with 70-71% sulphuric acid.

(b) Sulphation could not be obtained with the present type sulphator with acid weaker than 68%.

(c) The stronger the acid the more rapid the action, but the greater the tending to polymerise the butylene and also to liberate sulphur dioxide.

(d) The weaker the acid the greater the purity of the product but the more violent is the mixing required.

(e) A low initial temperature needs longer sulphation or more violent mixing but ultimately gives better results. Summarizing then it is desirable to use as weak an acid as possible probably about 70%, to provide a very powerful mixing device and if possible a cooling coil.

(f) It is important that the recovered acid should not contain aluminum and sodium sulphates either in solution or as crystalline suspension or deposit. These salts were derived from the concentrators and caused considerable trouble both chemical and mechanical.

Mechanical Considerations and Conclusions.

(a) The 3 bladed, big lift, slow speed propeller was a decided improvement on the small bladed high speed propeller.

(b) An acid and heat resisting enamel would have been preferable to the lead lining.

(c) With a cooling arrangement installed, the present type of mixing would be quite satisfactory.

Sources of Loss—Sulphation.

(a) Polymerisation of butylene. Not excessive provided the acid is not too strong and the temperature not too high. Normally about 5% under present working conditions.

(b) Incomplete absorption. If the acid is too weak or if there s excess of aluminum and sodium sulphate complete absorption ith the present type of sulphator is difficult. In the early stages osses were incurred through these causes.

(c) Mechanical losses. Leakage of the bottom lead valves aused considerable losses at one time through the charge escaping o B.H.S. tank before sulphation was completed. This was largely emedied by installation of new type of valve and removal of deposit which blocked seating of valves.

ydrolysis.

(a) At this stage the chief losses in the process occurred.

(b) The results of the operation of the continuous lead still indicate that a discontinuous still would have been preferable as time of passage of the liquor through the still when running at high capacity is not always sufficient to ensure complete hydrolysis of the B.H.S.

(c) Losses occurred at the start through lack of satisfactory feed control which enabled undiluted B.H.S. to enter still at times. This on heating yielded the olefine. Remedied by installation of constant level B.H.S. and water feed boxes.

(d) Samples of B.H.S. taken from the B.H.S. tank frequently yielded 93-96% yield of crude salted secondary butyl alcohol when distilled in the laboratory, whereas after passage through the lead still the yields were sometimes as low as 60%.

(e) The formation of the neutral ester which is not so readily hydrolysed was responsible for a certain loss and also for carbonisation in the concentrators.

Salting the Secondary Butyl.

(a) A small loss about 1% was incurred through the lack of means of dealing with the secondary butyl dissolved in the brine. Means for handling this were under construction.

Acid Recovery in Chemico Concentrators.

The acid recovery towers have been described elsewhere so that results of their operation only will be described here.

As the M.E.K. plant was not at all times supplying sufficient dilute acid to keep a tower running continuously and it was not advisable to intermittently shut down the towers, a system of concentration and redilution was adopted to keep the towers running during such times that the lead still was not running.

In order to obtain the best results in the lead still it was necessary to dilute the B.H.S. so that the acid slop contained about 20% H_2SO_4.

The recovery process was carried out as follows:

The acid slop from the still was run to a 2,500 gal. lead tank in which any high boiling insoluble oils were skimmed from the surface. The clear acid was then elevated by means of an acid egg to the distributing tanks at top of the tower.

After passage through the concentrator the acid was tested and if of insufficient strength, returned to the towers. On reaching the required strength the acid was run to strong acid storage tank and thence returned to the M.E.K. building for further use.

Altogether the towers dealt with approximately 200,000 gals. of acid slop from the lead still.

The troubles which occurred in connection with this process will be discussed under another heading.

Rectification of Salted Secondary Butyl Alcohol.

This is carried out in an old spirit still, 5,000 gal. kettle, 40 x 5 ft. column, with 26 plates and 3 boiling caps on each.

A charge of 5,000 gal. of the neutral or faintly alcoholic salted secondary butyl is used and gives approximately the following fractions:

FRSB First Runnings.

This is the product collected up to 185 ° F. (85° C) measured on vapour at top of column. It contains some dissolved butylene, a little M.E.K. and the secondary butyl water CB mixture. This fraction is returned to the separating tanks in M.E.K. plant building the top layer being resalted, and the bottom returned to the lead still. Periodically, however, the first runnings must be cut out of the system and subjected to a separate rectification as they contain constituents which interfere with the salting of the product from the lead still.

S.B.1.

This is the secondary butyl CB mixture free from the impurities contained in FRSB and containing less water. It comes over between 185° F. and 194° F. (85° C. and 91° C). It is returned to the separating tank and afterwards salted.

S.B.2.

Intermediate fractions between sec. butyl, CB mixture and dry secondary butyl. Collected between 194° F. and 206° F. (91° C. and 97° C). It is added to the next charge of salted secondary butyl.

RSB.

Rectified secondary butyl collected between 206° F. and 216° F. (97° C. and 102° C). This product is returned to the feed tank of the third stage catalysers.

LRSB.

Residue in kettle=secondary butyl plus high boiling oils. Can be redistilled to obtain RSB.

The following are approximate amounts for 5,000 gal. charge:

FRSB .... 1,500 gals.

SB.1	300 gals.
SB.2	200 gals.
RSB	2,300 gals.
Residue	700 gals.

Altogether since Sept. 17th, 14,940 gals. of RSB have been obtained and we now have on hand (Nov. 19th):

3,125 gals. of RSB.
1,025 gals. of SB.1 and SB. 2.
1,925 gals. of FRSB.
3,900 gals. of LRSB.

ACID RECOVERY.

Chemical Consideration and Conclusions.

The acid slop on leaving the lead hydrolysing still, was clear and colourless, with a very small amount of supernatant tarry matter. A skimming device was installed in the dilute acid storage tank for removing this tarry matter. In laboratory experiments it was found that the dilute acid on concentration to 75% strength, only showed slight discolouration but with the large towers it was found that considerable carbonisation occured with the formation of a tarry semi-carbonised deposit. This was due, in the early stages, in part to imperfect combustion of the oil, but on rectification of this trouble by increasing air and preheating oil the deposit was still found, and was due to carbonisation of small quantities of neutral esters which escaped hydrolysation in the lead still. If the acid slop is concentrated by boiling in a glass or porcelain vessel the carbonisation only occurs on reaching a strength of at least 80% by wt. of sulphuric acid, but in the Chemico Concentrators it occurred on bringing the product up to 70-75%. This would indicate that in the concentrators, local momentary over-concenration occurred with the deposition of carbon, the ultimate product being a result of a mixture of this over concentrated acid and the less concentrated acid. Had the neutral esters not been carbonised they would have been returned with acid to the sulphating system and had a further chance of being hydrolysed till an equilibrium was reached at which a definite amount of such esters would be passing round the circuit.

One of the main troubles with the concentrating towers was the apparent unusual solvent action of the acid on the materials of construction. This led to the formation of large deposits of crystalline aluminum and sodium sulphates in the strong acid tank. Means was adopted for removing this deposit, but it was also found that the acid by being saturated with these salts, threw out a further deposit after combination with the butylene to form butyl hydrogen sulphate. This deposit caused considerable trouble at first.

The Chemical Construction Company stated that the extended action of the acid in the towers was not in accordance with precedent, but previously they had only handled a comparatively strong acid. The solvent action was presumably due to the comparatively weak acid which we were handling and it is probable that this action would have diminished after a more extended period of working.

3RD STAGE (SEC. BUTYL TO M.E.K.)

The Plant and Process.

This was carried out in batteries of 3 catalysers, two batteries being run in parallel. The catalyst consisted of fused crystalline copper oxide obtained by fusing black copper oxide powder at 1,100° C. and breaking the masses obtained into lumps about ½ x ¾".

A variable stroke pump delivered the secondary butyl alcohol to an evaporator and thence to a gas heat interchanger utilising the heat from the catalysers to preheat the in-going secondary butyl. The preheated vapours passed through venturi meters to either or each of the two batteries. The resultant M.E.K., hydrogen and unconverted secondary butyl alcohol, after passing through the interchanging system and condenser, entered a separating tank whence the liquid condensate was pumped to crude M.E.K. storage and the hydrogen gas passed to the water scrubbing tower.

Blue prints of the scrubbing tower have been submitted previously and the process of scrubbing and recovery is carried out briefly, as follows: Water passes down the column at such rate as to provide a liquor at the bottom, containing about 2-3% of crude M.E.K. The liquor flows to a 2,500 gal. wooden storage tank and the hydrogen either to the atmosphere, or to a fresh battery of catalysers for the preliminary reduction of the copper oxide. The scrubbing liquor is pumped to a high level feed tank and from thence through a slop preheater to the exhausting column of the recovery still. The vapours from the exhausting column pass through a concentrating column, dephlegmator and condenser, to the tester. The temperature on the dephlegmator controls the operations and is such as to include the M.E.K. and secondary butyl constant boiling mixtures in the product. The product passes to a decanter, whence the bottom layer is returned to the feed tank and the top layer to an intermediate and thence to calcium chloride salting mixer. The salted product is decanted, the top layer passing to crude M.E.K. storage and the bottom layer being re-concentrated with return of the vapours to the still and of the liquor to calcium chloride storage. The scrubbing still and salting system gave very satisfactory results, but the scrubbing towers would have been more satisfactory if working nearer its full capacity, namely 10,000 cft. per hour.

Two methods of reducing the copper oxide were tried. (a) Passing secondary butyl alcohol through at a temperature of about 280° C (536° F.) and collecting the first portion of crude M.E.K., separating and passing it to the intermediate tank of the scrubbing system for salting, this being necessary to remove the water formed by reduction of the copper oxide. (b) Passing hydrogen from one battery over the fresh copper oxide of the second battery.

The first method was found to give the better results. The general plan of operation was to pass 25 gals. per hour of secondary butyl alcohol through each battery, starting at the lowest temperature necessary to maintain a conversion of at least 60% of butyl alcohol and raising the temperature as the activity of the catalyst was reduced.

Samples of the product could be taken periodically from each battery and from the results of an estimation of the percentage of M.E.K., the temperature could be controlled accordingly.

When the activity of the catalyst was reduced to a point at which it would not give a sufficient percentage conversion the battery was cut out and the catalyst re-burned in a furnace at 900° C. This restored the activity by removing the high boiling oils condensed on the surface.

LOG OF 3RD STAGE RUN FROM OCT. 15 TO DATE OF CLOSING.

November 14th, 1918.

Date	Time	Rate Feed Sec. Butyl gals. per hour	Rate M.E.K. formed gals. per hour	% Conversion No. 3 Batt.	% Conversion No. 4 Batt.
Oct. 15—	No. 4 battery working only. Temp. of catalysers 540° F. started at 4.30 p.m. Reduction taking place until 8 p.m.				
	9.00 p.m.	15	11.5		77.3
	11.00 p.m.	20	15.7		78.4
	12 mt.	20	16.0		80.5
	Feed pump not working from 12.15 to 2.15 a.m.				
16—	2.30 a.m.	20	14.7		73.4
	4.30	20	13.3		66.3
	6.00	15	12.5		83.5
	Temp. on catalysers rose to 620° F. which was sufficient to poison catalyst.				
	8.00 a.m.	20	8.4		42.0
	10.00 a.m.	20	5.3		26.6
	12.00 noon	20	6.1		30.4
	2.00 p.m.	25	8.9		35.6
	4.00 p.m.	25	8.1		32.4
	No. 3 Battery started at 4 p.m. Reduced with H2.				
	6.00	50	20.5	48.9	32.8
	8.00	50	25.2	77.1	23.8
	10.00	50		82.4	
	12 mt.	50			32.3
17—	2.00 a.m.	50		68.8	
	4.00	50	30.8	74.9	48.0
	6.00	50	27.0	71.5	37.1
	8.00	50	27.4	75.0	34.6
	10.00	50	24.6	68.9	29.8
	12.00 noon	50	24.4	68.6	29.2
	3.00 p.m.	50	27.4	73.2	36.7
	No. 4 Battery closed down at 4 p.m. to be recharged.				
	6.00	25	17.6	70.3	
	8.00	25	15.8	63.2	
	10.00	25	16.2	64.9	
	12 mt.	25	15.5	62.3	
Oct. 18—	2.00 a.m.	25	14.7	59.0	
	4.00	25	14.2	56.9	
	6.00	25	14.5	58.2	
	8.00	25	11.7	47.0	
	10.00	25	14.4	57.2	
	12.00 noon	25	13.3	53.1	
	2.00 p.m.	25	15.0	60.3	
	4.00 p.m.	25	16.0	64.3	
	6.00	25	15.1	60.6	
	8.00	25	15.0	60.1	

Date	Time	Rate Feed Sec. Butyl gals. per hour	Rate M.E.K. formed gals. per hour	% Conversion No. 3 Batt.	% Conversion No. 4 Batt.
	10.00	25	14.2	56.9	
	12.00	25	12.0	47.9	
19—	2.00 a.m.	25	12.6	50.3	
	4.00	25	12.4	49.6	
	6.00	25	13.1	52.3	
	8.00	25	12.8	51.0	
	10.00	25	12.1	48.4	
	Reduction on No. 4 Batt. with H2 started at 11.30 a.m.				
	12.00 noon	25	12.6	50.5	
	2.00 p.m.	25	13.6	54.3	
	4.00	....	......	......	
	6.00	50	24.2	55.8	40.9
	No. 4 Batt. started at 5.30 p.m.				
	8.00	50	22.5	53.2	36.7
	10.00	50	25.3	62.2	39.2
	12.00	50	20.0	45.0	34.7
20—	2.00 a.m.	50	24.8	52.5	46.0
	4.00	50	22.5	51.4	38.5
	6.00	50	23.3	49.5	43.7
	8.00	50			61.0
	10.00	50	14.1	26.7	29.8
	12.00 noon	50	15.6	28.1	34.0
Oct. 20—	1.00 p.m.	50			34
	No. 3 Battery closed down at 1 p.m.				
	3.00 p.m.	25	13.7		54.8
	5.00	25	11.8		46.2
	7.00	25	11.7		46.6
	9.00	25	12.9		51.6
	11.00	25	11.4		45.6
	1.00 a.m.	25	11.4		44.1
	3.00	25	11.0		43.1
	5.00	25	10.8		36.7
	7.00	25	9.2		42.6
	9.00	25	10.7		44.5
	11.00	25	11.1		48.4
	1.00 p.m.	25	12.1		59.0
	3.00	25	14.8		45.5
	5.00	25	11.4		45.5
	7.00	25	11.4		66.0
	9.00	25	16.5		43.8
	11.00	25	11.0		42.5
22—	1.00 a.m.	25	10.6		39.1
	3.00	25	9.7		39.6
	5.00	25	9.9		36.2
	7.00	25	9.1		43.3

FURTHER REPORT ON M.E.K. PROCESS

Date	Time	Rate Feed Sec. Butyl gals. per hour	Rate M.E.K. formed gals. per hour	% Conversion No. 3 Batt.	% Conversion No. 4 Batt.
	9.00	25	10.8		47.0
	11.00	25	11.7		48.5
	1.00 p.m.	25	12.1		48.0
	3.00	25	12.0		41.3
	5.00	25	10.3		44.1
	7.00	25	11.0		43.5
	9.00	25	10.9		42.3
	11.00	25	10.6		
Oct. 23—	1.00 p.m.	25	10.5		42.9
	3.00 a.m.	25	9.5		37.8
	5.00	25	9.5		38.1
	7.00	25	9.5		38.0
	9.00	25	15.9		63.5
	11.00	25	12.1		48.4
	1.00 p.m.	25	11.2		44.9
	3.00	25	10.7		42.7
	5.00	25	9.8		39.9
	7.00	25	10.1		40.2
	9.00	25	9.00		41.3
	11.00	25	9.85		39.7
24—	1.00 a.m.	25	8.75		35.0
	3.00	25	9.4		37.5
	5.00	25	8.75		35.0
	7.00	25	7.6		30.4
	9.00	25	9.05		36.2
	11.00	25	8.65		34.6
	12.00	25	8.4		33.5
	No. 4 Battery closed down at 12 noon. Temp. at finish 600° F.				
	No. 3 Battery. Reduction with Sec. Butyl started at 7.30 p.m.				
	9.00 p.m.	25	9.9	39.7	
	11.00	25	20	80.0	
25—	1.00 a.m.	25	23.8	95.4	
	3.00	25	18.9	75.6	Reduction completed at 4.30 a.m.
	5.00	25	18.6	74.5	
	7.00	25	19.7	78.8	
	9.00	25	19.6	78.3	
	Total Sec. Butyl used 6,533 gals.				
	Total Crude M.E.K. formed 6,600 gals.				
t. 25—	11.00 a.m.	25	17.8	71.3	
	1.00 p.m.	25	16.7	67.0	
	3.00	25	17.9	71.8	
	5.00	25	17.4	69.6	
	7.00	25	16.2	65.0	
	9.00	25	17.0	68.0	

Date	Time	Rate Feed Sec. Butyl gals. per hour		Rate M.E.K. formed gals. per hour	% Conversion No. 3 Batt.	No. 4 Batt.
	11.00	25		15.4	61.7	
26—	1.00 a.m.	25		14.1	56.6	
	3.00	25		14.0	56.0	
	5.00	25		13.6	54.5	
	7.00	25		13.2	52.8	
	9.00	25		13.0	51.9	
	Temp. raised to 550° F. at 10 a.m.					
	11.00	25		12.9	51.8	
	1.00 p.m.	25		12.7	50.8	
	3.00	25		12.9	51.8	
	5.00	25		11.7	46.8	
	7.00	25		12.4	49.6	Temp. raised to 560° F. at 1 p.m.
	9.00	25		11.75	47.0	
	11.00	25		11.3	45.2	
27—	1.00 a.m.	25		11.3	45.1	
	3.00	25		11.3	41.6	
	5.00	25		10.4	39.8	
	6.20 Catalyser closed down at 6.20 a.m.—no sec. Butyl, Maximu temp. noted was 580° on No. 1 Cat. No. 3 Batt. at 7.30 p.m., 26t Total Sec. Butyl used, 7,692 gals. Approx. crude M.E.K.					
Nov. 2—	3rd Stage continued Nov. 2nd at 12.50 p.m. Heat put on catalyse at 8.45 a.m. Temp. of catalysers 450° F. with steam. No. 3 Ba charged with new CuO CuO2 catalyst. No 4 Battery charged wi reoxidized CuO CuO2.					
	3.00 p.m.	50	39.6	77.1		
	5.00	50	41.7	92.0	74.8	
	7.00	50	35.3	71.4	70.5	
	9.00	50	38.4	75.6	78.2	
	11.00	50	40.3	86.1	75.0	
3—	1.00 a.m.	50	42.7	90.5	80.5	
	3.00	50	41.2	86.2	78.6	
	5.00	50	40.0	93.0	77.3	
	7.00	50	41.2	90.0	74.5	905
	9.00	50	38.8	83.5	71.4	
	11.00	50	39.7	88.0	70.7	
	1.00 p.m.	50	34.2	89.6	57.3	
	3rd stage shut down from 11.15 to 12.25 noon. Water sup repairs.					
	3.00	50	37.3	88.6	60.5	
	5.00	50	39.3	78.6	64.5	
	7.00	50	37.0	85.6	62.4	
	9.00	50	35.4	80.9	59.9	
	11.00	50	32.0	76.4	51.7	

FURTHER REPORT ON M.E.K. PROCESS

Date	Time	Rate Feed Sec. Butyl gals. per hour		Rate M.E.K. formed gals. per hour	% Conversion No. 3 Batt.	No. 4 Batt.
4—	1.00 a.m.	50	36.7	84.0	62.5	
	3.00	50	34.8	82.0	57.0	
	5.00	50	32.7	80.2	50.5	
	7.00	50	34.2	78.6	54.3	1140
	9.00	50	35.9	92.4	51.2	
	11.00	50	33.1	79.4	52.9	
	1.00 p.m.	50	31.0	78.0	45.9	
	3.00	50	30.7	76.1	46.4	
	5.00	50	28.5	72.3	41.8	
	7.00	50	26.7	65.5	41.3	
	3rd Stage shut down at 8.15 no sec. Butyl for continuation. Temp. 520° F.					
	8.15	50				663
				Total		2708
	3rd Stage continued Nov. 12th at 12.10 noon. Both batteries working.					
ov. 12—	3.00 p.m.	50	24.4	65.7	31.8	
	Temp. raised to 540° F. on No. 4 Battery at 3 p.m.					
	5.00	50	29.1	75.6	40.8	
	Temp. raised to 560° F. on No. 4 Battery and to 540° F. on No. 3 Battery.					
	7.00	50	28.3	70.9	42.4	
	9.00	50	29.8	72.63	46.7	
	11.00	50	27.2	66.4	42.1	
13—	1.00 a.m.	50	24.7	58.3	40.0	
	3.00	50	23.8	55.6	39.3	
	5.00	50	24.7	63.5	35.0	
	7.00	50	25.2	62.3	38.5	985-8 a.m.
	9.00	50	25.8	64.0	38.9	
	Temp. raised to 570° F. on No. 4 Battery.					
	11.00 a.m.	50	24.9	64.1	35.5	
	1.00 p.m.	50	26.6	68.0	38.5	
	3.00 p.m.	50	24.5	53.1	35.0	
	Temp. raised to 580° F. at 3 p.m. on No. 4 Battery.					
	5.00	50	25.5	63.4	37.5	
	7.00	50	22.6	54.2	36.2	
	9.00	50	24.5	60.5	37.5	
	11.00	50	24.1	59.5	36.7	
14—	1.00 a.m.	50	27.9	69.0	42.6	
	3.00	50	27.3	63.3	45.8	
	5.00	50	31.0	73.1	51.1	
	7.00	50	29.3	68.0	49.1	

Date	Time	Rate Feed Sec. Butyl Gals. per hr.	Rate M.E.K. formed gals. per hour	% Conversion No. 3 Batt.	No. 4 Batt.	Sec. Butyl Fed Daily
	9.00	50	28.8	71.5	43.7	1200-8 a.m
	11.00 a.m.	50	29.4	74.2	43.5	
	1.00 p.m.	50	30.8	82.0	41.0	
	3.00	50	27.9	76.9	34.5	
	5.00	50	27.1	72.9	35.6	
	7.00	50	26.5	70.5	35.6	
	9.00	50	27.0	75.6	32.4	
	11.00	50	27.4	75.6	34.0	
Nov. 15—	1.00 a.m.	50		63.9		
	3.00	50	25.2	64.2	36.7	
	5.00	50	24.1	61.0	35.5	
	7.00	50	26.6	70.7	35.6	1200-8 a
	9.00	50	29.3	81.1	36.3	
	11.00	50	27.0	76.9	31.27	
	1.00 p.m.	50	26.0	70.5	32.9	
	3.00 p.m.	50	28.4	78.4	35.5	
	5.00	50	26.2	68.6	36.2	
	7.00	50	25.7	70.2	32.7	
	9.00	50	25.0	69.1	30.8	
	11.00	50	25.8	71.5	31.8	
	1.00 a.m.	50	25.8	69.2	34.0	
	3.00	50	22.9	60.5	31.3	
	5.00	50	22.9	61.2	30.7	
	7.00	50				1200-8 a
	9.00	50				
	10.00	50				75

3rd Stage shut down at 9.30 a.m. Armistice.

Distillation of Crude M.E.K.

The M.E.K. refining still was a discontinuous still with a 7,0
gal. kettle, 60" x 30 ft. column, and 36 plates. It is constructed
iron and has copper dephlegmator and condenser. Also provi
with caustic scrubber which could be used or cut out at will.

A charge of 6,000 or 7,00 gals. of crude M.E.K. containing fr
50-60% M.E.K. could be used.

The following cuts were made:

FR M.E.K.

M.E.K. and water CB mixture collected up to 172° F. (78°

M.E.K. 2.

This is strong M.E.K. conforming to specification as regards S.G. but possibly failing as regards permanganate test, acidity or lkalinity.

Pure M.E.K.

The product conforming to specification.

E.K. Intermediate.

Intermediate fraction between M.E.K. and secondary butyl lcohol collected from about 178° F. (81° C.) up to 203° F. (95° C.)

SB.

Collected between 203° F. (95° C.) and 214° F. (101° C.) this action is returned to catalyser, being largely secondary butyl lcohol.

R M.E.K.

Consists of secondary butyl alcohol and high boiling oils formed om M.E.K. residue in kettle stored for redistillation to recover y secondary butyl alcohol.

fining of M.E.K.

This was carried out in the same still that was used for the ude M.E.K. Two charges of crude M.E.K. were run through the ll and it was found that it was not possible to obtain an appreciле quantity of M.E.K. up to specification in a single distillation.

The first runnings from the crude M.E.K. were, on account of water present, returned to the scrubber salting system and ted with CaCl. 2. This, together with the M.E.K. 2, obtained in first distillation formed a charge for the final refining distillan. The fractions collected in the final distillation are as follows:

M.E.K.

M.E.K. and water CB mixture 72° C.-78° C.

.K. 2.

Strong M.E.K., but failing to satisfy chemical tests of specifion.

e M.E.K.

Product up to specification.

K. Intermediate.

M.E.K. together with a small amount of secondary butyl alcohol.

From the two charges of Crude M.E.K. distilled, 4,600 gals. lted FR M.E.K. and M.E.K. 2, were obtained. This in distillation gave:

FR M.E.K.	1,040 gals.
M.E.K. 2	360 gals.
Pure M.E.K.	2,850 gals.
Residue	300 gals.

A composite sample of the M.E.K. gave the following results on analysis:

Specific Gravity	0.81015/15° C.
Residual Matter	0.0001%
Permanganate Test	90 minutes plus.
Acidity	0.0017 due to CO2.
Alkalinity	0.000 due to organic acids. No alkalinity to p-nitrophenel.

Miscible with equal volume of carbon bisulphide.

Distillation of 200 cc. at rate of 1 drop per second, without fractioning column gave following results:

75-77° C.	10 cc.
77-78	46 cc.
78-79	78 cc.
79-80	50 cc.
80-81	10 cc.
Residue	2½ cc.

Chemical Considerations and Conclusions.

(a) The short life of the 3rd stage catalyst in several of th runs was due to several causes including:

(1) Temporary rise of temperature beyond the safe limit.

(2) Contamination with tin chloride obtained from the swea ing of the catalysers and carried on to the surface of the catal in suspension in liquid secondary butyl. The latter occurred in l catalyser of each battery, owing to the preheating being inadequ at this plant to vaporise the secondary butyl alcohol.

(NOTE—The catalysers had been tinned to reduce porosity.)

(b) The most satisfactory catalyst tried either on the large experimental scale was the crystalline (CuO Cu2O) obtained fusing commercial black fine copper oxide powder.

(c) This catalyst, though superior as regards life and acti to all others tried, is very sensitive to high temperature, its ac ity being rapidly reduced if the temperature exceeds 300° C.

(d) The practical life of the catalyst if temperature contr satisfactory, would be about one week, during which the second butyl alcohol could be passed at the rate of 25 gals. per hour per battery.

(e) That by re-oxidising the catalyst at a high temperature its activity can be restored and it can be used again.

(f) It was found necessary to pump at least 25 gals. per hour per battery to obtain a fair reading of the temperature on the gases and to avoid local overheating.

(g) Reduction with secondary butyl alcohol appears to be superior to reduction with hydrogen.

(h) It is desirable to have as little water as possible in the crude M.E.K. owing to the fact that M.E.K. forms a CB mixture with water B.P. 74° C. and secondary butyl alcohol, a CB mixture B.P. 86° C. Thus if much water is present, perhaps the whole of the M.E.K. will come over as CB mixture and also some of the secondary butyl. The CB mixture would have to be salted.

(i) There is always present a small amount of water derived from the reduction of the copper and from the hydrogen scrubbing ystem. This carries over a certain amount of M.E.K. as CB mix- ure, which is returned to the salting plant.

(j) Laboratory experiments on the use of the copper catalyst in he presence of air or oxygen indicate that this method, though ex- hermic, is not so suitable as the direct dehydrogenation. Firstly, account of the water produced, secondly, on account of difficulty control and thirdly, on account of formation of bigger proportion bye-products. There is also risk of explosion when carrying out is method on a large scale.

echanical Considerations and Conclusions.

(a) As regards catalysers and interchangers, the same trou- s were experienced in this stage as in the first stage, namely, king joints and porosity of castings. However, the two batteries 3 catalysers were finally installed so as to give satisfactory re- s from this point of view.

(b) The pressure on the gases in the catalysers amounted to n 12 to 22 lbs. when running at 25 gals. per hour per battery. s pressure was due to the resistance in the interchangers and ned to increase towards the end of the period of working.

(c) After installation of a deeper seal on the scrubbing tower a few minor alterations, the hydrogen scrubbing and recovery m proved quite satisfactory mechanically.

d) The M.E.K. refining still proved to be of high efficiency, very sharp cuts being possible.

Sources of Loss.

(a) Provided the temperature does not rise beyond the safe limit this reaction is almost quantitative, very small amounts of high boiling oils being found, also traces of organic acids (propionic, butyric).

(b) When working at low capacity the scrubber did not give its best results. This being due to the comparatively small quantity of gases tending to take the path of least resistance on each plate, thus avoiding an intimate bubbling and scrubbing action as would be the case with a more rapid stream of gas and water.

(c) The main losses in this stage would be due to the number of distillations involved in obtaining the final product.

The accompanying record sheets indicate the data necessary for controlling the process. These were filled in throughout the trial runs.

Operating Staff.

The following is the number of men essential to operate the plant when handling 70 gals. per hour of Butyl Alcohol, as was the case during the last few months:

Chemists.

Two men per shift and three shifts per 24 hrs. (Complete control of plant during shift). One chemist as superintendent of operation and manufacture.

Catalyst preparation including production of Baked Kaolin an
Fused Copper Oxide.

One man per shift, 3 shifts in 24 hours. Alternately workin on kaolin and copper oxide, according to requirements.

N-Butyl Alcohol Distillation.

1 man per shift, 3 shifts in 24 hours.
One foreman distiller.

N-Butyl and S-Butyl catalyser feed pump.

1 man per shift, 3 shifts in 24 hours.

Electric Heating of Catalysers.

2 men per shift and 3 shifts per 24 hours.

Engineers.

One "stationary engineer" per shift for repairs, etc.
One engineer's help.

Sulphator, Lead Still, Scrubber, Sec. Butyl Salting Plant.
3 men per shift, 3 shifts per 24 hours.
One foreman per shift, 2 shifts per 24 hours.

Acid Concentrator.
One engineer in charge.
Two operators per shift, 3 shifts per 24 hours.

M.E.K. Refining Stills.
1 man per shift, 3 shifts per 24 hours.
1 foreman, covering 24 hours shift.

Increase in the output of the plant would not necessitate a very largely increased number of operators.

DECEMBER 8TH, 1918. D. A. LEGG.

STOCKS OF SOLVENT IN CONNECTION WITH M.E.K. PROCESS NOVEMBER 30TH, 1918.

SECONDARY BUTYL ALCOHOL.

Rectified Secondary Butyl Alcohol.

1,504 gals. R.S.B. recovered from 3rd stage Tank No. 9, Mill St. =	12,032 lbs.
3,125 gals. R.S.B. from 2nd stage Tank, No. 32, Trinity St. =	25,000 lbs.
Total rectified secondary Butyl	37,032 lbs.

Total—4,629 gals.

B. 2.

1,025 gals. in No. 23 Tank, Trinity St., containing about about 85% by volume sec. butyl=	6,968 lbs.

RSB.

1,925 gals. in No. 18 Tank, Trinity St., containing about 80% by volume sec. butyl =	12,320 lbs.

RSB.

3,900 gals. in No. 26 Tank, Trinity St., containing about 60% by volume S. B.	18,720 lbs.

R. M.E.K.

1,305 gals. in No. 15 Tank, Mill St., containing about 60% vol. Sec. Butyl =	6,284 lbs.

M.E.K. Intermediate.	
2,767 gals. containing 59% Sec. Butyl in No. 1 Tank, Mill St. =	13,056 lbs.
M.E.K. 2.	
565 gals. containing 24% by volume S.B. =	1,088 lbs.
Total S. B. in process	58,436 lbs.

M.E.K.

Pure M.E.K.	
34 drums of M.E.K. ready for shipment =	22,440 lbs.
gals. left in tank =	160 lbs.
	22,600 lbs.
M.E.K. Intermediate.	
2,767 gals. in No. 1 Tank, Mill St., containing about 41% volume M.E.K. =	9,075 lbs. M.E.K
M.E.K. 2.	
565 gals. in No. 2 Tank, Mill St., 76% vol. M.E.K. =	3,432 lbs. M.E.K
FR. M.E.K.	
1,044 gals. in No. 5 tank, Mill St., 89% vol. M.E.K.	12,504 lbs.M.E.K
600 gals. as antifreeze in lead still and scrubber, 89% vol.	
Total M.E.K. in process	25,011 lbs.

LOSSES AND YIELD IN WHOLE PROCESS.

It is not possible to fairly estimate the yield on account of th short period during which the plant was operated and the fact tha sources of loss were being eliminated throughout the period o working, but the main sources of loss may be indicated:

Chemical Losses.

(a) These represent losses incurred through failure to obtai the essential chemical reaction on account of the interference side reactions.

On the large scale the 1st and 3rd stages were not affected b this source of loss to an extent greater than in the laboratory.

In the second stage the losses on the large scale were considerably greater than in the laboratory, owing to the difficulty of *maintaining clean apparatus and acid,* and to other causes mentioned in the report. There was evidence that the losses were to some extent reduced and could have been considerably reduced through slight modification of the apparatus.

(b) *Natural Mechanical Losses.*

These represent losses which almost inevitably accompany the repeated handling of liquids or gases, especially at high temperatures. These include distillation losses and are to some extent chemical.

This source of loss was naturally higher when starting up the plant and dealing with comparatively small quantities of liquid.

(c) *Losses due to mechanical defects.*

Leakages in all sections were considerable at times, but were being eliminated.

(d) *Operating Losses.*

In starting a new process with new type equipment and with relatively unskilled operators, considerable losses may be incurred till the operators become familiar with the plant. This source of loss naturally occurred to some extent, but I must express my appreciation of the splendid way in which the control chemists and operators, few of them had any previous experience of such work, took hold of the work and rapidly became expert in their various capacities, so that operating losses were small.

Heating of Catalysers.

The 1st and 3rd stages of the reaction being endothermic it as necessary to supply a considerable amount of heat to bring bout the reaction.

The main heaters consisted of alundum tubes wound hairpin ethod with Chromel resistance wire, these were in the inner cham-ers. Additional heat could also be supplied from the outside, by ector alundum plates, also wound with resistance wire and fitted n to the outer shell.

Current was controlled by switch and barrel rheostats but auto-atic control was under consideration.

Full details of the electric heating will be reported upon by Mr. . J. Thompson, who designed the heaters and carried all the elec-ical work in connection therewith. From point of view of operation and suitability for the purpose the heaters gave entire satisfaction.

The radiation losses for the catalysers and interchanging system were somewhat high, but were considerably reduced towards the end of the period of working.

CATALYST PRODUCTION AND REQUIREMENTS.

1st Stage.

The catalyst used consisted of Kaolin, mined in Quebec, and of following composition:

Silicia	44.43%
Aluminum	40.48
Iron Oxide	0.039
Lime	0.24
Magnesia	0.36
Sulphuric anhydine	nil
Moisture, CO2, and organic matter	14.46

The clay was a levigated product, partly powder and partly in masses. It was made into paste with water rolled into cylinders of about ½" diameter, dried at about 50° C. in boiler house and then baked at 600° C. for fully one hour in a gas heated muffle furnace.

The product was almost pure white and brittle in nature.

Each catalyser requires about 80-90 lbs. of Kaolin, a battery therefore requires about 250 lbs.

Assuming a life of 3 weeks, which is indicated by our results, 250 lbs. of kaolin are capable of producing about 90,000 lbs. of butylene before becoming inactivated, i.e. 1 lb. of Kaolin produces about 360 lbs. of butylene before becoming inactivated. The inactivated kaolin cannot be conveniently re-activated.

Several other hydrated silicates of aluminum were tried, some giving even better results but were more difficult to obtain.

Stock on hand at close of plant.

Kaolin baked at 600° C., about 5 tons.

3rd Stage.

The catalyst used consisted of an ordinary commercial grade of black copper oxide fine, obtained from Drakenfeld of New York.

It was fused in a direct flame gas blow pipe furnace, capable of handling about one ton per day.

The furnace consisted of a solid fire brick hearth lined with special cement (Johns-Manville No. 32) and heated by three blowpipe flames. About 15 lbs. of the oxide were placed on the hearth and heated with direct oxidising flame for about 15 minutes with occasional stirring. At the end of this time the semi-molten product was withdrawn and allowed to cool, being afterwards broken into masses about ½ x ½". This method yielded a reddish crystalline oxide, which appeared to have been in no way detrimentally affected by contact with the gas flames and which possessed great catalytic activity.

Each catalyser requires about 200 lbs. of this oxide, i.e., 600 lbs. per battery.

Assuming a life of 6 days, as was indicated by our results, 600 lbs. of this would produce about 20,000 lbs. of methyl ethyl ketone before becoming inactivated, i.e., one pound of copper oxide produces about 33 lbs. of M.E.K. before becoming inactivated. In this case, however, the catalyst can, by being heated to 900° C. in the blowpipe furnace, be re-activated and used again. This and the fact that pure copper residues are obtained is one of the advantages of this catalyst for practical use.

Stocks on hand at close of plant.

Kaolin baked at 600° C., about 5 tons.
Copper oxide fused, about 3½ tons.
Copper oxide powder, 5 tons.

BRITISH ACETONES TORONTO, LIMITED.
JULY 17TH, 1918.

COMPARATIVE TESTS OF CATALYSTS
BY
D. ALLISTON LEGG.

(*Copy of part of report sent July* 17, 1918.)

All results shown below were obtained under same conditions which were as follows:

A 1 inch bore copper tube 4 ft. in length, placed in a 3 ft. electric tube furnace.

Catalyst layer 2 ft. in length, *i.e.,* 6" from each end of furnace. Effective cubic contents equals 14 ins. (230 cc).

Ends of tube outside furnace were lagged so as to prevent cooling of effective part of tube by conduction to and radiation from the ends.

Alcohol fed in by means of a burette so as to facilitate quantitative measurements and was found to be vaporised and preheated by the time it reached the catalyst.

Temperatures measured at point 1 ft. from top end of furnace on outside of copper tube. In the first stage experiments, at each temperature and with each catalyst, endeavor was made to feed at greatest rate at which 50% of the feed was converted and to estimate the amount converted per minute at this percentage conversion.

In the third stage 60% conversion in a single passage through the tube was aimed at. In these reactions there seems to be a short period during which the catalyst reaches its maximum activity, it then falls to an average activity which is maintained for a considerable time, at the end of which a slow decline takes place. The figures given represent conversion during the period of normal or average activity.

Silice tubes were abandoned in favor of copper tubes, on account of the poor heat transfer in the case of the former. The reactions being endothermic heat transfer exerts an important influence on the amount converted per unit of time in unit space.

We find that if the copper tube is not reoxidised internally its surface soon becomes inactive and does not cause appreciable conversion into aldehyde.

Note—Effect of metal of which catalyser is constructed.

Bronze was decided upon for the large catalysers on account of its superior heat conducting properties as compared with cast iron and we also found that iron tends to carbonise more readily than copper or bronze.

In both large and small scale experiments a slight amount of hydrogen and butaldehyde are formed during the first few hours with a new tube or catalyser, but the metal rapidly becomes inactivated and a purer gas is obtained (99-5% and over).

FIRST STAGE.

(Butyl Alcohol to Butylene.)

(a) *Aluminum Hydrate* heavy powder as used in preparation of metallic aluminum by Aluminum Ore Company of America, mixed into paste with half its weight of pure asbestos pulp and baked at 600° C. (found to be most effective baking temperature).

Temperature.	Litres of Butylene Gas per hr.	cc. of Butyl Alcohol converted per hr.	%Olefine.
350°C	6.3	24 cc.	98
450°C	27.	102	96
400°C	94.	360	94

These represent amounts converted per hour whilst converting 80% of the feed. For 90% conversion the rates would be somewhat slower.

NOTE—Numerous other grades of alumins have been tried, but the above product can readily be obtained in quantity and we have tried it in our full size catalysers.

(b) *American Hog Rock Kaolin* (Harris Clay Co., U.S.A.) made into paste and calcined at 600° C. Broken into lumps.

emperature.	Litres of Butylene Gas per hr.	cc. of Butyl Alcohol converted per hr.	%Olefine.
300°C	15	60	Over 99% by volume
340°C	40	150	
360°C	50-60	200-250	

(c) *English H.B. China Clay* (Cornwall, England) Paste and aked at 600° C.

360°C	50-60	200-250	over 99% by volume

(d) *Canadian China Clay* (Quebec).

360°C	50-60	200-250	over 99% by volume

NOTE—The effective life of kaolin appears to be about 10 days 2 weeks.

THIRD STAGE.

(Sec. Butyl Alcohol to M.E.K.)

Experimental conditions, furnace, etc., same as with first stage. In all tests below oxide was reduced in current of Secondary Butyl Alcohol, not with hydrogen.

(a) *Drakenfeld Black Copper Oxide on Pumice.*

Temperature.	Sec. Butyl Converted per hour.
240°C	50 cc
260°C	102 cc
250°C	140 cc
300°C	180 cc

NOTE—This catalyst is very variable and unreliable. Life is only 2-3 days at best, owing partly to catalyst falling to powder.

(b) *Drakenfeld Black Copper Oxide* made to paste with water, caked and broken into lumps.

Temperature.	Sec. Butyl Converted per hour.
300°C	60 cc

(c) Oxide as in "b" with 1% nickel oxide.

Temperature.	Sec. Butyl Converted per hour.
240°C	30 cc
260	60 cc
280	130 cc

In case of "b" and "c" life is short and lumps readily fall to a powder with very slight vibration.

(d) Copper oxide obtained by melting Drakenfeld Black Oxide fine, in a reverbatory furnace. The product obtained consists of bluish red mixed oxide, is hard, somewhate brittle and porous. I reduces readily throughout its mass even when in lumps 1" in diameter.

Temperature.	Sec. Butyl Converted per hour.
300°C	360 cc

In one test the normal activity represented above was maintained during four days. At the end of this time the temperature was raised to 380° C in order to kill the catalyst. At this temperature the activity was rapidly destroyed, but after passing a current of air for two hours at 380-400°C. to reoxidise and remove oils from the surface, the activity was partially restored again. This can be done in situ. How often this superficial reoxidation will be effective cannot yet be said.

This catalyst has the following advantages over other forms tried.

(1) It is coherent.

(2) Good conductor of heat.

(3) Very active and activity can easily be restored in situ (at least temporarily).

4. It can be made from inferior grades of copper oxide, impurities apparently having little effect.

(5) Being free from inert carrier the lumps of metallic copper when completely inactivated would probably have commercial value.

(6) It appears to be very easy to prepare this catalyst of uniform activity, all batches made so far being of approximately same activity.

(7) When oxidation in situ is insufficient to restore activity of the catalyst it can be removed and reoxidised at high temperature (900° C.) in reverbatory furnace. This appears to completely restore the original activity, oxidation at moderate temperature in the catalysers only partially restoring the activity.

COMPARISON OF EFFICIENCY OF CATALYSTS.

First stage.

Catalyst.	Temp.	% Purity Olefine.	Litres per hr. of Butylene per 100 cc. of catalyst.	Observer.
Aluminum phosphate and kaolin (silica tube)	360°C	99.0	15	Dr. W.
Tungstic oxide and kaolin (silica tube)	350°C	99.7	25	Dr. W.
Aluminum oxide and asbestos (copper tube)	400°C	96	11	DAL
	450°C	94	40	
Hog Rock Kaolin, English H. B. Kaolin, Can. China Clay Co.'s Kaolin	360°C	99.8	24	DAL

3rd stage.

Catalyst.	Temperature.	Ketone per hour per 100 cc catylst.	Observer.
(a) Pure CuO 1% NiO........	250-300°C	8 cc	Dr. W.
(b) Black CuO fine powder caked	300°C	26	D.A.L.
(c) Black CuO 1% NiO powder, caked	240°C	13	
	260°C	26	D.A.L.
	280°C	66 cc	
(d) Black CuO on pumice	280	60	
	300	80	D.A.L.
(e) Black CuO powder fused in reverbatory furnace	300°C	160	D.A.L.

Note—(a) and (b) in 1st stage and (a) in 3rd stage calculated from figures given in report recently received from England.

D. A. Legg.

REPORT
ON
THE MECHANICAL CONSTRUCTION AND EQUIPMENT
OF THE
CETONE, METHYL ETHYL KETONE AND ACID PLANTS
OF THE
BRITISH ACETONES TORONTO, LIMITED.
AT
TORONTO, CANADA.

PART II.

METHYL ETHYL KETONE AND ACID PLANTS.

E. METCALFE SHAW, WH.SC., ASSOC. M. INST. C. E.,
Engineer-in-Chief.

By

J. H. PARKIN, B.A.SC., M.E. ASSOC. MEM. AM. SOC. M.E.
Mechanical Engineer.

JANUARY 31, 1919.

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PART II.

M.E.K. SECTION OF REPORT.

THE METHYL ETHYL KETONE PLANT.

GENERAL—A plant for the conversion of normal butyl alcohol into methyl ethyl ketone may be regarded as one in which rectified normal butyl alcohol forms the raw material which in the plant is transformed into the finished product, rectified methyl ethyl ketone.

BUTYL ALCOHOL SITUATION.

PRODUCTION OF BUTYL ALCOHOL—When the first M.E.K. report of September 15, 1917, was presented followed by the authorization of the construction of the plant, the acetone plant was fermenting 2-43 fermenters per week with an 18,000 lb. charge of wet cornmeal each. The yields per fermenter were 1,224 lbs. of acetone shipped and 2,548 lbs. of 99% dry rectified normal butyl alcohol.

It was estimated that with the additions and improvements then being made or contemplated in the acetone plant, that the number of fermenters dealt with per week would be increased to 72 or 12 per day. At this rate of working there would be produced approximately 44 tons of acetone and 92 tons of butyl alcohol per week.

The butyl alcohol in storage in the plant at that time (September 18) was 1,342 tons of crude and 151 tons rectified, while 123 tons of rectified had been shipped up to that time; the total production being thus 1,617 tons. It was estimated, making allowances for the expected increase in rate of working, that by May 1, 1918, when the M.E.K. plant was expected to be completed) that the total butyl sold or in storage would be 4,363 tons (the actual quantity was 3,420 tons).

Butyl at the time was being sold at a rate of about 44,000 lbs. 2 tons) per week, while the rate of production, assuming 72 fermenters per week was 92 tons so that the butyl alcohol was accumulating in storage at a rate of 70 tons per week.

Disposal of Butyl Alcohol—There were four methods of dealing with butyl alcohol:

(a) That in use up to that time, namely, allowing it to accumulate in the crude state (wet), rectifying and selling as much as possible.

(b) Build a small M.E.K. Plant for the conversion of a fraction of the butyl, accumulating or selling the remainder.

(c) Build a conversion plant capable of converting the whole of the butyl produced, taking care of butyl requirements of customers from previously accumulated stock.

(d) Build an M.E.K. plant sufficiently larger than that required to handle the butyl production, so that the accumulated stock of butyl can be converted in a certain time.

The Report on the Proposed Methyl Ethyl Ketone Plant at Toronto by E. Metcalfe Shaw of September 15, 1917, dealt wit the first three of these methods very fully, from different points o view, solvent production and costs, plant costs and expenditure transportation, etc., and reference should be made to this repor for these considerations. Two alternative sizes of plant wer proposed, namely, a 50 gal. plant and a 150 gal. per hour plant, th latter capable of handling the then full output of butyl alcohol.

Advantages of M.E.K. Plant—On the assumption that methy ethyl ketone is as efficient as acetone as a solvent either for cordit or aeroplane dope, the advantages in favor of the construction o a conversion plant at Toronto as against the manufacture of a equal quantity of acetone by the biological process elsewhere wer on a basis of 72 fermenters per week and an 18,000 lb. charge:

(a) An increase in solvent production from 2,203 to 5,872 to with a saving of 54,459 tons of corn (foodstuff) yearly, which wou be the extra amount required for the production of an equal amou of acetone by the bacteriological process.

(b) If the acetone were to be manufactured in England, 54,4 tons of shipping would be required for the corn as against 3,6 tons for the M.E.K.

(c) With the manufacture of more acetone instead of M.E. a total of 12,217 tons of butyl alcohol would be put on market i stead of 4,586 tons with probable reduction in selling price.

(d) If no demand for butyl could be worked up the probl of storing the 12,217 tons of butyl accumulating each year wo be serious.

Other factors to be considered in arriving at a decision regarding the erection of the M.E.K. plant were, whether the M.E.K. as solvent was needed, whether an equal amount of acetone could be secured elsewhere in less time or for less money, the question of making the expenditure for new plant in Toronto or England, the value of the plant after the War and keeping idle the capital represented by the value of the butyl in storage.

A consideration of the above points in conjunction with the imperative need for solvent at the time, led to the authorization November 15th, 1917, of the construction of the methyl ethyl ketone plant to deal with the full quantity of normal butyl alcohol being produced at Toronto.

Necessary Capacity of Plant—In the meantime the fermenter charge in the acetone plant had been increased from 18,000 to 24,000 lbs. of corn with a resultant increase in butyl yield to 3,397 lbs. A plant for the conversion of the whole output of butyl under these altered circumstances would require a capacity of 212 gals. per hour. In order to provide capacity for converting the accumulated butyl alcohol in storage, and as a safeguard against possible failure of parts of the plant to operate up to rating, which was a distinct possibility due to the unusual nature of parts of the equipment, the nominal capacity of plant was placed at 250 gals. per hour of rectified normal butyl alcohol.

During the last weeks of operation of the acetone plant, previous to the signing of the Armistice, butyl alcohol was being produced at the rate of approximately 200,000 lbs. or 100 tons per week. This corresponds to a rate of practically 175 gals. per hour, and the rate was still increasing as shown by the production curves.

THE METHYL ETHYL KETONE PROCESS.

The process for the conversion of normal butyl alcohol resulting from the manufacture of acetone from corn by the biological process into methyl ethyl ketone is divided into three principal stages:

Division of Process.

Stage I—The conversion of rectified normal butyl alcohol into butylene by catalysis. The reaction is endothermic. The 99.0% pure alcohol is passed over the dehydrating catalyst at a high temperature and supplied with endothermic heat. The resulting butylene is then separated from the water, unconverted butyl alcohol and butyl ether, etc., and liquified.

STAGE II—The transformation of the butylene into secondary butyl alcohol. The liquified butylene is mixed or sulphated with an equal quantity of 75% sulphuric acid resulting in the absorption of the butylene forming butyl hydrogen sulphate or butyl sulphuric acid. The latter is diluted with water and the butyl hydrogen sulphate decomposed and alcohol separated by steam distillation in a lead still. A constant boiling mixture of secondary butyl alcohol and water, together with impurities and excess water results, which is separated and the upper layer salted with sodium chloride and distilled from which refined secondary butyl alcohol results.

STAGE III—The conversion of rectified secondary butyl alcohol into methyl ethyl ketone by catalytic dehydrogenation. This reaction is also endothermic, but takes place at a lower temperature than that of the first stage. Methyl ethyl ketone, hydrogen unconverted butyl alcohol and impurities result. The M.E.K. i refined by distillation and the hydrogen passed through a scrubbe to recover M.E.K. contained.

Each of the above three principal stages consist of a number o more of less individual processes or operations carried out in different pieces of equipment. These are briefly as follows:

OPERATIONS.

STAGE I.

Operation 1—Preparation of the rectified normal butyl alcoho This consists in heating and evaporating the liquid butyl and pr heating the vapor up to or near the reaction temperature befo admission to the catalysers. This is carried out in heat interchang ers or evaporators and is fully dealt with under the heading "He Interchangers."

Operation 2—The catalytic reaction. For this catalysi chambers are required, gas tight, maintained at the proper catalyt temperature and supplied with necessary endothermic heat. Th subject is fully dealt with in section of report on Catalysers.

Operation 3—Cooling of catalytic gases. The butylene, unconverted butyl, steam, etc., leaving the catalysers at high temperature must be cooled, the steam and unconverted butyl, etc., condensed and separated from the cold gaseous butylene, which is stored in a gasholder. This operation is similar to the heating and is treated under the heading of "Heat Interchangers."

Operation 4—Liquifaction of butylene. The butylene at temperatures above 23° F. and atmospheric pressure is a vapor and therefore to liquify, compression is necessary. The vapor is compressed in ammonia compressors, cooled and the liquid stored in tanks under pressure.

Operation 5—Recovery of Unconverted Butyl. The treatment of the catalytic water to recover the unconverted butyl alcohol, butyl ether, etc., which it contains is dealt with in the section on Catalytic Water Disposal.

STAGE II.

Operation 6—Preparation of Acid. Fresh acid when purchased has a density from 60°-66° Be. (77.67-93.19% acid) and requires more or less diluting down to the 75% strength fixed by chemist, which must be carried out in a special diluting tank. If an acid ecovery plant is in use, the acid can be concentrated to the desired trength.

Operation 7—Sulphating. The butylene and acid are run into mixer and violently agitated. The absorption is apparently facilitated by multiplying the surface of contact between the fluids. Considerable difficulty has been experienced with the mixer for this peration at Toronto. Although the absorption in towers of gaseous butylene by the acid has been successfully employed elsewhere, e chemist has not permitted its use at Toronto.

Operation 8—Hydrolysing Distillation. The butyl hydrogen sulphate from storage tanks is fed through a diluting device, where is diluted with water into the column of a lead-lined still. The condary butyl constant boiling mixture and water flow from the ndenser and the hot dilute acid escapes from the kettle of the ill.

Operation 9—Salting of Crude Secondary Butyl Alcohol. The crude alcohol from the lead still is separated in a settling tank, the upper layer passing to the salting plant and the lower aqueous layer being returned through the lead still as diluting water. The upper layer is salted in a continuous salting plant with sodium chloride (with small quantity of caustic soda for the sulphur dioxide) and separated, the upper salted butyl being distilled and the brine layer passed through a recovery system.

Operation 10—Rectification of Salted Secondary Butyl Alcohol. This is carried out in ordinary alcohol discontinuous rectifiers and results in refined secondary butyl for the third stage, and various head and tail products which are returned for resalting. See section of Report on Purifying Stills.

Operation 11—Recovery of Secondary Butyl Alcohol from th brine. This is dealt with in a separate section of the report.

STAGE III.

Operation 12—Preparation of Rectified Secondary Butyl Alco hol, for catalysers. This involves the heating and evaporation o the liquid and preheating of the vapor, and is carried out in he interchangers which are dealt with in a separate section of t report.

Operation 13—Catalytic Reaction. Catalysing chambers a required here as in first stage catalyser reaction. Reference sho be made to the section of the report on Catalysers.

Operation 14—Cooling of Catalytic Gases. The gases requ to be cooled condensing the M.E.K. and unconverted second butyl which are separated and sent to storage while the hydro passes to the scrubber.

Operation 15—Purification of Crude M.E.K. This is carr out in ordinary discontinuous rectifying stills and is dealt w under M.E.K. Purifying Stills.

Operation 16—Hydrogen Scrubbing. The hydrogen from catalysers carries away a certain amount of M.E.K. which is covered in a water scrubbing column, the scrubbed liquor being afterwards purified in a continuous still in connection with the scrubber from which the partially purified M.E.K. is sent to stills for further refining. See section of report on Hydrogen Scrubbing System.

ACID PLANT—The spent weak acid from the second stage must be concentrated for re-use and this is done in a tower concentrating plant described in a separate section of the report.

ESTIMATED YIELDS—Theoretically, the yield of the conversion plant should be 97.3%, that is 100 parts by weight of normal butyl yield 97.3 parts by weight of methyl ethyl ketone. The operation of the small experimental plant of a more or less improvised nature, with numerous leakage and other losses rendered the making of n estimate of the yield of the full-sized plant based on that of the mall one, difficult. In addition, the process involves new types of quipment about which little could be foretold with regard to full ized operation, but bearing in mind these considerations, Mr. Legg timated the conversion at 80% of the alcohol into pure M.E.K. ater, as a result of several runs on the full sized equipment, this timate was reduced to 75%. Professor Moureu places the conrsion at 77%.

DATA—The design of the plant has been based on data furnished the Chemical Department. This data for several reasons has n limited, indefinite and subject to constant revision and cortion as additional information and data became available.

The very important endothermic heats were first given as 345 .U. per lb. in the first stage and 190 B.T.U. per lb. in the third ge, based on text book values for heats of formation of reaction stances. This was later changed to the present value of 102 .U. per lb. in the first and 300 B.T.U. in the third, calculated n the heats of formation of the reaction substances which were ived from the heat values of linkages and radicals in carbon pounds. Even these latter endothermic heats are apparently, n actual measurements made during full sized operation, inect, but no more correct figures have been supplied.

Specific heats of the different liquids, gases and vapors of the ess, except where already published, have not been accurately determined, although these are of considerable importance when dealing with the temperatures existing in this process. The specific heats of the normal and secondary butyl and M.E.K. liquids was given as 0.5 and of M.E.K. vapor 0.4. No others were given.

Temperatures of the catalytic reactions were given for the first stage as 690-716-752-788-824° F. in order of preference (as catalyst duty falls off) with an upper limit of 842° F. and for the third stage 536° F. (this was previously placed at 300-480°) with an upper limit of 662° F.

The information supplied by the Chemical Department together with that derived from other sources is tabulated in convenient form in a table at the end of this report.

METHYL ETHYL KETONE PLANT.

GENERAL—The methyl ethyl ketone process as has been seen is a chemical manufacturing proposition having no resemblance to any common process and the plant to carry on the conversion therefore involves almost entirely the installation of new and unusual equipment, the single exception being the purifying stills. For the latter alcohol stills may be satisfactorily employed.

The ketone plant at Toronto has been built for the most part in remodelled buildings, using new equipment practically throughout since the requirements precluded in most cases the use of any existing equipment.

PRINCIPLES—There are several principles which have been followed in the design of the plan:

(1) Segregation of the different operations of the process of a like nature in separate buildings or portions of buildings, to render operation easier and fire and explosion dangers less. There are thus:

The catalyser room containing first and third stage catalysers.

Interchanger room containing first and third stage interchanging apparatus and pumps.

M.E.K. plant proper containing butylene equipment, sulphators, lead still, salting plant, scrubber and storage tanks.

Switch House containing electrical control apparatus.

Transformer House containing high tension transformers.

Still Houses—two—containing rectifying stills.

Tank Houses—two—containing storage tanks.

Acid Plant—containing the acid concentrating towers.

Acid Tank House containing the acid storage tanks and eggs.

Catalyst Manufacturing Rooms—containing first and third stage catalyst baking furnaces and drying oven.

(2) Gravity Flow. The tanks and equipment have been arranged as far as possible to give gravity flow throughout the plant.

(3) Conservation of Heat. By the use of heat interchangers heat throughout the plant is conserved wherever possible by using waste heat to heat incoming fluids.

(4) Recovery as far as possible of valuable liquids in waste, etc. This is exemplified in the case of the catalytic water, the brine, water layer from crude secondary butyl, the hydrogen scrubbing and the acid concentration.

DESCRIPTION OF M.E.K. PLANT.

A somewhat detailed description of the Toronto M.E.K. Plant follows. This description is given in order that the exact methods of construction and to some extent the operation of the plant may be thoroughly understood and the difficulties of the problem realized.

FIRST STAGE.

Rectified Normal Butyl Supply—(See Ref. 1)—The rectified normal butyl alcohol (RNB) is pumped from No. 2 Tank House through a 2" W.I. pipe line, 500 ft. long, exposed, in open air, across bridges over Trinity Street into the top of No. 1 storage tank in the M.E.K. Building. The No. 1 or RNB tank is on the second floor of the building, and is the south one of four similar tanks, each having a capacity of 2,760 gals. (See album, page 148).

Catalyser Feed Arrangements—(See Ref. 2)—From the outlet pipe of the RNB tank a 1½" W.I. line passes into the interchanging room to the suctions of two variable stroke pumps. (See album, page 135). Before the pumps are reached a 1½" gate valve s placed in the line, and beyond it a connection is taken off through valve to a 9" x 30" galvanized iron feed gauging drum fitted with ⅝" x 16 gauge glass. The drum has been used for regulating and measuring the feed to the catalysers during the experimental work of plant. In doing this the drum is run full, which may be done even, with the pump working, owing to large size of feed pipe (1½") and the head of butyl in the RNB tank and when full the main valve is closed and the feed pump draws from the drum. The time taken to feed each gallon, as shown on the gauge glass on the drum, which is graduated in gallons (3), is then readily measured.

CATALYTIC WATER FEED—(See Ref. 3)—Arrangements are also provided to enable catalytic water from the first stage to be fed to the catalysers with the pure RNB feed. The catalytic water contains a certain percentage of unconverted normal butyl alcohol. There are two means of recovering this which are discussed in the section of report on Catalytic Water Disposal. One method is to pump the catalytic water back into the catalysers, which is the one here referred and actually tried. The results are doubtless given in the chemist's report.

The arrangements provided for doing this consist of a ¾" W.I. suction line from the side of the catalytic water storage tank (No. 2 of battery) about 4 ft. from the bottom, in order to draw upper layer to a feed gauging drum, the outlet of which is connected into the suction line of the two first stage feed pumps. The outlet valves of the RNB and catalytic water gauging drums can be then regulated to give any desired proportion of each in the first stage feed.

FEED PUMPS—(See Ref. 2)—The variable stroke catalyser feed pumps are arranged in parallel, drawing through 1½" branches from the RNB line, and discharging through 1¼" branches into a 1½" W.I. line to interchangers. Between the discharge line and the suction line of the pumps a 1½" bypass containing a 1½" relief valve set for 15 lbs. is arranged. (See album, page 135). This arrangement is installed in order to secure easier and better adjustment of the feed when running several batteries of catalysers. Thus, if the pumps are driven at a higher rate than is necessary when feeding, say, two batteries of catalysers, and the excess is short-circuited through the relief bypass, then when a third or fourth battery of catalysers is put into working they simply take some of the alcohol bypassed previously, and no adjustment of the pump is necessary, nor is the balance of feed to the two original batteries disturbed, which is important because of the nicety of adjustment necessary of the feed to each battery. The same is true when a battery or batteries are taken out of working, the surplus feed not then required is short-circuited through the bypass while the pressure of the feed remains the same and the rate of feed is thus not affected.

PUMP DRIVE—The pumps are belt-driven at 60 r.p.m. through 2½" rubber belting from a countershaft (104 r.p.m.) at the ceiling, in turn driven by a 3 H.P. 700 r.p.m. induction motor (No. 19). The motor is started or stopped by oil circuit breaker beside the motor.

DRIPS TRAY—The feed pump, gauging drums and necessary interconnecting piping, as well as a similar system for the third stage, the latter including wriggle evaporators and coolers, are all bolted in place along the west wall of the interchanger room (see album, page 135). A galvanized iron tray is built on the floor, extending under all this equipment, about 24" wide, and with sides 4" high, into which at one end a stream of water is turned from a tap, while from the other end a drain is taken off. The tray was found necessary to catch the drips and leaks from pumps, valves, etc., of the system, and the water flowing through continuously carries the drips away, preventing evaporation and fouling of air of room.

INTERCHANGING SYSTEM—(HEATING)—(See Ref. 4)—The liquid RNB is delivered from either of the two feed pumps through a 1½" W.I. feed pipe to the heat interchanging system, where it enters a 1½" copper header from which two branches lead vertically to two liquid preheaters (3 ft. interchangers). (See album, page 137, and drawing A264). The RNB is pumped through the middle passage of each of the preheaters against the butylene and other gases from the catalysers in the inner and outer passages. The preheated liquid butyl leaving the liquid preheaters at the top enters a 1½" copper header from which a line drops to another header (fitted with a 1½" drain valve at the end) feeding two evaporators. In the evaporators the liquid RNB flows upward against high pressure steam, is vaporised and escapes into the 2½" outlet header, passes down around a bend and into the gas preheater header. There is a 2½" branch leading to a copper liquid trap fitted with gauge glass, taken off the above bend in such a way that the centrifugal force tends to throw any liquid particles into the separator, allowing only dry RNB vapor to proceed. (See album, page 137). The unevaporated liquid thus trapped is drawn off when necessary through a 1" W.I. line into drums for re-use. In the gas preheaters, two in number, the vaporised butyl passes upward against the hot gases from the catalysers coming downward, and is heated to a high temperature, passing out into a 2½" copper header, which is connected at the end with a long 2½" distributing header, from which the branches to the various batteries of catalysers are taken off. Six of the latter were provided for in the layout, of which two only have up to the present been installed and used. (See album, page 136).

FEED MEASUREMENT AND CONTROL—(See Ref. 5)—The branches are taken off horizontally and each passes through 1½" regrinding feed control valve to a bend, thence downward to a 1½" x ½" venturi meter (see album, page 136). The pressure difference reading is taken on an 18" manometer, and a pressure gauge is also connected into the upper pressure ring of the venturi meter tube. The gauge and venturi manometer are conveniently located close to the feed valve. By this means the rate of feed to catalyser is controlled, and pressure kept within the limits defined by the chemist.

A drips tray is arranged under the interchanging system similarly to and for the same purpose as that under the feed pumps and system.

From the venturi meters the feed lines drop vertically through the tray and floor into the catalyser room beneath, and pass along close to the floor to the inlet flanges of the first catalyser in each battery.

CATALYSER LAYOUT—(See Ref. 6)—The Catalyser Room was laid out to provide for nine rows of catalysers, six to a row, and three catalysers to a battery, so that each row contained two batteries. (See album, pages 130-131). The flow through the batteries is from the outside end catalysers towards the middle catalysers. The north three rows as laid out were to be occupied by first stage catalysers, the next six by third stage catalysers. Between each row of catalysers is a passage, each alternate one being given up to the electric conduit and connections arranged back to back, and the others constituting the operating passages.

The catalysers are carried on steel bases, made up of channels standing on brick footings, the tops of which are flush with the floor (concrete) of the room. Each base carries a battery of three catalysers, and the catalysers are placed in insulation pans set on the base and hold the insulation. This phase of the catalyser layout is fully treated in the Electrical Report.

The catalysers are connected by means of S bends of 1½" copper pipe, leading from outlet (upper) flange of one catalyser to the inlet (lower) flange of the succeeding catalyser.

INSTRUMENTS—The catalysers are provided with various instruments for indicating the condition of the gases. There are 950° nitrogen filled mercury thermometers inserted in the thermometer pocket of the inlet to the first catalyser and the outlets from all the catalysers. A 30 lb. 30" pressure vacuum gauge on the end of a long (36") ¼" pipe and loop (to protect it from heat as well as raise it to a convenient height) is connected into the thermometer onnection in the inlets to the second and third catalysers.

The catalysers, after having the heating elements put in place, re thoroughly lagged, the upper tin cap and cover put on, and an ron guard bolted around each catalyser to protect the operators nd others from the bare connections between the outside elements.

CATALYSER OUTLET ARRANGEMENTS—The outlet line from each attery of catalysers is of 1½" copper pipe, passes through a rams-orn expansion bend at the outlet connection, and thence vertically, arallel to and beside the feed line coming down, through the floor nto the first stage interchanging system in the interchanging room bove. Here the 1½" pipe is flanged to the side opening (pointing ownward) of a 1½" bronze tee, and on the other two openings of e tee are bolted 1½" flanged regrinding valves, by means of hich the gases from the catalysers may be directed either into a ½" "test" header or a 2½" "collecting" header, both of which tend along and receive the connections from the six discharge es from the six first stage batteries of catalysers. (See album, ges 136-137).

INTERCHANGING SYSTEM—(COOLING)—The 2½" "collecting" ader at the south end is connected through a 2½" bend with the header of the gas preheaters. The hot gases pass downward ough the inner and outer passages of the latter, preheating the B vapor going to the catalysers, and leaving, pass into another header which is connected through a horizontal expansion bend with the header of the liquid preheaters. The partially cooled gases pass downward through the preheaters against the RNB liquid, and are further cooled while heating the liquid butyl. The catalytic gases leave the liquid preheaters quite cool, and pass from the header at exit from the liquid preheaters into a long sloping 2½" copper pipe line leading along the wall of the interchanger room to the south-west corner, where it passes through into the M.E.K. section of the plant.

BUTYLENE TESTING SYSTEM—The 1½" copper line from the test header of the interchanging system passes into the M.E.K. section of the building, and enters the top of a 3 ft. interchanger (see album, page 142) through which it passes downward through the middle passage against cold water flowing upward through the inner and outer passages. The cold gas with condensable portions condensed leaves the interchanger at the bottom and passes through a slightly sloping 1½" copper pipe to a small 8" diameter 10" deep copper separator. The latter is provided with a flanged cover, and a gauge glass, covering the full depth. The ¾" drain or bottom outlet is fitted with a pet cock for sampling the condensate, and is connected through a ¾" W.I. line with a condensate pump by which the condensate from the separator may be pumped to the catalytic water storage tank.

(See Ref. 5)—The dry gaseous butylene from the top of the separator passes through a short length of 1½" copper pipe to a horizontal 1½" x ½" venturi tube, provided with a 30 lb. 30" pressure vacuum gauge, and manometer connections. The rate of butylene production can thus be measured, and knowing rate of feed to the battery from the reading of the feed venturi, the per cent. conversion or duty of catalyst may be readily calculated. Beyond the venturi meter the line passes through a copper tee, on the downward branch of which is a ½" sampling valve for taking a sample of the butylene for testing purposes.

The test line then passes to the 2½" copper pipe between the bottom header of the last cooler and the trap at entrance to the gasholder (referred to later), where it is brazed into the back of a bend and the test butylene is thus returned to the system without loss.

BUTYLENE COOLING AND SEPARATING—The 2½" copper line from the first stage interchanging system passes through the wall from interchanger room in to the M.E.K. section, and connects to a header at the top of a pair of 3 ft. interchangers (coolers). (See album, page 138). The catalytic gas and condensed vapours from this header pass down through the interchangers against cold water flowing up through the inner and outer passages, and are further cooled and condensed, passing into a bottom 2½" header. The latter connects horizontally to the tangential inlet to a copper sep- rating tank, in which the condensed portions of the products from he first stage reaction (water, unconverted butyl, etc.), are separ- ted from the gaseous portion, butylene.

BUTYLENE SEPARATOR—The separator is a 128 gal. 30" diameter y 45" deep copper tank (formerly first yeast tub) with flanged, omed cover and dished bottom. It is fitted with 2½" tangential let 3" from top, a 2½" copper vent from centre of cover, and a 1" I. drain from centre of bottom. It is further provided with three erlapping ⅝" gauge glasses for indicating liquid levels and sur- ces of separation. The separator is carried on a stand of angle on (2½" x 2½" x ¼"), 24" above the floor.

The condensed catalytic water and unconverted butylene which e separated from the vapours in the separator, settle to the bot- m and are pumped out by means of a small pump drawing rough the 1" drain, and delivered to the catalytic water storage nk.

FINAL BUTYLENE COOLING—The 2½" copper gas outlet from tre of top of separator bends and enters the end of a 2½" der from which 1½" branches lead vertically downward. One the latter at present connects to the top of a 12" interchanger oler) (see album, page 138), through which the butylene flows wnward against cold water flowing upward and receives its final ling, to ensure positively that no liquid gets to gas holder.

The cooling water is supplied to bottom of the 12" interchanger ugh a 1½" pipe, and passes from the interchanger to a 1½" header supplying both the 36" interchangers (coolers) at the oms, and from the tops enters a 1½" W.I. line passing to the er.

Another 2½" copper header is located below the one supplying 12" interchanger, and has two corresponding upward branches.

It is connected to the 12" interchanger through a length of 1½" copper pipe. The second interchanger, branches for which were provided on the headers, was not found necessary up to closing down of the plant, and was not therefore connected in. The two headers were placed sufficiently apart to permit of connecting in 3 ft. interchangers, should more cooling surface have been necessary.

CONDENSATE TRAPS—The lower header leads through a shor bent 2½" copper pipe, into which the butylene line from the testing system connects, to the top of a trap placed in a pit close to th gasholder. The trap is of copper 18" x 18" x 24" deep, and i fitted with three 5" diameter glass bulls-eyes, which overlap an show level of the liquid in the trap, and the surfaces of separatio of the different liquids. In the side near the bottom are also pro vided two ¾" screwed flanges, one above the other. The lowe one is simply a drain through which the lower water layer i drained off to the sewer until the surfaces of separation of wate and alcohol layers is just above the bottom of bottom eye, whic is at the level of the upper draw-off connection. The latter is co nected to a small steam pump, which draws the alcohol layer off, r turning it to the catalytic water storage tank.

The cold, dry butylene passes from the top of the trap throug a 2" W.I. pipe, laid in a pipe channel in the concrete base unde the gasometer, to the centre of the bottom of the gasholder tan passes through the bottom, and vertically upward inside to a poi 2" above the top of the outer tank of the gasholder.

The gas outlet line from the gasholder parallels the inlet li coming out through pipe channels to edge of gasholder tank, whe connection is made to the compressor suction line. The top of t outlet line is also 2" above the top of the gasholder tank, and provided with an elbow to prevent condensate dropping from r of bell into outlet pipe.

A third pipe stands up inside the gasholder parallel to the oth three, a 1" W.I. pipe, which is 4" shorter than the others. emerging from the pipe channel this pipe enters the top of a sec trap similar to the first, beside the first in the pit. This line used for drawing off the alcohol, butylene, etc., that has been c densed in the gasholder and settled on top of water surface. T upper layer is drawn off into the trap, where it settles out into ers, the water is drained out to the sewer, and the upper alcohol-butylene layer is pumped to storage.

CATALYTIC WATER PUMP—A 3 x 2 x 4 duplex steam pump is connected on the suction side through a 1" W.I. pipe, and branches to the bottom of the butylene separator and test separator and to the upper draw-off connection of each of the two traps, and discharges through a ¾" line vertically to the top of the catalytic water storage tank.

CATALYTIC WATER STORAGE—(See Ref. 1)—The catalytic water torage tank is No. 2 tank of the battery of storage tanks. (See lbum, page 148). It is a 2,760 gal. glass enamelled tank, provided ith fittings as described in the detailed description of these tanks iven under heading of Tanks.

The catalytic water tank is in addition provided with a second ⅛" gauge glass extending from just above bottom flange to the iddle of the second section (3' 9"), and from the top fitting a ¾" ne leads to the catalytic water gauging drum for feeding the rst stage catalysers. This arrangement is provided to indicate the rface of separation between water layer and unconverted butyl yer, and in order to draw off the latter layer. The water layer drained off to the gutter on the ground floor through a 1½" .I. line.

BUTYLENE GASHOLDER—The gasholder (see album, page 138) nsists of a galvanized iron tank 6' 9" diameter x 7' deep, reinrced with 1" x 1" x⅛" angles, and containing a 12" x 15" manle in the side near the bottom. The tank is provided with a 2" ain flange in bottom, as well as double flanges for the other es (refer back). The bell is of No. 16 gauge copper 6' diameter 7' deep, with domed top, and provided with two sets of guide lers, upper and lower. The lower ones, of wood, barrel-shaped, l on the inside of the tank; and the upper ones, of cast iron, 4" meter, with 6" diameter flanges, roll on 4" channels extending ween concrete base and ceiling and acting as guides. There are ee guide posts or columns which were originally intended to ry pulleys for the counterweight chains. This was abandoned en the gasholder was set up inside, and the columns act now ply as roller guides. The top of the gasholder bell is provided a ¾" sampling cock, and an eye or shackle to which the chain carrying the counterweight is attached. The chain passes over two pulleys at the ceiling, and the weight is suspended behind the gas holder at the wall. The compressor control chain is also attached to the eye of the bell.

BUTYLENE COMPRESSING EQUIPMENT—(See Ref. 7)—A 2" copper suction line connects to the outlet from the gasholder, and leads through two 2" copper branches to the suction of two, two-cylinder, single-acting 9" x 9" No. 12 York ammonia compressors, rated at 200 cu. ft. of gas per minute. (See album, page 142, and Drawing A287). The standard bypassing arrangement between suction and discharge as provided with the compressors for ammonia work is used to connect the suction and discharge piping.

The compressors are direct connected to two vertical single cylinder steam engines, one a 9" x 8" and the other a 9" x 10" using the 70" diameter compressor flywheel as the only flywheel in each case. The flywheel acts as one half of the shaft coupling also. Only one compressing unit has so far been used, the east one, which employs the 9" x 10" engine.

The engine is controlled through a chain from the gasholder be acting on a Fisher 2" balanced valve, (see album, page 142), so that the compressor rotates at the proper rate to keep the gasholder be within definite limits. The engine is also provided with a flyba throttling governor.

In addition to these two compressing units, there is a thir emergency compressor connected into the system, an 11 x 11 x 1 Westinghouse locomotive compressor, which draws through a 1½ copper pipe branch from the suction line to the east York compressor, and discharges back into the discharge line from the latter. The latter compressor has only been used for experiment purposes.

The York compressors may be water cooled.

BUTYLENE LIQUIFICATION—(See Ref. 7)—The 1½" copper discharge pipe from the compressors passes vertically upward a enters the top of a 3 ft. interchanger just under the roof. (S album page 141). The interchanger is connected up with cooli water for taking out the heat of compression of the butylene, and liquifying it. From the bottom of the interchanger the liqu butylene passes through a 1½" copper pipe into the back of a 1 copper header behind three copper butylene storage tanks. Branches lead from the header into the tanks through 1½" brass, screwed gate valves.

LIQUID BUTYLENE STORAGE TANKS—There are three copper butylene storage tanks 3' diameter by 4' deep on the straight (6' overall) with a capacity of 175 gals. and built to withstand a pressure of 250 lbs. per sq. in. (¼" copper). See album, page 141, and Drawing 8678. The tanks have deeply domed heads and bottoms, and are heavily wash-tinned inside with pure block tin. The head is fitted with a 6" handhole, and a 1" angle brazing nipple reduced to ¼" for connection of gauge, vent, etc., while the bottom is fitted with a 1½" drain (elevated inside 12 in. to ensure obtaining dry butylene) and a 1" draw-off for any lower layer that may settle out.

(See Ref. 8)—The tanks are provided with a ⅞" gauge glass overing the straight part, and a second gauge overlapping the first nd running from bottom to indicate surface of separation. The rass gauge glass fittings supplied by the makers have been replaced owing to the impossibility of keeping these tight) by standard mmonia fittings, which have proved quite satisfactory. A standrd ½" brass gate valve is placed between the tank and gauge fitng, as an additional safeguard in each case. The gauges are proided with U shaped wooden protectors, graduated in gallons.

The lower layer draw-off is 1", and the tank outlet is 1½", th provided with ammonia, metal-seated globe valves (iron). e opening in the head is provided on each tank with a tee, on p of which is a special Schaeffer & Budenberg 200 lb. diaphragm uge, while the side opening connects to a ¾" cross header linkg up all three tanks, into which a 1" compressed air connection is de, and from which a ¾" vent passes through the roof. The air used to assist in emptying a tank rapidly.

The tanks stand on iron stands about two feet high, made up of x ½" flats.

BUTYLENE PIPING TANKS TO SULPHATOR—From the three out- valves of the butylene tanks 1½" copper pipes drop through the r to a 1½" horizontal cross header just under the floor; from ich a second header branches at right angles to supply through ee 1½" copper branches the sulphators. (See album, page 142). se branches are each fitted with 1½" regrinding valves.

Only one sulphator has as yet been placed. Bolted to the butylene branch regrinding valve is a 2" lead valve (angle seat type) to protect the former from acid, but which because of the unreliability of lead valves in general has the regrinding bronze valve placed above it as an additional safeguard. A short vertical 2" lead pipe drops from lead valve to one of the sulphator inlet flanges.

SECOND STAGE.

ACID DILUTING—Concentrated acid is received at the acid diluting tank in the M.E.K. section from the acid plant (concentrated acid tank) through a lead lined 3" W.I. pipe provided with standard lead lined fittings, which reduces directly above the diluting tank to 2½" W.I. lead lined pipe, and passes through a 2½" lead lined valve (plug gate type) into the top of the tank, and is carried to the bottom through a lead pipe. The diluting water line 2" W.I. pipe also enters the top of the tank, and passes down through a 2" I.D. lead pipe to a 3' 0" diameter perforated circular sparger pipe at the bottom of the tank. There is also a 1" compressed air connection into the diluting water line to provide agitation by blowing air through the sparger.

ACID DILUTING TANK—The acid diluting tank (see album, 1 and drawing 8675) is of steel, 6' diameter by 7' deep, on straigh with flat bottom and domed flanged cover. The tank shell is o ⅜" steel, heads ½", and is lined throughout with ¼" lead rein forced to sides with steel bands, lead covered. The cover of th tank besides carrying necessary connection flanges is fitted with 16" diameter manhole.

A 1½" W.I. vent leads from the top of the tank to a vent co lecting system which carries the vents to the sewer.

All the above lines entering the top of the tank, with the e ception of the acid line, are fitted with brass gate valves.

The cooling water coil is supplied with water through a W.I. line, and a 2" outlet carries water from tank to the sew The coil is composed of 2½ coils containing about 40 ft., of 2" I x ½" thick lead pipe, carried on antimonial lead (5%) cast o stays, about 4 ft. from tank bottom.

The tank is provided with a ⅞" gauge glass, extending prac ally over the full depth of the tank, connected to it through lead lined valves (plug gate type), a valve being provided at the bottom connection also for draining. The gauge glass fittings are of iron, lead lined.

A 2½" W.I. lead lined outlet pipe leads from the 3½" flanged outlet of the tank (this was unnecessarily large), and divides into two 2½" lead lined valved (plug gate type) branches. A 2½" W.I. lead lined branch passes to the centre of the top of the Dilute Acid Tank, below the diluting tank, and the other, a 2" W.I. lead lined branch leads into the acid returns line from lead still kettle to acid plant. The latter was used in putting the acceptance test on the acid towers, the acid being concentrated by towers, diluted in diluting tank, returned through above line and re-concentrated.

DILUTE ACID TANK—The Dilute Acid Storage Tank (see album, page 142) is similar to and of the same size as the Acid Diluting Tank, but is provided with none of the interior fittings, cooling oils, sparger, etc. It is provided with manhole and gauge glasses n the same way, and stands on 3' 6" high timber stand on the round floor (6" x 6" timber posts, with 4" x 4" cross bracing).

(See Ref. 9)—A 1" W.I. compressed air line is connected into he top of the tank, by which the acid is forced out of the tank. 2½" lead lined W.I. line runs from the outlet in the bottom of the ank vertically upward and into the top of the Acid Measuring Tank n the floor above. There is a 2" sampling connection at the tank ttom. Both are controlled by plug gate valves.

DILUTE ACID MEASURING TANK—The dilute acid measuring or ed tank is of the vertical cylindrical type, of steel (¼" thick roughout), 3' diameter by 4' deep on the straight with flat botm and domed flanged head. (See album, page 141). The tank lined throughout with 3/16" lead, and is provided with neces- ry connection flanges.

The line from the dilute acid storage tank enters the acid arging or measuring tank through a 2" lead lined valve (P. G. pe), and inside the tank a 2" I.D. lead pipe carries the acid to the ttom of the tank. A 1¼" W.I. vent leads from top of this tank ough a 1¼" brass gate valve, directly through the roof, for vent- air when sending a charge up from the storage tank below.

This tank is provided with gauge glass of same type as other d tanks, and stands on four 2" W.I. pipe legs 2 ft. above the r.

A 2½" lead lined W.I. outlet from the centre of the bottom of the tank passes through a 2" lead valve (angle seat type), and a 2½" W.I. lead lined line, down through floor to a horizontal header just under the floor, from which three 2" lead lined W.I. branches lead (from tees and elbows) to the sulphators. Two of these branches are now blanked off, and the third passes through a 2" lead valve (angle seat type) into the second inlet nipple of the one sulphator that has been installed and worked.

The lead valves on the acid and butylene charging lines to the sulphator are some 2 ft. above the sulphator flanges.

SULPHATORS—The sulphators are lead lined steel reaction or mixing tanks, 3' diameter x 42" deep on straight, provided with dished bottom and cast steel head. (See album, page 142, and Drawings 8679, B365). The shell is of ½" plate, and is lined throughout with ¼" sheet lead, reinforced to steel shell. The tanks are provided with a cast steel manhole cover, covering central opening in the head, which also acts as a long steadying bearing for the rotating agitator shaft. This cover was provided with two composition bushings around the shaft, together with a double gland arrangement consisting of a primary gland, fitted with a cover and a second gland, with vent to carry off leakage from space betwee the two glands. The two bushings were supplied with oil throug ducts in the casting.

The agitating arrangements consisted of an 8" bronze lea covered propeller, mounted on the end of a lead covered 1 7/16" shaft, which was not steadied at the lower end and projecte through the cover at the top, and a bearing in a frame on the cas steel head, and was provided with a bevel pinion meshing with an other on the horizontal driving shaft carrying fast and loose pu leys, and carried in bearings on the head. The propeller rotated i an antimonial lead cylinder 10" I.D. x 25" long. Speed of rotatio was set at 600-1,000 r.p.m., and the tanks were designed for working pressure of 200 lbs. per sq. in.

The sulphator on actual working developed a number of defect resulting in modifications and improvements, which are more e tensively treated in the Operation Report.

These improvements include modifications in glands, in stead ing of shaft, in driving pinion and in the mixing gear. The pr peller is now a three-bladed 12 in. diameter, 24" pitch bro marine propeller, lead covered, carried high in the tank, and rotated at 350 r.p.m.

The tanks are each provided with two 1½" lead lined inlet nipples, and one 1" inlet nipple on the cover, and a 2" draw-off nipple in the bottom. The sulphators are each carried on four brackets riveted to the sides, and are supported on a structual steel framework, carried in four concrete pedestals about 6 ft. 8 high.

SULPHATOR DRIVE—The sulphators are belt driven through rubber belt and fast and loose pulley from a counter-shaft at the ceiling, and the latter is in turn driven by a 15 H.P. 730 r.p.m. induction motor (No. 21) on a bracket on north wall of building. The auto starter of the motor is on the wall at the end of the sulphator operating platform, while the sulphator is provided with a draw bar operated belt shifter.

A 1½" lead lined tee is bolted on the remaining opening in the cover of the sulphator, from which a W.I. vent line leads to the vent system referred to above through a 1½" acid valve (P.G. ype) and 1¼" globe valve. A 200 lb. 9" dial pressure gauge, protected by a ⅜" brass globe valve, and a 1" compressed air line is connected into the other opening of the tee through a globe valve. The latter is for use in emptying the sulphator.

The sulphator is provided with an oil splash cowl over the gears, nd a gas hood, from which a 7" air pipe leads to a 12" air duct, ading in turn to the suction of a fan on floor above, for drawing way the fumes from the gland. The 12" pipe beyond the first sul-hator is at present blanked off, but is arranged so that future sul-hator vents may be connected into it when extended. An operating nway is built along the south side of the sulphator stands (see bum, page 142) giving convenient access to the various charging lves, etc., and to the lever belt shifter extending toward this de of the sulphator. The auto starter for the driving motor is cated at the end of this runway on the wall. From the runway cess may be had to an elevated platform between the two buty-e compressing units for use in attending to lubricators, valves, c., of these engines.

SULPHATOR OUTLET PIPING—The sulphator outlet is 2", but is uced to 2" W.I., lead lined, and passes through a lead valve, gle seat type) arranged as an angle valve, from which the line passes through the sulphator pedestals to beyond the end one, (this line when all sulphators are in will be a header with branches to the three sulphators) where it is provided with a 2" lead-lined drain valve (plug gate type) extending vertically upward to near the roof and entering the butyl hydrogen sulphate tank No. 1 (B.H.S.) through a flanged nipple in the side close to the top flange. A 2" W.I. lead lined branch from this line, just above the third floor, runs to the top of the second B.H.S. tank. Two lead lined valves (2" plug gate type) control the delivery of B.H.S. to either tank.

Butylene Hydrogen Sulphate Tanks (B.H.S.)—(Still Supply Tanks)—No. 1 B.H.S. storage tank see (album, page 145, and Drawings A396, A397) is a lead-lined steel tank 6' diameter by 8' high on the straight, provided with dished heads, bottom riveted to shell and top flanged. The tank has a ⅜" steel shell, ½" heads and is built to withstand an internal working pressure of 25 lbs. The tank is lined throughout with ¼" lead, fitted to bottom head, reinforced to side with steel bands, lead covered, and spotted to top head.

The cover of the tank is provided with a 1" I.D. vent which connects through a 3" W.I. pipe with the above-mentioned venting system to the sewer. A 1½" W.I. line from the salted butyl pump below runs into this vent (referred to later), and was formerly used for sending up the brine layer from salted secondary butyl tank.

The tank is provided with two overlapping ⅞" gauge glasses of the same type as already described, provided with drain valve at bottom of each.

(See Ref. 10)—The tank is supported on legs, of 4" W.I. pipe, with bottom about 4 ft. above the floor. The tank was raised some 18" over its previous height to secure more head to feed through various control devices to the still. The outlet from the tank is through 2½" W.I. lead lined valve (P.G. type), from which a 1½" bore lead pipe leads.

B.H.S. No. 2—(See Ref. 1)—A second B.H.S. tank (see album page 147, and Drawings A396, A397) has been set up to provid additional B.H.S. storage capacity (especially during experimenta stages) in order to accumulate a large quantity so that the lea still may be operated at near its proper capacity for the run. Thi tank is known as B.H.S. 2, and is a glass enamelled tank, built of three 30" flanged sections, 7' 6" diameter by 7' 6" deep, with domed heads. The sections are bolted together with lead gaskets, and the 12" x 16" manhole in the top section is pulled up on a lead gasket.

The 2" lead lined branch from the B.H.S. line from the sulphators passes into the top of the tank, and the cover is also provided with a 1½" vent through the roof. The inlet and outlet nipples are similar to those of the other glass lined tanks, but the brass nipple is lead lined, and the lining is turned over under the flange of nipple to act as a gasket on the enamelled inner surface of tank, and is also similarly passed over a flange screwed to the outer end of the brass nipple.

A tee is arranged below the outlet nipple, on the side branch of which is a ¾" lead lined valve (P.G. type) from which a pipe is to be run to the side to carry a gauge glass fitting and gauge glass. At present a lead float is used, which is inconvenient because of leakage of B.H.S., etc., through the chain hole. There is a 2" P.G. type lead lined valve on the other opening of the tee, from which a 1½" I.D. lead pipe drops through the floor.

The B.H.S. No. 2 tank is supported on a timber framework at as great a height above the floor (4 ft.) as was permitted by the roof steel, and under this tank and the B.H.S. No 1 tank lead pans are arranged to catch the drips, leaks or overflows from the tanks, and carry them through lead waste pipes to open ends on the ground floor by which any overflow or leak is indicated at once.

The two 1½" lead emptying lines from the two B.H.S. tanks join together, and from them a 1½" lead line passes back up through the floor at the west wall to a constant level B.H.S. feed tank.

B.H.S. CONSTANT LEVEL FEED TANK—(See Ref. 10)—The B.H.S. constant level still feed tank (see album, page 145) is a lead lined (6 lb. lead) wooden tank, 24" x 36" x30" deep, divided by a V notch plate 12" from one end. The tank is carried on two wooden stands about 12" above the floor (so that its top is just below bottom of B.H.S. tanks to permit flow to take place), and the B.H.S. enters the tank through a specially constructed antimonial lead angle float valve, controlled by a 12" diameter lead covered float on the downstream side of the V notch. The lever arms, etc., of the valve are outside the tank. There is a perforated baffle provided to smooth out flow over notch, and in the sides of the tank are three 5" diameter glass windows. On one the head of B.H.S. on notch is indicated, one permits observation of the size of the stream over the notch, and the third, on the other side, admits light to the interior of the tank for observation purposes. The tank is covered with a lead lined lid, half of which is stationary, through which the float valve rods project, and from which a 1¼" W.I. vent passes through the roof; and the other half hinged, by means of which access may be had to interior of tank for adjustments, repairs or examination. The hinged portion of the lid is battened down on a rubber gasket by means of eyebolts and wing nuts. A 2" lead overflow from the side about 3" from top carries excess B.H.S. away to sewer and prevents overflow of tank. The tank stands in the same lead pan as B.H.S. No. 1 tank.

This tank enables the head on the still to be maintained constant by the float and valve which permit only as much B.H.S. to enter the tank as is permitted to enter still through feed control valve, and at the same time by graduating the window properly the rate of flow is indicated and the size of the stream may be observed. The outlet of the tank is 2" diameter, through a 2½" W.I. lead lined flanged nipple to which is bolted a 2½" lead still feed control valve (globe valve type), and from which a 1½" I.D. lead pipe runs across floor to the lead still diluting device.

DILUTING WATER CONSTANT LEVEL FEED TANK—An exactly similar tank has been provided for the diluting water feed to still (see album, page 145), except that the tank is lined with galvanised iron, and has a galvanised iron V notch plate. There are two 1" W.I. supply lines, uniting in a single 1" line to the tank, which is fitted with a standard 1" float valve inside the tank. One of the lines supplies hot water from coolers, and when this is not available the other line supplies cold city water.

A 1" W.I. line also passes through the cover on the downstream side of the notch. This line is the discharge from a variable stroke pump at the salting plant on the ground floor, which draws the aqueous layer, containing a certain percentage of secondary butyl alcohol, from the crude secondary butyl alcohol tank, and discharges it through the line into the diluting water constant level feed tank for repassing through lead still and recovery of some of the alcohol.

The outlet from the tank is through a 2" gate valve controlled W.I. line on the floor to the diluting device of the lead still.

Lead Still Diluting Device—(See Ref. 10)—The 1½" lead B.H.S. line and the 2" W.I. water line enter the diluting device at opposite ends of a short 2" I.D. back header in order to have the two streams meet head on to receive good mixing. This, however, has been found to give trouble, owing to one stream backing up the other, so that this arrangement was to have been changed. From the small header the B.H.S. and water enter the back of the diluting device proper, which is of lead, cylindrical in form, 7" I.D. x 14" deep, and contains seven 5% antimonial lead plates, drilled with ¼" diameter holes, through which the water and B.H.S. percolate and become thoroughly mixed before leaving through the 2" I.D. outlet at the bottom. There is, a ½" sampling nipple at the outlet, which is not used because of the position of the diluting device which renders its use awkward. On top of the device has been placed a 4 ft. length of lead-lined 6" W.I. pipe to allow ample space for collection and release of gases, which are vented through a water-jacketed lead pipe vent (4 ft. long) and 2" W.I. pipe to the roof.

From the bottom of the diluting device the diluted B.H.S. passes hrough a 1½" I.D. lead pipe into the column of the lead still on he eighth plate. A ¾" lead pipe sampling branch is taken from he feed pipe at the operating floor, passing through a ¾" lead-ined valve (P.G. type) to a lead tray, which is fitted with a drain o the sewer. Samples of the feed are taken from this connection or testing purposes.

Lead Still—The construction of the lead still is described in etail in the section of the report on Stills, and reference should lso be made to Ref. 10 on Lead Lined Still and to Drawings A396, 397, 8683-8688.

Acid Outlet—The acid line from kettle to concentrating plant of 2" x 2¾" lead pipe, and in the acid plant is encased in a 3" .I. pipe.

The kettle has a 2½" W.I. nipple drain, to which is bolted a 2½" d lined valve (P.G. type), and from the latter a 2" W.I. lead-ed drain leads over the floor to the sewer.

The tester of the still is conveniently located on the operating r at a window, and from a 1½" copper flanged tee bolted to the tester a 1½" drain line drops to the sewer, and a sloping 1½" copper line runs to the top of the crude secondary butyl tank of the salting plant. Both branches are controlled by regrinding valves.

The steam supply to the kettle coils is through three 2" globe valves controlled by long handles from the floor above (operating). Pressures on the coils are indicated by three 200 lb. 9" pressure gauges on a gauge board at the operating floor opposite the control handles of the valves. The six outlets from the coils (see album, page 144) are at the same level as the inlets (there is thus no outlet for condensate other than blowing out with the steam) through 1" W.I. pipes and gate valves to a 1½" drips header leading either to a 1½" steam trap or direct to sewer. The trap also takes care of condensate in the steam supply line.

The 1½" copper crude butyl line from the tester of the lead still is tapped into the side of the crude butyl tank about 6" from the top flange. The line was originally W.I. pipe, but corroded so rapidly under action of sulphur dioxide, etc., that it was replaced by copper.

Crude Secondary Butyl Tank—S.B.1—The crude secondary butyl tank (SB) (see Drawing A236) is a glass enamelled tank 7 6" diameter by 6' deep, 1,650 gals. capacity, made up of two flanged 36" sections with dished heads. The tank stands on adjustable leg on a heavy timber framework 12 ft. above the floor in order t give gravity flow through the salting plant. The tank has bee provided with three overlapping ⅝" gauge glasses; and a 1¼ gate valve vent from the centre of the cover to the roof. The lowe section has a 12" x 16" manhole (hinged). Three 1½" draw-o connections were tapped into the tank, one 12" from top flang and the other two 27" and 54" respectively below the first. The connections connect through 1½" gate valves into a vertical heade A 2" W.I. line from the Trinity Street Stills is connected up to t top of this header for returning secondary butyl fractions to t salting plant for re-salting. A 1½" outlet line from the cent of the bottom of the tank connects into the header at t bottom, and this outlet line is provided with a 1½" drain the sewer. From the bottom of this header two lines lead, one 1 ½" line to the salting plant hopper, and the other a 1¼" line the suction of a variable stroke pump, which discharges throug

1" line to the diluting water constant level tank of the lead still. The latter line is for the purpose of drawing off the aqueous layer which settles out in SB 1 tank, and returning it to the lead still where it is used as diluting water for the feed, which enables the secondary butyl which it contains to be recovered. The three draw-off connections in the tank side (SB 1) permit the secondary butyl to be drawn off from as near the top of liquid (wherever that is) as possible, where it is driest.

All the connections to the SB 1 tank mentioned are of W.I. pipe with brass gate valves.

SALTING PLANT—The salt feed hopper and salt drum (see Drawing A236) are of the same size and type as those of the normal butyl salting plant (see album, page 138). Reference should be made to Report on Acetone Plant for a description. The design of the drum has been somewhat improved to permit of better construction. The heads are now flanged to the angle flanges of the riveted plate shell, and the latter is provided with a longitudinal angle in the inside to fix the interior cage, and a pulley band is bolted around the drum to take the driving belt.

The salt feeding hopper first used was a duplicate of that of the normal butyl salting plant, but owing to rapid corrosion was being replaced by a similar hopper lined throughout with lead.

The salt settling tank was also at first made a duplicate of that n normal butyl plant, but the sulphur dioxide and brine rapidly corroded the black sheet iron, and a new tank was therefore de- igned and built. The new tank is of No. 16 gauge black sheet, ned with 12 lb. lead throughout. This has necessitated minor al- erations in the design of the observation chute and the salt valve to rmit of taking care of the lead lining, but otherwise the tank is f the same form and size. The windows in the observation chute e now in the sides, and the examination gate for arresting the w is of different form. The salt valve has been constructed in o flanged sections to permit of bringing the lead lining through the valve.

SALT FEEDING DEVICE—Because of the sulphur dioxide liber- d from the salting plant, it was necessary to provide a closed t feeding arrangement. The first one was a belt-driven feed, ed with a pair of toothed rollers provided with an adjustment for varying rate of feed. This apparatus had to be abandoned owing to the dampness of the salt which jambed in the feeding chute and caked on the rollers, and a new feed was designed and built.

The new feeding device consists of a rectangular gas casing, extending from floor above to top of feeding hopper, to which it is bolted, and from the casing a vent pipe leads to the fan. Inside the casing is a pair of four-bladed feeding rolls, which mesh together and are gear driven at a slow speed through a worm and wheel mounted on outside of casing. Each roll is fitted with a joggling device consisting of cam and spring, and the sides of the chute guiding the salt in the casing into the feeding rolls are flexible and are joggled from the same device as the rolls. The joggling of chute sides and rolls feeds the salt properly, preventing jambing, and also clears the rolls. The top of the casing is also fitted with a wire screen through which salt to be fed must be forced, preventing lumps or foreign matter reaching rolls.

VENTILATION—The whole of the salt feed end of the plant has been encased with galvanised iron, and galvanised iron ducts lead from various points about the plant (see album, page 138) from which vapours escape through a large 15 in. duct to the suction of a 21" Keith motor-driven ventilating fan. The latter also draws the vapours from the sulphator (refer back).

The salt drum, hopper and settling tank are set up on a wooden platform 8' 0" above the ground floor, and about 8' 0" below firs floor. The plant is so placed as to take advantage of gravity flo through the plant.

CAUSTIC SODA TANK—A caustic tank is placed on the floor immediately above the salting plant, beside the salt feeding chute. The caustic solution for the salting plant is prepared in this tank and from it a 1" W.I. line drops to the feed hopper of the sal ing plant. The caustic tank is a 30" diameter by 30" deep vert cal cylindrical tank, made of No. 16 gauge black sheet, and pr vided with a loose cover. Suspended from an iron cage inside th top of the tank is a smaller basket 18" diameter by 21" deep, ma of perforated sheet iron. In this the caustic is placed and wat run in through a 1" filling flange in side of tank close to top. T water penetrates the perforated caustic basket, dissolving t caustic. The caustic solution is fed to the salting plant through a funnel outlet screwed into the 1" draw-off flange in the bottom of the tank. The top of this funnel is 5" above the bottom, so that no sediment is drawn off, and as an added precaution a conical removable wire screen is fitted into the funnel. The tank is provided with a 1½" drain in centre of bottom for drawing off sediment, etc.

SALTED BUTYL SETTLING TANKS—From the overflow of the salt settling tank a short 1½" W.I. horizontal line runs to the first of two salted butyl tanks, and is tapped into the side about 6" from the top.

The two tanks are each 7' 0" diameter by 7' 6" deep, 1,800 gals. apacity, glass enamelled, built of two 45" sections with domed op and bottom. They stand on adjustable legs on the ground floor. The lower section of each is provided with a 12" x 16" hinged manole. The tanks have been provided with three overlapping gauge lasses and three draw-offs at different heights, similarly to the SB1 tank. Both tanks have 1¼" vent valves on the covers.

A 1½" W.I. overflow runs from first tank (settling tank) to cond tank (salted SB) about 6" from the top flanges. Through is line the upper salted secondary butyl layer from the first tank erflows to the second tank.

The vertical draw-off headers of these tanks connect to a 1½" ction line to a 6 x 4 x 6 single cylinder pump by which the salted condary butyl may be discharged either through a 2" W.I. line to e Mill Street stills or a 1½" line to the top of the BHS No. 1 tank. is latter line was formerly used to return bottom aqueous layer SB1 tank to the BHS tank as diluting water for recovery of the condary butyl it contained. Into the suction line of this pump o comes a 1½" line from the crude M.E.K. tank which was used en pumping the crude M.E.K. to Trinity Stills for rectification.

(See Ref. 11)—The drain lines of the SB1 tank, and of these tanks, connect in a single 1½" drain line to the sewer. The ne layer from the salted butyl settling tank is thus run off to sewer at present.

SALTING PLANT DRIVE—The salting plant is driven by a 3 H.P. r.p.m induction motor (No. 22) carried on a wall bracket. The or drives by belt a countershaft over the scrubbed liquor receiving tank, from which rubber belts drive the salt drum, salt feedin mechanism and variable stroke pump below.

The salt for the salting plant is elevated to a third floor windo by winch and pulley suspended from a wall bracket, and sent dow a wooden chute from the third floor to the second, at the salt fe chute. It was not practicable to bring the salt in any of the secon floor windows because of their obstruction by equipment.

THIRD STAGE.

The third stage catalyser feed arrangements installed are of temporary nature, similar in principle to the first stage syste designed to take care of the feed to two batteries (Nos. 3 and 4 i row 2) of catalysers, which are temporarily operated as thi stage catalysers.

Catalyser Feed—A 1½" W.I. line from the bottom of the rec fied secondary butyl storage tank RSB (No. 3 tank of row) pass through the wall into the interchanger room to the suction of variable stroke feed pump. The suction line is arranged with c off valve and feed gauging drum similarly to the first stage syste

Evaporators—(See Ref. 4)—The pump discharges through 1" W.I. line to the bottom of a pair of evaporator boxes, throu the coils of which the secondary butyl is pumped upward agai high pressure steam supplied the two boxes, flowing, down in t passage around the tubes. The drips run to a trap on the fl below (Catalyser Room), which also collects drips from the fi stage evaporators.

Preheater—Cooler—The butyl is evaporated by the ste and the vapour passes over through a 1½" W.I. pipe into the top a 3 ft. interchanger, through the central passage of which it pas downward against the hot catalyser gas flowing upward thro the inner and outer passages. The vapours are preheated in interchanger, and leaving the bottom divide and pass through 1½" W.I. branches, through two 1½" regrinding feed con valves and a pair of 1½" x ½" venturi meters (arranged pressure gauge, catch cups and manometers, similarly to the stage) down through the floor into the Catalyser Room, and system of valves and copper piping at the catalysers. (See al pages 130-131).

HYDROGEN ADMISSION AND EXHAUST—This piping system is rranged so that the feed line to either battery can be closed (by 1½" regrinding valve), and hydrogen passed through the battery r reducing the catalyst (copper oxide). A 1½" W.I. pipe line rom the top of the scrubbing column, which divides at the cata- sers into two branches, is provided for this purpose.

On the outlet of the catalysers (two batteries) a similar ar- ngement of piping is provided, by which the products of the re- tion may be directed through a 1½" W.I. line vertically to the terchanger room, or the hydrogen (or steam) from the reduction the catalyst vented through a 1½" line (with seal) to the roof.

CATALYSERS—The two batteries of third stage catalysers, aside om these different feed and outlet arrangements to take care of e hydrogen, are exactly the same as in the first stage. Ther- ometers and pressure gauges are provided as in the first stage in e catalysers, and in addition a branch is provided in the outlet e from each of the batteries beyond the cut-off valve, carrying pressure gauge.

EXIT PIPING—The outlet line from the catalysers in the inter- nger room enters the side connection at the bottom of the pre- usly mentioned interchanger, acting as a feed preheater, ough which the catalytic gases pass and are cooled while heat- the secondary butyl feed.

COOLERS—The cooled gas passes over through a 1½" W.I. pipe he tops of a second pair of evaporator boxes (beside the previ- ly mentioned two), and down through the tubes of the boxes, ch are surrounded by cold water flowing upward from a 1¼" water supply line. The M.E.K. in the gases, together with r condensable products, are condensed in these boxes, acting oolers or condensers, and from them a short horizontal 2" W.I. runs with a slight slope to a copper M.E.K. separating tank (a licate of the butylene separating tank).

DISPOSITION OF PERMANENT GASES—The hydrogen and uncon- ed gases escape from the top of the separator through a 1½" line either to the atmosphere (through the roof) or through all into the M.E.K. building, and to the bottom of the scrub- tower.

CRUDE M.E.K.—The crude M.E.K., etc., settles in the bottom of the separator, and may be drawn off through the 1½" W.I. drain at the bottom. The liquid level and position of surfaces of separation between the various layers are shown by three overlapping gauge glasses, and the separator is also provided with a 15 lb.-30 lb. pressure vacuum gauge in the top.

The condensed M.E.K. or other condensate may be drawn from the separator by means of a variable stroke pump (on wall beside catalyser feed pumps and driven by same countershaft), and discharged either through a 1¼" W.I. pipe through the wall into the M.E.K. section to the top of the crude M.E.K. tank, or through a 1½" W.I. line to the top of the intermediate tank of the scrubbing system.

CRUDE M.E.K. STORAGE—The crude M.E.K. storage is No. tank in the battery of 2,760 gal. glass enamelled storage tanks i the M.E.K section (See album, page 148).

The outlet from the crude M.E.K. tank has one branch leadin over the floor and through the wall to a 6½ x 4½ x 8 single cylinder pump in the interchanger room, which discharges through a 2 pipe across to the Mill Street Still Building. The other outlet is 1½" W.I. line and drops through the floor to the drain system the secondary butyl settling tanks (salting plant) through which may be drawn by a 6 x 4 x 6 single cylinder steam pump and discharged through a 2" W.I. pipe across to the Trinity Street St Buildings. The latter connection was used previous to the installation of the Mill Street Stills.

HYDROGEN SCRUBBING AND M.E.K. RECOVERY SYSTE

(See Drawings A251, 8703, 8705, 8706, 8937, 8938, 8939.)

OUTLINE OF SYSTEM—A detailed description of the various elements of the scrubber and continuous rectifying still and salti systems making up the installation is given in the section on St but a brief outline of the system is here given together wit description of the connections between the system and the remainder of the plant.

The hydrogen from the separator of the catalysing system (containing possibly 10% of the total M.E.K.) enters the bottom of scrubbing tower and percolates upwards against the scrubbing water flowing down. The water dissolves a large proportion of the M.E.K. in the hydrogen and passes from the bottom of the column to the storage tank. From storage the liquor is elevated to the still feed tank by means of a pump controlled by a float in the feed ank. The liquor flows under gravity through a preheater, where t is heated against the slop leaving the column through the slop eal, to the top plate of the exhausting column of the continuous urifying still.

The M.E.K. distills off in the form of 162°F. constant boiling ixture and leaving the top of the rectifying column passes through he goose dephlegmator and condenser to a regulating bottle and hence to the tester. Two other lines lead from the bottle, one a eflux line in connection also with one from dephlegmator for re-urning reflux to the column, and the other for returning liquor to e scrubbed liquor storage tank.

From the tester the crude distillate is passed to the decanter here the top layer (crude M.E.K.) overflows to the intermediate orage tank and the aqueous layer returns to the scrubbed liquor orage tank.

The intermediate tank is in effect a feed tank for the continuous lcium chloride salting section of the system. The crude liquor is d from this tank through a float tank to the salting mixer, which also supplied with calcium chloride solution from the salt solution rage tank above. After salting, the two layers are again sep-ated in a decanter, the upper crude M.E.K. passes to storage and lower, salt solution passes to a recovery or evaporation system.

In the latter system, the solution flows through a preheater inst the concentrated solution leaving, into the evaporating tle from which it is drawn after concentration through the pre-ter referred to above by the small centrifugal pump and re-ned to the storage tank. The vapors from the evaporation pass ough a separator and are returned to the continuous still for recovery of any M.E.K. dissolved in them.

CONNECTIONS GAS INLET—The hydrogen liberated in the third e catalytic reaction is separated from the crude M.E.K. un-verted secondary butyl alcohol and condensable bye products in separator. From the top of the separator a $1\frac{1}{2}$" W.I. line is to the gas inlet at the base of the scrubbing tower.

Water Inlet—City water (potable) is supplied to the top of the column through a 2" W.I. pipe from a small 4' 6" dia. x 4' 10" 478 gal. steel constant level water feed tank supported by the roof truss. The water feed pipe also receives a 2" drain from the separator on the gas outlet from the scrubber, and is arranged with the usual seal against escape of gas.

Gas Outlet—The 6" gas outlet from the scrubber, of W.I. pipe, leaving the top of the separator, passes through the roof and is provided just above the roof with an elbow and short horizontal length of pipe, ending in a 6" gate valve. From between the valve and elbow a 2" W.I. hydrogen line is taken off and passes down t the third stage catalysers. By closing the 6" valve sufficiently, th hydrogen is forced through this pipe to the catalysers, supplyin the hydrogen for reduction of copper oxide when required. Th arrangement outlined is, however, only temporary in that som sure means would have to be provided in operating at full rate capacity, of absolutely preventing any choking back of the hydr gen outlet putting back pressure on the catalysers with possible r sultant overheating and trouble.

Scrubbed Liquor Outlet—From the bottom of the scrubbe tower a short 3" W.I. pipe (see album, page 138) passes throug a deep seal (5 ft.) into the top of the wooden scrubbed liquor tan This seal was deepened over that called for by the builders in ord to take care of back pressure due to throttling back hydrogen outl from top of column.

First Runnings M.E.K.—Returns—A 2" line from t Mill St. Stills (see section on arrangement of Rectifying Stills M.E.K. plant) enters the top of the scrubbed liquor tank and branch of it passes to the tester of the scrubber rectifying st The F.R.M.E.K. fraction from the M.E.K. rectification or purifyi is pumped back from the F.R.M.E.K. tanks (No. 5 and 6) in t Mill St. Tank House and directed either to the scrubbed liqu tank, from which it will pass through the rectifying still system the scrubber, or to the tester from which the fraction will p through the salting section only of the scrubber. The properties the fraction determine to which destination it is directed.

A 3" W.I. overflow line from the top of the scrubbed liquor f tank (S.L. Feed) on the top floor of the building also enters the of the wooden tank.

Separated Liquor to Scrubber Purifying System—The condensed crude M.E.K. separated from the hydrogen in the separator after the third stage catalysers, is drawn off by a variable stroke pump and may be pumped either to the main crude M.E.K. storage tank, or to the top of the Intermediate Tank of the scrubber rectifying system. Thus, this condensate, or a certain layer of t as shown by the gauge glasses, can be pumped into the latter tank nd proceed through the salting section of the system.

Calcium Chloride Solution Preparation—For preparing the alcium chloride solution for the salting section of the rectifying ystem, a similar tank to that for the preparation of the caustic olution for the secondary butyl salting plant, but built of copper, as being installed (refer back). This tank was to have been in-talled on the top floor of the building beside the salt solution torage tank, the calcium chloride placed in the perforated basket, ater supplied from the constant level tank above, and the solu-on raised to the top of the storage tank when necessary to replen-h supply by means of a small hand pump, or a small compressed ir egg suspended from floor beneath the tank.

Crude M.E.K. From Hydrogen—The crude M.E.K. resulting om the rectifying of the scrubbed liquor from the hydrogen scrub-er, is separated from the brine solution in the decanter after the lting and passes through a short 1½" line to the top of a small 28 gal. copper tank (formerly yeast tub duplicate of separators) ovided with gauge glass, flanged cover, etc. (See album, page 6). This tank acts as a pump reservoir from the bottom of which 1½" W.I. suction line leads to a 3 x 2 x 4 duplex steam pump. e latter discharges the crude M.E.K. through two 1¼" W.I. lines either the top of the main crude M.E.K. storage or through a eck valve into the discharge from the crude M.E.K. pump in in-changer room and thence across to Mill St. Stills.

STEAM, WATER AND EXHAUST SYSTEMS.

Centrally located on the second floor of the M.E.K. building are steam, City water and bay water manifolds, from which the s pass to the various pieces of equipment. (See album, page).

Steam Supply and Distribution—Three steam mains enter the steam manifold, one a 4" main from the 60 lb. system at the Mill Boiler House, another from the high pressure system at the beer stills and a third, a 6" main from the newly installed cross connecting main from East to West Boiler House. The latter has, as yet, not been used. The former two lines are so connected to the manifold that either the 60 lb. steam may be supplied or high pressure steam returned to the manifold from the beer still supply and into manifold branches through reducing valves. 60 lb. steam can, when required, on the other hand be supplied to the beer stills through this same main.

Three 2" branches drop from the manifold, one to lead still coils, one to salt evaporator of scrubber and one to scrubber pump and sump pump. A small branch from the 60 lb. main supplies the salted secondary butyl pump, and before the manifold is reached a branch leaves to supply butylene compressor engines.

Exhaust and Drips Systems—The exhausts from the various pumps and compressor engines are collected in a 4" main returning to main exhaust header in Distillation Department and the drips from the various coils are also connected into the main drips system.

City Water Distribution—Beside the steam manifold is the City water manifold, which is supplied through a 2" line from the 4' 6" dia. x 4' 10" steel water tank on roof truss, which receives water through a 2" float valve controlled branch from City system. Two branches only leave this manifold, one to sparger of acid diluting tank and the other to the steam regulator of the scrubber still.

Bay or Cooling Water Distribution—The third manifold i the bay water, supplied through a 4" main from tank on roof o Distillation Department and a 4" drain runs from manifold t sewer. Two 2" branches from top of manifold supply scrubbe still dephlegmator and condenser and a $1\frac{1}{2}$" delivers cooling wate to the coil of the calcium chloride storage tank. Three 2" branche leave the bottom, to dephlegmator and condenser of lead still and t cooling coils of acid diluting tank, while a $\frac{3}{4}$" line leads to sl tester condenser of lead still.

PURIFYING STILL AND TANK HOUSE OF M.E.K. PLANT.

(See Section on Stills.)

RECTIFICATIONS NECESSARY—If the M.E.K. plant be considered as one, which receives rectified normal butyl 99½% dry from an outside source and converts the butyl into pure methyl ethyl ketone, there are two rectifications that have to be carried out, namely, the rectification of the salted secondary butyl alcohol and the rectification of the crude M.E.K. In addition to these, there is also the still in connection with the hydrogen scrubbing system, which however delivers crude M.E.K. which must be purified, and the lead still for the hydrolysing distillation of the butylene hydrogen sulphate, but here again the product is impure and has to be salted and rectified so that there are the two only purifying rectifications.

PROPOSED RECTIFICATION SYSTEM—The original plans for the methyl ethyl ketone plant for the handling of 250 gals. per hours of rectified normal butyl contemplated carrying out these rectifications in stills as follows: The two large (7,000 gal.) Trinity stills were to be used for the rectification of the normal butyl, leaving only the No. 1 4,000 gal. still unused. It was planned to use this still and a new 150 gal. per hour discontinuous still on the rectification of the secondary butyl alcohol and two new (duplicate) 150 gal. per hour discontinuous stills on the methyl ethyl ketone rectification.

Since neither the rectification of methyl ethyl ketone, nor of secondary butyl alcohol, had ever before been carried out on a commer-ial scale, the design and construction of the stills had to be based on mall scale experiments and data, and probable performance of the still was difficult to foretell. In view of these factors it was con-idered best to instal two duplicate M.E.K. stills of half the capac-y instead of one for the full capacity, and to order only one still t first until actual trial had indicated what alterations or im-rovements were necessary, which could then be incorporated in e second still at the start. There was also the possibility that a ss pure ketone for aeroplane dope would be the principal require-ent, in which case the single still might handle the full quantity 250 gals. per hour.

LOCATION OF STILLS—The question of the location of the new stills received a great deal of attention and consideration. It was obviously an advantage to have all the stills working on M.E.K. rectifications together, from standpoint of ease and convenience of operation, but the situation of the Trinity Still House, with buildings on either side, precluded any possibility of building an addition to the Trinity Still House for the new stills. The other alternative was to built a new still house for six stills and move the three Trinity Stills to the new location. While no definite arrangements were arrived at with Messrs. Gooderham & Worts regarding the movement of these three stills, the possibility was borne in mind in designing and building the new still house. A storage building in the north side of Mill St. was placed at our disposal by Messrs. Gooderham & Worts, a portion of it torn down and a new still house capable of housing the two stills on order and the third M.E.K. still to be ordered in the future, was erected. Provision was made for the future building of an addition to the building for the three Trinity St. Stills.

The rear portion of the old building was at the same time remodelled to form a tank house, for the various distillates and crude liquids in connection with the two rectifications.

The stills were recently installed, properly connected up, subjected to tests for tightness, and in the case of the M.E.K. still, tried out on an actual run.

Secondary Butyl Still—The secondary butyl still (see album, pages 150-152, and Drawing 8906) is of iron construction except the dephlegmator and condenser and consists of a 10' dia. x 30 ft. long steel kettle provided with steel pipe heating coil, 60" x 24 plate column, together with dephlegmator, condenser and tester, and was designed for the production of 150 gals. per hour of rectified secondary butyl from a mixture containing approximately 90% of secondary butyl alcohol together with small quantities of heads, water, sodium chloride and other impurities.

M.E.K. Still—The methyl ethyl ketone still (see album, pages 150-152, and Drawing 8892) is of similar construction to the above still, having a steel kettle 10' dia. x 16' long with steel tube heating coil, 60" x 36 plate column, together with dephlegmator, condenser, tester, etc. In connection with this still a caustic washer (see drawing 8911) was also installed for treating the vapor from the column with solid caustic. The still was designed to handle 150 gals. per hour of purified methyl ethyl ketone from a mixture containing approximately 75% M.E.K., 25% secondary butyl alcohol with small quantities of other impurities such as butyl aldehyde, etc.

For a detailed description of these stills, see section of report on Stills.

STORAGE TANKS—The Mill St. Tank House is provided with eighteen 13,157 gal. 16' dia. x 10' 7" deep copper tanks with wooden covers (see album, page 153). Four of these are elevated still supply tanks to give gravity flow into the still kettles, while the remainder are on the ground floor, some fitted with triple gauge glasses (three lengths overlapping) to receive the various distillates from the rectifications.

There are also provided four duplex steam pumps in the south west corner of the Tank House for transferring the liquids from tank to tank or to stills in other buildings.

PIPING—The piping arrangements (see Drawing A407) of the two stills have been laid out in as simple and straightforward a manner as possible compatible with the complex nature of the work to be done including the delivery of the crude liquids to the still supply tanks, from the supply tanks to the kettles, from the tail boxes and testers to the storage and settling tanks, and from the latter to pumps for delivery for re-distillation or shipment or return to M.E.K. plant. The piping unless otherwise noted is all of 2" W.I. with screwed fittings, valves either of gate type or plug cocks. The feed lines to the tanks pass through holes in the wooden covers into the tanks, while the emptying lines come from flanges in the tank bottoms near the edge. All the drain lines of the tanks are carried to the south side of the building, where valves are located in each and they enter headers or pass east or west to the suctions of the pumps.

The Mill St. Still and Tank House is connected to the rest of the plant by means of a bridge across Mill St. from the north west corner of the Drying Kiln Building to the Still Building at first floor level. From the corner of the Drying Kiln Building a second bridge spans the court between the latter building and the east end of the Fermenter Building.

Five 2" W.I. pipe lines pass over these two bridges and along the east fermentation department and acid plant walls, from the Still Building to the Interchanger Room of the M.E.K. plant proper, and thence to various destinations. The lines are approximately 200 ft. long.

Two of these lines are used to deliver the crude liquids for rectification. One of these leads to a 6" x 4" x 6" pump on the ground floor of the M.E.K. Building, which draws from the second salted secondary butyl settling tank and delivers to either of the two east ones of four elevated still supply tanks, being directed to either one by inverted plug cocks. The other line leads from a 6½" x 7½" x 8 single cylinder steam pump in the north west corner of the Interchanger Room which draws from either the No. 4 glass lined crude M.E.K. storage tank in the M.E.K. building, and discharges into either of the two west elevated still supply tanks through inverted plug cocks.

Two of the three remaining pipe lines are used for returning distillates to the M.E.K., while the other is not as yet connected up at either end, but was to provide a line for return of F.R.S.B. and S.B., head products and intermediates for redistilling.

SECONDARY BUTYL RECTIFYING STILL CONNECTIONS.

Charging Piping—From the two elevated crude secondary butyl still supply tanks No. 17 and 18, two drain lines meet in a single line and pass through the wall into top of kettle of still.

Distillates Piping—There are three lines from the tester of the secondary butyl still running as follows:

(1) A line to either of tanks 8 and 11, designated F.R.S.B. and S.B. respectively, into which the first runnings secondary butyl and secondary butyl fractions are directed (headproducts and intermediates 183-207° F.) From the latter tank the upper layer overflow through a 2½" copper pipe 9" from the top of the tank into No. 1 tank, designated S.B. 2.

(2) A line leading to either of two tanks 9 and 10 both designated R.S.B. into which the rectified secondary butyl fraction run (207-214° F.)

(3) A line leading to tank 14, designated L.R.S.B. which r ceives the last running fraction of the secondary butyl distil

tion. (Tail products, high boiling polymerides, alcohols, etc., 214°).

PIPINGS TANKS TO PUMPS—No. 8, F.R.S.B. tank emptying line enters a header which has not as yet been connected up to the pump. It was proposed to connect this header up to a fifth pump to discharge back to feed tank of salting plant for re-salting and distillation.

Tank 12—S.B. 2—emptying line passes through a header leading to a 7½ x 4½ x 10 duplex steam pump (east), which discharges the S.B. 2 into the kettle of the secondary butyl purifying still for redistillation.

Tank 11 S.B. empties into the same header as No. 8, which has not been connected up to a pump yet.

Tanks 9 and 10—holding R.S.B.—empty into the same header leading to a 6 x 4 x 6 duplex steam pump (west) which discharges into one of the five long lines to the M.E.K. building where it enters the top of the No. 2 tank holding R.S.B. for second stage supply.

Tank 14—L.R.S.B.—the emptying line from this tank connects into the same header as that from No. 12 leading to the 7½ x 4½ x 0 pump delivery to kettle of secondary butyl still.

METHYL ETHYL KETONE STILL CONNECTIONS.

CHARGING PIPING—The charge of crude M.E.K. is run from ither crude M.E.K. tank No. 15 or 16 to the kettle of the still hrough a single line, under gravity.

DISTILLATES PIPING—Four lines lead from the tester of the still, amely:

(1) A line to No. 5 tank—F.R.M.E.K.—through which the first nnings are directed to the tank, and from which it overflows rough a 2½" copper overflow 9" from the top into No. 6 tank, so designated F.R.M.E.K.

(2) A line to Nos. 1 and 2 tanks for M.E.K. intermediate and E.K. 2 respectively, to which these fractions are directed. The nks are connected by overflow.

(3) A line which connects with the R.S.B. line from the sec- dary butyl tester to tanks Nos. 9 and 10. The connection is de beyond the point where the tank branches come off, and a lve is placed in the line at the connection. This enables the

R.S.B. or rectified secondary butyl fraction to be run into the R.S.B. tanks.

(4) The fourth line from tester is a short one, passing under the still operating floor to a header from which two lines pass up through the floor and branch to the tops of four gauging vessels similar to those used on acetone rectification and for the same purpose. (See album, page 151). The M.E.K. from these gauging vessels or tanks, depending upon whether it tests up to standard or not, is directed into either of two headers through branching outlets. One header leads to the two pure M.E.K. tanks, Nos. 3 and 4, and the other connects into No. 2 line above, through which the M.E.K. is run to either No. 1 or No. 2 tank.

(5) The residue left in the kettle of the M.E.K. purifying still is pumped out by means of a small duplex steam pump beside the kettle and delivered to tank No. 14—L.R.M.E.K.. This pump will also be connected up to the kettle of the secondary butyl still and the residue from the latter will be discharged through the above line to Tank 13—L.R.S.B.

Piping Tanks to Pump—Tanks 5 and 6 F.R.M.E.K. empty into a header running to a 6 x 4 x 6 duplex steam pump which pumps the first running through one of the five long lines to either the scrubber tester or the scrubbed liquor tank.

Tanks 1 and 2—M.E.K. intermediate and M.E.K. 2—From these tanks the emptying lines run into a header, into which also connects a branch from No. 6 tank emptying line. A 6 x 6 x 6 pump draws from the header and discharges into the still kettle. From the pure M.E.K. tanks 3 and 4 separate 1½" gravity emptying lines (temporarily) run through walls into Still Building where they are provided with cocks and were used in racking off the 2,500 gals. of pure M.E.K. obtained previous to the Armistice and closing down of Plant.

CATALYST MANUFACTURE.

First Stage Catalyst—The catalyst used in the first stag reaction is kaolin, which is first mixed with water, rolled into lon pencils, about ½" to ⅝" in diameter, given a preliminary dryin out at a moderate heat in the boiler room and then baked in a g furnace. After baking the sticks or pencils are broken up into ½" or ⅝" lengths.

It is considered that the natural broken porous surface of the clay is more active than any finished surface such as would be offered by the catalyst if prepared in pill form and is to some extent the case in the finger form. The chemist attributes the falling off in duty of this catalyst to the finger form.

Extensive investigations carried out by the Chemical Department have led to the abandoning of the earlier forms of first stage catalyst, a mixture of alumina and high grade asbestos, and combinations of asbestos and kaolin, in favor of the kaolin only.

The equipment to be provided for the production of the catalyst consisted of a drying oven and baking furnace.

The data on which designs were based, was supplied by the chemist and is as follows:

At the 250 gal. per hr. rate, 200 lbs of kaolin are required per day, weighing when placed in the catalyser 45 lbs. per cu. ft. The atalyst has to be dried at 194° F. to drive off the moisture present (3% if dried as received, 35% if mixed with water), and afterwards baked at 1,076 to 1,112° F. to drive off the remaining 10% f water. The length of time for drying and baking was not given.

It is given as essential that no flue or combustion gases be llowed to come in contact with the catalyst in the furnace because f the danger of poisoning from carbon or sulphur present in the ases.

The quantity was at an earlier time fixed at 500 lbs. per day, ut as a result of several successful runs of long duration at high nversions the figure was reduced. The decrease in conversion y the catalyst appears to be due to coating with carbon. The talyst is frequently removed quite black in appearance. This rbonisation not only prevents contact of gases with kaolin but elf induces side reactions, and is apparently due to overheating her local or general, or presence of carbon in the catalysing ambers.

A small experimental two muffle gas furnace having proved ccessful on the alumina-asbestos catalyst and later on the kaolin, was decided to build the large size furnace of this type, and to e care of the preliminary drying by means of a steam heated n.

First Stage Catalyst Drying Oven—The latter has just been designed and consisted of a 6 x 4 x 8 ft. high outside, double walled chamber constructed of angles and 16 gauge black sheet, with 2" of insulation between the two walls. The bottom of the chamber was sunk about 15" below floor so that two pair of channel rails running from front to back were flush with the floors. The front was provided with two 2' 6" x 6' 0" doors and from the top a 12" dia. vent pipe carried off the vapors. Beneath the rails carried on a rack was a steam heating coil of W.I. pipe.

Two tray racks, each carrying ten 24 x 36 x 1½" deep trays, 6" apart, were arranged to run into the oven on wheels rolling in the channel rails. This construction permitted of the filling of the oven with minimum loss of time and heat, and permitted the kaolin to be laid out in thin layers accessible to the hot drying air from coils.

Assuming each tray covered with a ½" layer of kaolin, the 20 trays would carry about 200 lbs. or one day's supply, which permits of practically a 24 hour drying period, which with 60 or 100 lb. steam in coils was considered ample.

First Stage Catalyst Baking Furnace—The baking furnaces (see album, page 121, Drawing B295), two in number, were each provided with two 20" x 37" x 10½" fireclay muffles. Muffles o this size (the largest obtainable) were used in order to secur as large a surface as possible on which to spread out a thin layer o kaolin for baking. This permits of about 7 lbs. per muffle pe charge, or 28 lbs. per charge for all muffles or to bake the 200 lbs required seven or eight chargings, three hours to a charge whic appeared ample.

The muffles are placed 4½" apart in the furnace proper (se Drawing B 295) properly supported 7½" above the furnace floo and 6¾" from the sidewalls. The furnace roof is arched over t muffles, with a special tile baffle projecting down from roof ne the 9¼" x 12½" vent to throw the hot gases down on top of muff The vent is nearer the front of the furnace than the back in ord to induce a current of hot gases over the front to make up f greater radiation loss there. The front arches over the muffles a supported on special tiles, and the muffles are provided with a ti fitting door.

Three burners are inserted 9" apart along each side of furn below muffles, so that burners on opposite sides are staggered with respect to each other.

The burners are made up of pipe fittings with a ½" gas supply and ⅛" compressed air.

The furnace outside dimensions are 6' 4" x 4' 11" x 6' 4" high, the floor of the furnace being on top of nine courses of ordinary brick and four of fire brick.

THIRD STAGE CATALYST—The third stage catalyst is fused copper oxide. The oxide is fused, cooled and broken into ½" lumps for packing the catalyser. This has proved the most satisfactory catalyst that has so far been tried. Previous to deciding on the use of the fused oxide, powdered copper oxide on pumice had been tried, but the former possesses advantages in that the life and duty are more steady and greater.

DATA—The copper oxide requires heating to 1,940-1,976° F. or a few minutes, after which it is cooled and broken into lumps. he oxide in the catalyser weighs 128 lbs. per c. ft. and no definite uantity per day could be fixed upon until extended runs had been ade on the full sized plant.

The design of a furnace capable of handling this problem was difficult matter. Various stock patterns of furnace were tried, cluding a nickel furnace, but none of them could stand up to the gh temperatures. The furnace must be lined with a non-absorbt refractory to prevent the oxide when formed from permeating e lining. The furnaces installed, three in number, were evolved Toronto for this particular work. Two furnaces were to be d on production of new oxide and the third on the renewal of , as it has been found that the fused oxide can be restored to ivity by reoxidation at temperature from 750° to 950° F.

CONSTRUCTION OF FURNACE—The construction of the furnace is follows. (See album, page 122, and Drawing A343):

A 14" x 24" hearth is enclosed in a 4' 0" x 4' 8" x 3' 6" high k of fire brick masonry. The hearth has a 3½" bed of J.M. No. refractory cement. The hearth is fed from the front of the ace through an 8" x 6" steel door frame. This was rendered ssary through oxide adhering to brick, etc. From the back e hearth, a flue leads upward and to the side, back over top of hearth, then back again and out to flue. This keeps up the temperature of the hearth roof. Three ½" gas supply, ¼" air supply gas burners are placed in the front of the furnace, directing their flames downward at 45° to the top of hearth. The burners are made up of standard pipe fittings. Surrounding the furnace is a 3" insulating space and the furnace is reinforced with buck stays and tie rods, and is built on the top of a 24" concrete pedestal.

REFERENCES ON M.E.K. PLANT.

The following references give more detailed information an data respecting the more important elements of the plant:

REF. NO. 1 STORAGE TANKS FOR LIQUIDS IN PROCESS

Necessity for Storage—Aside from the main storage fo the liquids of the process, which it is desirable to keep in an out side storage building of some kind, there must be provided in th plant itself storage capacity for feeding the various processes an for receiving the products of the different processes. The storag thus in each case acts as a pump reservoir from which pumps hand ling liquids may draw and provides a margin so that in case on process works faster or slower than another, or in case of a break down of one section, there is a reserve capacity available to suppl or receive liquid until repairs can be made or until it is convenie to remove the accumulation or make up the deficit.

In this case the minimum reserve capacity provided for in t case of absolute stoppage is approximately 6 hours, which affor sufficient time to either make the necessary repairs or arrange f some other disposition of the liquids.

Type of Tank—A number of storage tanks were provid as part of the equipment being furnished by outside builders (chie ly lead lined tanks for acids, etc.), but to supplement these whe deemed advisable and to provide for storage other than that th taken care of glass enamelled steel storage tanks have been ext sively used for the storage of the liquids in process. The coming i force of the prohibition law with the resultant shutting down a dismantling of breweries threw a number of this type of tank the market when the M.E.K. plant was under construction. T nature of the liquids to be handled in the plant rendered the of some non-corrosive tank advisable and therefore a number of the glass-lined tanks were secured.

The tanks are of various sizes built up of several flanged cylindrical sections, one of which contains a single arch manhole and all contain various holes for connections. The heads are flanged and domed and have holes for connections also. The tanks are normally stood on end by means of adjustable feet consisting of brackets bolted to lower flange, floor plate and adjustable leg. (See album, page 148).

MAKING JOINTS—Due to the properties of many of the iquids, butyl alcohol, sulphuric acid, etc., the ordinary standard acking material could not be employed for making up the joints f the tank and these were accordingly made on lead. The joint s made on two rings, one of ¼" lead wire and the other of ⅜", ach burned to form a complete ring. The former is placed outside e bolts of the flange, the latter inside. The bolts are ⅝" dia. d spaced around the flanges 1⅝" apart. The joint is made on e ⅜" wire while the ¼" wire prevents the flanges being drawn wn due to the great pressure required to make the join on lead.

Openings not required in the tank are plugged, using a lead vered bolt and washer inserted in hole and drawn up with nut the outside.

INLET AND OUTLET CONNECTIONS—Connections for the inlet pe in the cover and for outlet in the bottom are made with a ecial brass nipple, threaded with 2" pipe thread on the outside h a flange at one end and provided with a brass locknut. The ple is inserted in the hole in the head from the inside resting flange on a small gasket of lead. The locknut on the outside the tank is tightened up, drawing the brass nipple flange down the gasket. The nipple is sufficiently long and is threaded with rge thread to permit of screwing on a standard fitting and ging it up tight.

MANHOLE—The manholes in most cases gave considerable ble in making tight through the fact that they were supplied only one arch rendering it difficult to apply enough pressure to the springing of the cover. (See album, page 148). To overe this, a U of square iron 1" x 1" or heavier was inserted under arch and around main screw, extending lengthwise of the cover and two bolts were placed through U with a nut or two nuts under. These additional bolts were then used to force extremities of manhole cover down.

Gauge Glasses—Gauge glasses are applied to the tanks in two ways. Where the tank is to contain a pure or rectified liquor, the outlet line from the centre of the bottom or a branch of it is run to the edge of the tank, where it is provided with a tee or elbow in which the gauge glass fitting is screwed. The gauge glass is carried in the fittings and extends up the side of the tank attached to the gauge board, and has an open upper end.

Where a separation is likely to take place, short overlapping gauge glasses must be used to indicate the surface of separation and these are drilled and tapped into side of tank, taking as much care as possible in order to chip the enamel as little as possible.

Overflows or Inlets—In many cases it is required t be able to draw off liquid or layers from different heights in a tank which necessitates getting in a number of connections of fairl large size. These have been made using ratchet and standard boiler-makers' drill, after which the hole is tapped and the overflow and additional inlets screwed in. If reasonable care is taken, th enamel inside is not seriously chipped.

REF. NO. 2. VARIABLE STROKE PUMP.

Fine Adjustment of Feed Necessary—A pump of speci design was used to secure the fine adjustment of feed necessa in connection with the catalysers. (See album, pages 132 and 1 Drawing A184). These pumps were of the variable stroke t which had been proved successful by Mr. Shaw in dealing w sugar evaporation.

Construction of Pump—The pumps are 2¾" bore w a stroke variable from zero to 3½", and are of the semi-dou action type. That is, the face of the plunger—3½" dia.— double the area of the back (1-15/16" dia. rod), so that on e down stroke one-half the stroke volume passes out the disch and the other half around and into the upper portion of cyli on top of the plunger. On the return stroke this latter half is discharged and the lower portion of the pump filled with fresh liquid.

ADJUSTMENT—The pumps are belt driven, and the driving shaft carries an eccentric (⅞" throw) which operates through a slotted link and adjustable block, the plunger. By adjusting the handwheel controlling the sliding block, the stroke of the pump may be accurately varied from zero up to 3½". The link is so arranged that the handwheel has little motion and is easily manipulated while moving.

A 1½" adjustable check valve is bolted on the suction side of the pump and a second check valve is placed in the discharge passage from lower end of pump.

The plunger is packed with two cast iron packing rings.

CAPACITY—The speed of the pump is 60 r.p.m. and rated apacity at full stroke 250 g.p.hr.

The gland as originally designed gave a great deal of trouble s it was designed to take only four rings of packing which proved nsufficient on the low density liquids being handled. An addi- onal length added to the stuffing box enabling six rings of packing be used improved the tightness considerably.

EF. NO. 3. CATALYTIC WATER DISPOSTL.

SOURCE—The first stage catalytic reaction yields 1.95 lbs. water per gallon of butyl feed, or at normal rated capacity 487.5 . or 48.75 gals. per hour of water are produced assuming 100% version. Actually the quantity of water produced will be less, there will be instead, for each 1.95 lbs. of water lacking, 1 gallon nconverted butyl alcohol. Thus with 80% conversion there will 50 gals. of butyl and 39 gals. of water. In addition, small quan- es of butyl ether, aldehydes, etc., will be produced.

These vapors are condensed as the gas from the catalysers is ed and separated from the gaseous butylene first in the separa- after which a further cooling occurs followed by a separation e trap at entrance to the gas holder. There may be a further t throwing down of the condensed vapors on top of the water of the gasholder. The upper layer of water is run into the d gasholder trap and the condensed vapors separated.

The gases condensed and separated in this way, consisting of water, unconverted butyl alcohol, butylene dissolved in butyl ether, aldehydes, etc., are all pumped to the main catalytic water tank for storage.

There are two methods of recovering the butyl alcohol, etc., contained in the catalytic water.

EVAPORATION—The butyl alcohol, etc., may be recovered by evaporating the catalytic water. This method was under consideration, and a system was proposed as follows:—

In the separators and traps, and in the catalytic storage tank a separation occurs of the condensate into two layers, the upper consisting of a solution of butylene in butyl alcohol, butyl ether etc., and the lower, an aqueous layer. The upper layer is sent t a kettle evaporator (copper probably 36" x 48") where the solutio is boiled by means of steam coils.

The butylene is driven off from the unconverted butyl an passes to a separator (either the same one as above, or another and thence to the gas holder. The residue in the kettle, butyl a cohol, butyl ether, etc., is pumped through the catalysers again.

RE PASSAGE THROUGH CATALYSERS—The other method, a one actually tried out at Toronto consists in withdrawing the upp layer from the catalytic water tank and feeding it into the catal sers direct, the feed to the catalysers thus being made up of fre butyl alcohol with a small percentage of the upper layer. T only disadvantage of this method is the interference of the butyle contained with the conversion of the remaining butyl alcohol, b the quantity of the butylene, both actual and relative may be small as to cause little trouble in this respect.

The results of this method are doubtless given in the Chemis report.

REF. NO. 4. HEAT INTERCHANGERS.

NATURE OF PROBLEM—The subject of heat transfer tween fluids is one of prime importance in the M.E.K. p Liquids require to be evaporated and heated, vapors condensed cooled, and gases heated and cooled.

The heating and cooling of gases is a difficult problem, usually involves the use of large, bulky, inefficient apparatus of the multiple tube type. In the M.E.K. plant, dealing with the temperatures and gas quantities occurring there, the installation of standard apparatus would have required besides the use of extensive valuable building space, a large expenditure for the apparatus, which is costly to construct and the use of a great deal of cooling water.

In connection with this matter, the builders of the chemical equipment installed pointed out that the cooling of the gas in the quantities contemplated, would require careful consideration.

There are four principal points in the M.E.K. plant, at which ases must be heated or cooled, namely, heating at entrance to rst and to third stage catalysers and cooling at exit from these atalysers, the heating in each case involving the evaporation of the quid previous to the preheating at entrance to the catalysers.

While the heating and cooling are essential in themselves, it is esirable, in addition to improve the heat efficiency of the process, y combining the heating and cooling in each stage in a single pparatus, using the hot gases to heat the cold and vice versa.

The success of the M.E.K. plant largely depends upon the fficiency of the heat interchanging devices employed, and for this ason a high efficiency type is particularly necessary.

In view of the vital nature of the problem from the standpoint the process itself and its importance from that of fuel economy d general heat efficiency of the plant, together with the lack of y real efficient apparatus on the market, it was considered ad- sable and necessary to institute a research to try and evolve an proved apparatus for the work.

As a result of the extensive experience of Mr. E. Metcalfe Shaw connection with heat transmission and interchange, an apparatus s been designed, constructed and operated at Toronto of a type ving an extremely high duty in the transmission of heat from d to fluid of any kind whatever. In addition to this, the bulk the apparatus is small, its cost low and durability high. The criptions, mathematics, test data and results of extensive experi- nts under test and actual operating conditions, are given in Shaw's report on the subject. A description only of its appli- ons to the M.E.K. plant is given here.

Previous to the development of the so-called "Heat Inter- nger" another form of apparatus was used for evaporation and cooling purposes, which, while of less efficiency than the Interchanger, is of much greater efficiency that the ordinary stock type of heat transfer apparatus.

Shaw-Wriggle Apparatus—This apparatus was of similar design to the Shaw-Wriggle Cooler, as described previously for cooling mash. (See Mr. Shaw's report.)

Shaw Lead Interchanger—For dealing with sulphuric acid, a lead interchanger was designed. Interchangers of pure lead, 5% and 8% antimonial lead were constructed. (See Mr. Shaw's report.)

Application of Heat Interchangers—Heat Interchangers have been used in the M.E.K. plant in the following locations:—

(a) Preparation of hot butyl gas feed to first stage catalysers and cooling and condensing of exit gases and vapors.

(b) Preparation of hot secondary butyl gas feed to third stage catalysers and cooling and condensing of exit gases and vapors.

(c) Removing heat of compression from butylene gas.

(d) Oil heater for acid concentrating plant.

(e) Acid concentration (experimental).

(*a*) *First Stage Catalyser Heat Interchanger System.*

Heat Required for Feed—The temperatures at which the first stage catalysers have so far been operated have varied from 650° to 800° F., the temperature being gradually increased as catalyst duty falls off. Assuming a feed temperature of normal butyl alcohol of say, 60° F., the heat required to heat the liquid butyl evaporate and preheat the gas to 800° for a 250 gal. per hour plan is:—

$$250 \times 8.1 \times [0.5\ (242-60)+257+.45\ (800-242)]=1{,}015{,}000 \text{ B.T.U. per hour.}$$

Heat Available in Exit Gases—On a basis of 80% conversion and no losses, the exit gases from the catalyser will b composed of 200 gals. butylene, 50 gals. unconverted butyl alcoho and 39 gals. water. Assuming an exit temperature of 800°, an cooling down to 60°, the heat to be removed is:

200 x 6.07 x .45 (800-60) .... = 404,000 B.T.U. per hr.
50 x 8.1 x [.45 (800-242)+257
+0.5 (242-60)] .... = 203,000 " " "
39 x 10.0 x [.465 (800-212)+
1034.6+(212-60)] .... = 569,000 " " "
1,176,000 " " "

At 100% conversion the heat quantity would be 1,216,000 B.T.U. per hour.

These figures are only approximate as no figures are available for the specific heats of butylene and butyl alcohol vapor, and values have been assumed which may or may not be correct.

HEAT INTERCHANGE—From these figures, however, it is apparent that with no radiation losses, etc., and 100% efficiency of transfer there is sufficient heat to prepare the ingoing gas from the heat contained in the outgoing gases. Actually, however, the radiation and other heat losses will be high, even with the best of lagging (this was amply demonstrated in actual trial) so that much less of this outlet heat will be available than is indicated. To allow for this, the heat interchanging system was laid out so that the latent heat of the butyl alcohol is supplied by steam.

SYSTEMS OF HEAT INTERCHANGE—There are two plans on which the system for the interchange of heat in the first and third stages may be laid out:

MULTIPLE TYPE (a)—The interchanging system is laid out as a single unit, into which the whole quantity of feed to all batteries is fed, and from which individual leads carry gas to various batteries, and into which the various outlet leads from the catalysers enter and the butylene, etc., from all the batteries is brought ogether and leaves through a single outlet pipe. This method requires the use of a single pump, and of meters and control valves working on hot preheated gas, as well as numerous valves in order o be able to cut out any one interchanger for repairs.

INDIVIDUAL TYPE (b)—An individual interchanging system laid out for each battery of catalysers, with a separate feed pump for each. Each battery of catalysers, interchange unit and feed pump, is a self-contained system, drawing liquid butyl from the main storage or supply pipe and delivering condensed steam, unconverted butyl and butylene gas (cold) to a header to the butylene separator. This arrangement possesses the advantages that only two valves are required, namely, where branch leaves butyl header, and where one enters butylene header, and that the venturi meter is working on liquid.

EXPERIMENTAL SYSTEM—The experimental interchanging system first installed was of the first type (See Drawing A264). The interchangers, all of the 3 ft. type, were arranged in parallel sets for each purpose, preheating, evaporating, etc., connected up to headers through valves. Two interchangers were at first installed in parallel throughout with provision made for a third, while provision was also made for supplying six batteries of catalysers, only two being taken off up to shutting down of the plant. The number of valves used, in the alcohol and butylene circuits alone, was 30 for two batteries of catalysers.

REASON FOR CHOICE—The reason for initially installing the system of this type was the greater flexibility resulting from this method. No information was available regarding heating properties, resistance to flow, etc., of the interchangers, and the layout was planned so that data could be secured from the interchangers operating under actual conditions. Using the multiple system enables additional interchangers to be placed in, in event of ones provided being insufficient, or if more than sufficient, more batteries of catalysers, which would be impossible with the unit type of installation.

A single variable stroke feed pump supplied the inlet header of the system.

Actual operating test data of this interchanging system is given in Mr. E. Metcalfe Shaw's report together with curves ,etc.

As a result of the information secured from running the two batteries regarding the actual operation of the catalysers and interchangers about which little was known or could be accurately predicted, the layout of the interchanging system for the permanent plant was to have been of the unit type and was in process of design when the plant was closed down.

PERMANENT SYSTEM—The permanent interchanging system was being laid out on the individual or unit system. (See Drawing A409). A small variable stroke feed pump capable of handling up to 50 g.p.h. draws liquid butyl alcohol through an ordinary gate or regrinding valve from a butyl main and delivers butyl through a 5/8" x 1/4" venturi meter to a set of three interchangers arranged as a unit, from which after passing through the catalysers, the cooled butylene, water, unconverted butyl mixture flows through a check valve and gate or regrinding valve into a header leading to the butyl separator. Leaving the separator, the butylene gas passes through a battery of interchangers in parallel into a header to the gasholder traps. By this system valves in connection with gases or hot gases are entirely eliminated with the resultant danger of leakages, leaking valve stem glands, etc.

An ideal arrangement of heat interchangers and catalysers offering many advantages would be that shown in Drawing A409—Ideal Layout. This arrangement, with catalysers above and heat interchangers below reduces the feed and outlet pipes to a minimum, thus reducing heat losses by radiation, it eliminates fire risks, is compact and gives improved ventilation.

(*b*) *Third Stage Catalyser Interchanger System.*

HEAT REQUIRED FOR FEED—Making the same assumptions as in the first stage and using an average reaction temperature of 540° as actually employed in tests so far, the heat to be supplied to the entering gas in this stage is: 250 x 8.1 [0.5 (212-60)+245+0.45 (540-212)]=948,000 B.T.U. per hr.

HEAT AVAILABLE IN EXIT GASES—The exit gases from the catalysers at 100% conversion will be composed of 245 gals. per hr. of M.E.K. at a gravity of 0.804 corresponding to 1,970 lbs. and 10,000 cu. ft. or 55 lbs. of hydrogen and their heat content will be:

1,970 [0.4 (540-175)+186+0.5 (175-60)]= 767,000 BTU per hr.
55 x 3.40 x (540-60) ....= 89,700 BTU per hr.

856,700 BTU per hr.

In this case, therefore, the heat leaving even assuming no losses, s insufficient to prepare the gas entering and steam or electricity or ome other source of heat must be utilised.

PERMANENT THIRD STAGE INTERCHANGING SYSTEM—The third stage system of heat interchanging proposed was laid out on the individual system similarly to the first stage, with the exception that smaller interchangers were used since the heat quantities and temperatures are less than in the first stage. The number of the individual systems was larger due to greater number of batteries.

TEMPORARY THIRD STAGE INTERCHANGING SYSTEM—While awaiting deliveries of interchangers a temporary system was installed for two batteries of catalysers, arranged as outlined in the description of the plant. A pair of evaporators (wriggle type) were used to preheat and evaporate the liquid secondary butyl, after which the gas was preheated in an interchanger against the exit gases. The exit gases leaving the preheater passed to a second pair of evaporator boxes installed as coolers, using water as the cooling medium.

(c) *Removal of Heat of Compression from Butylene Gas.*

The quantity of heat required to be removed from the butylene is small, as the rise of temperature is comparatively small. For this reason a 12" interchanger only was inserted in the system for the work, but was replaced by a 3 ft. temporarily in order to release the 12" one for another purpose. The 12" unit cooled the butylene from two batteries of catalysers (45-50 gals. per hour) quite easily with a small flow of water.

(d) *Oil Heater.*

A charcoal oil heater was installed as part of the oil burning equipment of the acid towers. This heater because of its inconvenience, was not used by the operators except under compulsion and the feeding of cold oil to the burners resulted in incomplete combustion, and heavy deposits of carbon in the combusion chamber, black acid and choking of the towers.

A 12" interchanger was connected on the oil line replacing the charcoal heater (see photo 129) and has given excellent results. The interchanger is too powerful for the duty required, but was the smallest available. It is found that the steam valve needs to be barely opened in order to secure 230° temperature with a rate of feed of 14 gals. per hour of oil.

(e) *Sulphuric Acid Concentration.*

An experimental acid concentrating system using the lead interchanger was laid out and installed as follows: (See album, page 107).

The dilute acid egg of the acid plant is arranged to discharge through a 1¼" lead pipe to the bottom of the interchanger. The interchanger is suspended vertically from the wall. The acid passes up through the inner passage and around through a 1½" x 2" lead pipe to the bottom connection of the outer passage passing up through this passage and out the top. A 1½" steam line is connected to the top connection of the central passage and a trap on the bottom connection.

From the top outlet of the interchanger the acid and steam passes through 1½" x 2" lead pipe and lead valve to a 6" I.D. x 20" deep lead centrifugal separator, from the bottom of which the separated acid runs through a 2" x 2½" lead pipe to the acid storage tank. The steam passes out through a 3 x 3½" vent pipe from the top. A small condensate tray is arranged under this vent to catch any condensed steam running back into the separator. The tray discharges through a ¼" lead pipe to the gutter.

Complete data from tests carried out in the concentration of sulphuric acid are given in Mr. Shaw's report.

REF. NO. 5. VENTURI GAS METER.

METHODS OF MEASUREMENT UNDER THE CONDITIONS—In conection with the interchanger system, a meter was required for he measurement of the feed to each battery of catalysers. This meter with the layout as installed had to be capable of measuring he hot preheated butyl alcohol, at a temperature of say 600-900° F. Only two methods were available of measuring the gas under these ircumstances, namely Pitot Tube and Venturi Meter. The decision was in favor of the latter because of possibility of leakage in conection with point of insertion of Pitot Tube in the pipe.

VENTURI TUBE—Special 1½" venturi tubes were made up of talyser bronze, with ½" throat, cast in a single piece.

For the measurement of the cold butylene in the butylene testg system, the chemist preferred a standard gas meter, as used municipal systems. It was found impossible, however, to obtain one of these of sufficient size so that a venturi meter was installed here also.

Pressure Measurement—The pressure differences of the venturi meters are indicated on special mercury manometers made up of gauge glasses between steel gland blocks. Water cannot be used because of mixing with the alcohol. The connections between meter and manometer are through iron pipe leads providing a catch cup on each lead for condensed butyl and a horizontal bypass between the leads so that when reading the manometer, the head of condensed butyl may be equalized on both legs of instrument and any excess liquid blown back into the throat ring. (See album, page 136).

REF. NO. 6. CATALYSERS.

The process for the conversion of normal butyl alcohol contains two important catalytic reactions. The first and third stages are entirely catalytic, while the second stage is a type of reaction familiar to chemists and offering no difficulties of a chemical nature. On the other hand, the catalytic reactions of the process possess several unique points, not the least of which is that the reactions, contrary to the general rule, are endothermic in both cases, with high endothermic heats and reaction temperatures.

Conditions to be Fulfilled—From an engineering point of view the design and production of a catalyser or catalyser tube or chamber to fulfil all the conditions imposed by the chemist was a difficult problem. When coupled with this one considers the very limited extent of the present knowledge of catalytic reactions, how they take place, the time required, the period of contact necessary between catalyst and substance, nature of surface required on catalyst to give best results, and so on, the difficult nature of the problem will be realized. The information possessed by the chemists and placed at the disposal of the engineers was limited and indefinite, and was subject to constant revision and correction, as further knowledge on the subject became available.

The principal conditions which were at first laid down to be fulfilled by the catalyser were briefly as follows:

1. Must be a gas-tight vessel at the temperature of the reactions, and remain so under repeated heating and cooling.

2. Must be capable of holding the necessary volume of catalyst in such a way as to permit the passage of gas through and in intimate contact with the catalyst.

3. Must be constructed of alloys containing no iron, zinc, lead or phosphorus. This restriction with regard to the last three was later removed. Iron was permitted later in third stage.

NOTE—In connection with these restrictions on the alloy, it is interesting to note that while the chemist at Toronto insisted on a copper alloy and would under no circumstances permit the use of iron in the first stage, in two government reports on the process received, the use of copper was condemned as resulting in a side catalytic reaction producing hydrogen, while iron was recommended.

4. Must be so constructed as to permit the ready and rapid removal of catalyst and replacement by new or fresh catalyst.

5. Must be of such a nature that the necessary endothermic heat can be supplied to the gas with the least possible temperature drop; or that is, temperature range of the gas must be as small as possible to prevent overheating.

6. Must be so heated that the temperature and rate of heat flow is at all times under direct and close control. Too high a temperature results in side reactions, poisoning of the catalyst, etc.

GENERAL CONSIDERATION OF CATALYSER PROBLEM—The ques- ion of the catalyser is one that has received a great deal of atten- ion and investigation.

Previous to the preparation of the first M.E.K. report of Sep- ember 15, 1917, a considerable amount of experimental work had een done on a small scale, and the question of the catalyser, upon hich depended the success or failure of the whole proposition, was haustively studied from every angle; and following the authorisa- on of the construction of the plant and the beginning of actual ilding operations, was considered further in the light of addi- onal information acquired as a result of tests or experiments.

There are many different angles from which the problem may regarded.

APPLICATION OF THE ENDOTHERMIC HEAT—From the point of w of supplying the heat for the reaction there are three possible thods of doing this, viz.:

(a) By direct application of heat to the catalyser or tube in which the catalyst is, and through which the fluid is flowing.

This is the commonest method of all, and in it the heat is supplied to the gas and catalyst practically at the instant at which the reaction takes place. This is the method employed at Toronto. Unless care is taken in the design of the catalysing tube this method involves, with non-conducting catalysts, a marked drop in temperature between wall of tube and catalyst farthest from wall, with resulting danger of overheating at the wall, causing side reactions.

(b) By heat carriage by the gas.

There is a certain maximum temperature beyond which the fluid undergoing the reaction may not be heated, and there is a certain range of temperature below this maximum where the reaction takes place but at varying rates, depending on variation of the temperature from that temperature at which the reaction proceeds best and most rapidly. This being the case, it is possible to heat the gas in some outside apparatus to this maximum temperature and force it into the catalysing chamber, where the reaction will proceed in contact with the catalyst using up the heat in the gas due to its temperature, until the temperature becomes lowered to such an extent that the reaction ceases. The gas must then be taken to another heating apparatus and its temperature raised, to be subsequently lowered again in the next catalysing chamber which the gas enters. This process is repeated until all the gas has been converted or until it becomes unprofitable to proceed further. The number of steps or stages necessary to complete the reaction is a function of the endothermic heat, the allowable maximum and minimum temperatures and the specific heat of the gas.

This method was just about to be tried on a large (50 gal. per hour) plant at Toronto when the plant was closed down.

(c) A combination of direct application of the heat and heat carriage by the gas.

This method appears to offer many advantages, and preparations were being made for a trial of the system in connection with the M.E.K. plant at Toronto. Tests were in fact being carried out on parts of the apparatus.

In this method, in addition to applying the heat directly to the walls or interior of the chamber in which the reaction is proceeding, the gas is heated by some means to a point at or near the maximum allowable temperature before it is admitted to the cat

ytic chamber. This method possesses the advantage, in connec-
ion with the reactions requiring a large amount of endothermic
eat, of reducing the quantity of heat that must pass through the
alls of the reaction chamber. This is important, because there
a very definite limit to the amount of heat that can be supplied
r forced through a metal wall without exceeding a safe working
mperature either of wall or the electric heating element, where
he latter is used (this was reached in the case of the Toronto in-
tallation) and the duty of a given catalyser is thereby limited,
lthough the volume of the catalyst may be sufficient for a much
igher rate of working, unless more heat can be supplied. The only
ay this can be overcome, once the heat absorbing limit of the
alls has been reached, is by delivering the heat to the gas itself
efore it is admitted to the catalyser.

It was proposed at Toronto to insert an electrical heating device
tween each pair of catalysers and to boost the temperature (pre-
at the gas) at these points, removing that amount of work from
e main heating elements.

SOURCE OF HEAT—From the point of view of source of heat,
ere are generally speaking four sources of heat usually available,
z.: coal, oil, gas and electricity.

Coal—The use of coal has the disadvantages of applying the
at, inconvenience, dirt, and difficulty of controlling temperatures
curately; which renders its use out of the question.

Oil or Gas—The use of oil and of gas are in many ways similar,
volving the use of some form of burner and combustion chamber,
m which the incandescent or burning gases are taken over the
ject to be heated. Gas heating was tried in the first small ex-
imental catalysers, but here again the difficulty of accurate con-
l rendered the experiment unsuccessful. It was planned to use
as the source of heat in connection with the system of catalysing
erred to above in which the heat is carried by the gas. But
e the system was so laid out that overheating was made impos-
e through inserting another heat carrying medium between the
e and the gas.

Electricity—Electricity was adopted in the original design
he M.E.K. Plant as the safest and most certain heating agent.

DISPOSITION OF THE CATALYST—The disposition or support of the catalyst is of great importance, and is closely linked up with other considerations, such as material of catalyser and provisio for heat distribution.

Catalyst Stationary—(a) The usual method is to fill a cylindrical vessel or chamber with the catalyst in some form permittin the passage of gas. The catalyst is thus stationary and "en masse." This is subject to the disadvantages that the catalyst in time work down and packs, throttling the flow of gas, with resultant overheating, and with non-conducting catalysts renders heat transmission to central portion of catalyst difficult without local overheatin at the walls.

(b) The latter difficulty may be overcome by running throug the large chamber in any direction tubes containing heating elements, or through which some heat carrying medium is flowin This method would secure a uniform distribution of heat, but i subject to constructional difficulties.

(c) The supporting of the catalyst on perforated trays in thi or thick layers, depending on the nature of the catalyst. This prevents jambing and packing. If the perforated trays are conducto and in good contact with the walls, good heat distribution secured. If in addition the shape of the chamber is annular so th heat may be supplied to both sides of a narrow annulus, this, together with the trays, secures a very uniform distribution of t heat.

Catalyst in Motion—While no information is available of results of tests in which the catalyst was in motion, proposals we made for the carrying out of the M.E.K. reactions with catalyst motion, but were abandoned as involving too great an expenditu of time in experiments before definite information could be secur

Two methods of attacking the problem had been proposed, vi

(a) Feeding the catalyst (where feasible) in finely powde form with the gas through a chamber or tube heated to the necessary temperature.

(b) The passing of the fluid through the catalysing cham in which the catalyst is kept in motion either by means of padd or by rotating the chamber.

Either of these methods involve the rapid reduction of the catalyst to powder, except in the case of metallic or hard catalysts;

even in the latter case results in the eventual rounding or smoothing of the surfaces, which is apparently detrimental to the reaction. On the other hand, these methods would tend to keep the catalyst at a more uniform temperature through constantly bringing fresh catalyst in contact with the hot walls of the chamber.

It is possible, also, to arrange such a system that the catalyst is poured in sheets from rotating shelves or blades, trapping a pocket of gas in each case to secure the necessary intimate contact between gas and catalyst.

MATERIAL TO BE EMPLOYED—From this point of view the construction of the catalyser is dependent on a number of other factors, which are, in the order of their importance:

(a) *Chemical Action*—The material of which the catalyser is constructed must be such that it will resist corrosion or attack by he fluids or substances which pass through it; and also must be uch that neither it nor its constituents will induce side reactions etrimental to the main reaction, either through chemical or cata- tic action.

(b) *Heat Conductivity and Absorption*—In endothermic reac- ons where the quantity of heat to be supplied is large, the material f which the catalyser is made must be a good conductor of heat in der that the requisite amount of heat may be forced through the alls. The finish of the surfaces of the catalyser which are ex- sed to the source of heat and which must receive the heat for ansmission through the walls is an important factor. Natural ugh cast surfaces are superior in this respect to machined sur- ces or rolled plate surfaces.

(c) *Freedom from Porosity*—In many cases it is difficult to anufacture a catalyser which is absolutely gas tight or water ht. Tightness is in many cases, as in this case, absolutely vital; d where dealing with gases of a penetrating nature and low den- y at high temperatures the problem of securing a gas tight cham- r is a difficult one.

(d) *Strength*—Although strength was not required in this re- ion (the pressures rarely exceeded 16 lbs. per sq. in.), when king under high pressures a material must be chosen which l be able to resist such pressures.

(e) *Production*—This aspect involves the question of securing the material, and also that of ease of manufacture. The question of whether the materials necessary can be readily obtained within the necessary time and in the required quantities is an important one, especially in war time. The ease or difficulty of manufacture, time necessary, labour required, percentage rejections through faulty workmanship or causes beyond control, are all factors of importance.

DEVELOPMENT OF TORONTO CATALYSER—*Early Experimental Catalysers*—In the original researches carried out by the chemist in the laboratory use was at first made of an ordinary laboratory gas tube furnace. This was later replaced by an electric tube furnace in which the catalyst was packed and the gas forced through. Various types of catalysers were tried in the first small experimental plant, using larger scale pieces of apparatus, but without success until finally, as a result of the investigations, an experimental catalyser was designed and constructed which embodied, so far a could then be determined, all the essentials of a successful catalyser and which in fact proved very successful. This is the predecesso of the present catalysers.

Experimental Catalyser—This catalyser consists primaril of an outer tube or casing of 2¾" O.D. x No. 12 gauge copper tubing 12¼" long, with cast 4¾" diameter flanges brazed to the en of it. The bottom end of this tube is covered with a cast flang and the upper end is fitted with cast head tapped for a ½" the mometer pocket and a ½" steel ring type joint stud outlet conne tion. A phosphor bronze tube 1 3/64" O.D. x ⅝" bore exten down inside this outer casing, and at the lower end has a flange head of sufficient size to just permit it to slide down inside th outer jacket. This flange is drilled with eight ¼" holes. T upper end of the central tube is threaded, extends through a hole the head casting, and is provided with a locknut and a steel ri type joint for the inlet.

The central tube carries a series of perforated No. 20 gau copper discs, just large enough to slip inside the outer jacket, a these discs are spaced by means of ½" sections of 2½" O.D. x N 12 gauge copper tubing.

In assembling, the trays and spacing rings are threaded on t central tube alternately, the trays being filled with catalyst as they are placed on the tube.

When all the trays are on, the head casting is slipped on and the nut tightened up. This compresses the trays and spacers rigidly together. The whole is then dropped into the outer jacket, the bottom of which has already been bolted on, and the head is bolted on and the connections made.

The catalyser was heated by means of nichrome wire, wrapped with asbestos cord and then wound in helical form around the outer tube of the catalyser, which was first wrapped with mica.

In operation, the gas enters the central tube at the top, passes down to the bottom, and returns up through holes drilled in flange f the central tube, through the trays and catalyst alternately, be-ng heated as it passes through the perforations in the tray. There was a certain short circuiting loss due to gas passing up between uter jacket and outside of trays and spacers, and this space also cted as an insulator against heat transfer from outer jacket to atalyst.

Large Catalyser, Preliminary Design—When the large lant was under consideration a design was prepared based on the bove experimental catalyser. Two sizes were drawn up, one a 2" and the other a 48" catalyser. These consisted principally of head and base casting of bronze containing the outlet and inlet assages, respectively. The former passage came off at 45°, the tter horizontally. Between these castings was brazed a cylinder f ⅛" sheet copper with an inside diameter of 18". This formed e outer casing, inside which a cast inner tube was inserted, hav-g an inside diameter of 10½" and outer of 11¼", with closed ttom and open upper end, the latter having a flange pairing with at of the head casting of outer jacket. Shrunk on the inner be were a number (17 in 48" tube and 25 in 72" tube) of cast ays, 3" apart, drilled with 236-½" holes. Thermometer pockets ere provided in inlet and outlet. It was proposed to use two bat-ries of two 48" tubes each in the first stage, and two batteries three 72" tubes each in the third stage for a 50 gal. per hour ant. The castings were to be a copper tin alloy, containing as gh a percentage of copper as possible.

Alternative Construction—An alternative construction was posed, providing for the casting of the trays and inner tube integrally, and the trays instead of being perforated or drilled (now impossible) were slotted with 32-5/16" x 2¾" and 32-5/16" x 1⅜" slots, with a milling cutter.

Heating System—The catalysers were to be heated by means of an inner heating element only, made up of several (separate) coils of resistance wire, wound spirally on a cage formed of studs carrying grooved insulating spools. The cage was provided with nichrome diaphragms acting as spacers and reducing convection currents, and the whole was enclosed in a nichrome cylinder, The heaters for the first stage catalysers were provided with three separate automatically controlled heating coils, in order to graduate the heat supply to suit the requirements. The automatic controls were of the Leeds and Northrup recorder-controller type.

After the authorization of the plant and the commencement of construction it was found difficult to get any firms to attempt the manufacture of the tubes, which necessitated a reconsideration of the design.

Design No. 2—The improved catalyser was nominally a 24" unit, and was similar in general outline, diameters, etc., to the previous design, but different in several respects, besides being reduced in length. (See album, page 128.)

The outer jacket was a single cast pot or bowl with the inlet and outlet connections, the latter now with flange at right angles to axis to permit of removing a unit from connections with the least derangement. The outlet still left the bore of the tube at 45° upward slant, which was to prevent catalyst dropping and getting into connection pipes when filling or emptying.

The inner tube was cast with trays integral, and the trays were now spaced 2" apart, a total of 13 in the working length (24") of the catalyser. The working length is considered as that portion containing catalyst and receiving heat from the elements.

The walls of both tubes were to be ½" thick, not machined in any way, except that the edges of the trays were to be bevelled off to prevent jambing of lumps of catalyst in withdrawing, and the necessary facing of flanges and tapping of core print holes for plugs. The trays were originally designed with the slots, but later a method was devised of drilling the holes and a few were made this way, but this in turn was soon abandoned in favour of coring the holes in the original mould.

Latest Improved Type—The latest improved type of atalyser as now being built differs from the one just described nly in minor details to facilitate casting and reduce porosity (See rawing A410). These points of difference are listed here without xplanation, the reason for the change being given elsewhere in onsidering the basis of design or the methods of manufacture.

(a) The flanges of both inner and outer castings are cast with raised grinding face from bolt holes inwards, which alone is achined and ground.

(b) The curvature of the top of the inner tube has been simpli-ied, and the centering shoulder eliminated. The side wall of the atalyser now curves uniformly and thickens gradually to the ange.

(c) The feet are now thin, provided with a stiffening web, and he back of the feet is cored out.

(d) The outlet has been lowered slightly and brought away rom the upper flange, while still maintaining the same centre to entre distances of flanges.

(e) The thermometer pocket bosses have been lightened and oved away from flanges. That in the lower is run in on a slant o clear the insulation.

(f) The core print hole in the inner tube is eliminated.

(g) A recess is cast around the outlet opening into which is tted a perforated screen of 16 gauge copper.

Separate Connections Type—Another type of outer cast-g was also designed, but after a few had been tried was aban-oned. It differed in that the inlet and outlet connections were cast parately, machined, and screwed and brazed into bosses on the ter shell. The outlet was reduced to 2" diameter and was pro-ded with a copper wire screen held in a recess by means of a nut ng. The catalyser was abandoned for the following reasons:

(a) The casting was no easier to mould, involved more work oulding the three castings, and required a great deal more ma-ine work. The separate connections were screwed and brazed , but it was found impossible to secure a tight braze without aning.

(b) The screens, placed as they were, would catch catalyst dur-g withdrawal of inner tube and jamb.

(c) The thermometer pocket provided insufficient room for the insertion of the automatic control tube, which requires a 1" x 4" space.

Basis of Design—The design of the Toronto catalyser was based on the following considerations:—

Form—The cylindrical form was adopted because such a form permits of the simplest machining operations, while the patterns and cores are more easily made.

Connections—The inlet at bottom and outlet at top were used so that the flow of the gas upward would have a tendency to lift the catalyst, preventing packing on shutting off of gas flow, and dropping of loose small particles to bottom.

Annular—The annular construction was employed owing to the heating requirements. With this form heat can be supplied from two sides of a comparatively narrow annulus, so that the greatest distance of heat travel from either wall is only 1½".

Trays—The horizontal, perforated tray was cast integrally with the inner tube. The trays necessarily had to be horizontal in order to perform their primary function of supporting the catalyst. This is one of the distinguishing features of this catalyser, the carrying of the catalyst in thin layers in a vertical tube, preventing settling, jambing, and securing a more even flow of gas through the mass of the catalyst.

Perforated Trays—The trays were made perforated so that while supporting the catalyst they would at the same time permit the free passage of the gas through them into the catalyst mass. The holes in a sense assisted in the uniform distribution of the gas flow through the catalyst. Another important reason for the perforated trays is touched on under Heat Conduction.

Cast Integral—The decision was arrived at to cast the trays integrally after a great many other forms of constructio had been proposed and rejected for reasons given in the next section.

Heat Conduction—The other principal reasons for the us of trays, besides their use as supports for catalyst, was to provid a means of distributing or getting the heat into the reaction spac into the catalyst and into the gas. This necessitated contact b tween the heating walls and the trays to secure effective heat transfer. Trays riveted to the inner tube were rejected on account of the necessity of making holes through the tube and the danger of leaks. Trays shrunk on the inner tube were rejected because of the loosening effect of the repeated heatings and cooling to which the tube and trays would be subjected. Trays threaded or screwed on were rejected for a reason that led to the rejection of all trays made separately, viz.: the lack of perfect contact between tube and tray and resulting loss of heat conductivity.

With trays cast integrally with the inner tube there is a perfect bond or connection between tube and tray, and the heat received by radiation by the cylindrical walls is transmitted by conduction to the trays and through the trays to their tips. The trays act similarly to the radiating or cooling fins on an air-cooled gas engine cylinder. The holes or slots in the trays through which the gas passes assist materially in the transfer of heat to the gas by providing more surface of contact between gas and tray. The gas in passing through the holes, which are essentially short tubes, or through the slots wipes off a certain amount of heat from the walls. In addition, the entire under side of the plate is free for gas contact, the catalyst resting only on the upper side.

Feet—The placing of the feet of the catalyser at the bottom under the vertical walls was done in order to carry the weight where it could best be resisted. Projecting brackets, either at the bottom or up the side, were not used because of bending tendency under the high operating temperature, while any position except the top and bottom would interfere with the heating elements. Placing the feet directly under the vertical wall brings the weight into the supporting feet with the minimum overhang. Suspension of the catalyser was given up because of interference with flange joint and with filling and emptying operations.

Bell Mouth—The form of inner tube flaring over and out at the top to form a flange, pairing with the flange of the outer casting, was adopted in order that the closing of the catalyser could be carried out with the making of a single joint, at the same time leaving the inner pocket of the inner tube quite clear for the insertion of the inner heater, and having no inward projection on outer casting to prevent insertion of the inner tube with its trays. The flaring or bell-shaped top was adopted to give a smooth running casting and to make suspension of tube and trays from flange joint less liable to result in distortion.

Filling and Emptying—The trays were so arranged on the inner tube that filling and emptying of the catalyser could be carried on by lowering the inner tube into the outer until the bottom tray was just below the flange of the outer casting. The space between this tray and the next was then filled with catalyst by hand and the tube lowered until the next tray was similarly placed, when the process was again repeated. On lowering the tube the catalyst packed between the trays scrapes down the inside of outer casting and there remains no dead space through which gas may circulate without being in contact with catalyst, as would be the case if a metal cylinder surrounded the trays on the outside. Packing a number of separate chambers assisted in the securing of a more uniform distribution of gas flow throughout the catalyser.

Prevention of Jambing—The edges of the trays were bevelled off to prevent the catalyst jambing between edge of tray and outer tube, which would happen if edges were parallel to bore. With the bevelled edge this is unlikely, as the sharp edge either relieves itself at once or breaks the lump of catalyst.

Form and Size of Connections—The form of gas inlet and outlet was fixed by a number of considerations. The length was governed by the probable thickness of heating element and lagging. The flattening out to an oval shape of the bottom inlet was to reduce vertical height occupied by inlet. The taking off of the outlet at 45° upward and the use of oval form was to prevent catalyst in lowering or raising inner tube from falling into the outlet and so passing into the inter-connecting piping.

Thermometer pockets were provided for the insertion of ordinary chemical thermometers (more accurate than others). The pockets were placed in inlet and outlet because more accurate readings of gas temperatures are likely there, and they were so placed in the inlet and outlet as to clear outside heaters and insulation. They were also of such size and so placed as to take the tube of the automatic electric heating controls when installed.

The diameter of the inlet and outlet connections was determined by the flow of gas to be passed, which primarily was taken as the flow of gas from the whole rated capacity of plant (150 gals. per hour) which was to be passed through a single battery of catalysers. When the decision was made to use a number of parallel batteries the patterns and some castings had already been made, and no alteration was therefore made in the size.

Size—The size of bore of inner tube was fixed upon to permit of the insertion of an electrical heating element with a reasonable heating power. This, and the width of annulus thought advisable in order that heat would have to travel only a short distance, determined the diameter of the outer casting. The depth of the catalyser was fixed by considering the question of manufacture and operation. It was considered that the length decided upon made the casting about as large as could be reasonably expected to be produced satisfactorily. It was also felt that a longer inner tube would give considerable difficulty when withdrawing for recharging. The spacing of the trays was decided upon in order to give a reasonable depth of catalyst on each tray, while putting the trays as close together as possible, to facilitate delivery of heat into the gas. The spacing was at first set at 3", but before any castings were made this was reduced to 2" to improve the heat delivery.

It will be seen from the above that the catalyser size was based solely on questions of manufacture and not to do a certain amount of work. The latter could not be done as the information available relative to endothermic heats, specific heats, etc., was inadequate and the results from the small experimental catalyser not sufficient. The catalyser was therefore designed for best construction and the duty left to be whatever could be obtained.

MANUFACTURE.

MODIFICATIONS IN DESIGN TO FACILITATE CASTING—Most of the catalysers produced were moulded in a box split on the centre line, and poured in vertical position with flange at top. Inner tubes thus cast were very often spongy around the upper flange. Increasing the height of head cast on the catalyser seemed to improve things but little. It was thought that possibly the thick spots in the metal were causing the porosity and the design was carefully revised, eliminating all thick spots. Thus the bell mouth of the inner tube was simplified in form and given a smooth curve gradually increasing in thickness to flange, and eliminating the shoulder; the thermometer pockets were moved away from the connection-flanges, the outlet connection was dropped slightly from upper flange to allow of elimination of mass of metal there, and the feet were made lighter, and in addition dents or pockets were made in the inside, slightly into the feet, further to eliminate thick spots. Some catalysers were later cast with practically no flange at all; owing to difficulty with the flange porosity. A special packing ring was to have been used with these, but difficulties arose with the bolting down system which rendered its use unwise.

Owing to the strain put on the bolts in tightening up the flange joints by inexperienced operators when trying to close up a leaking joint, many of the flanges of the first catalysers were permanently distorted. To overcome this use was made of a heavy cast iron reinforcing ring on top of the faced back of the inner tube flange. This, while preventing distortion of the flange, caused leaks due to the skin having been removed from the back of the flange.

In order to necessitate as little machining as possible of the flanges to make the joint (since apparently the removal of the skin of the casting opens the inside porous metal under the outer close texture skin) a narrow raised facing strip was cast on the flanges, while the flanges themselves were thickened, resulting in an improvement in the catalysers and their tightness.

The facing strip only was faced off, and the strip of the two flanges ground, first separately, using a cast iron ring, then together until the faces were absolutely smooth, practically polished and showed no porosity whatever. The joint was then made o a soft copper wire gasket between these ground faces.

CASTING, ORIGINAL METHOD—Most of the catalysers hav been moulded in a box split on the centre line of the catalysers with the baked cores forming the trays dropped into place in th moulds. This method is subject to two defects: first, owing to th 140 sand projections for coring the holes, it is difficult to get a these to touch the flat surface of the adjacent core, and in man cases a sheet of metal is cast at one end of the cored holes in th tray. This may be broken through, using a drift with a bevelle face, but in many cases results in broken trays. Secondly, it i difficult to secure a perfectly circular casting, owing to the saggin of the cores, and also to difficulty of getting two halves of co properly spaced. The inside of the inner tubes in some of the first castings had to be reamed out with a large rose reamer to accommodate the heating element due to this sagging of the core.

The cores for the inside of the inner and outer castings are made up as light as possible to carry off the gases. That for the inside of the inner tube is built up on four 3" diameter by ⅛" thick steel tubes, perforated to vent the gas. The cores forming the trays are made up with a surface of rough silica sand, which, while giving a rounder casting results in trouble with tools used to clear the cored holes.

The casting is run vertically with flange at top, and every tray is gated, but not the bottom of the casting, and a good head of metal is cast on top to ensure proper pressure and to get rid of bad metal.

Castings made in this way were usually porous around the upper flange, and occasionally where trays left the body of the inner casting. Little trouble was experienced with the outer casting.

IMPROVED METHOD OF CASTING—The new and successful method of casting is to cast the tube entirely in baked moulds and cores (See album, pages 125, 126 and 127). The inner tube is cast in a three-part box, and is moulded vertically with the large flange at the bottom. The lower part of the box contains the baked mould or core for the flange and bell-shaped portion, the middle section contains the cores forming the trays. Each of these cores is in one piece, making up the full circle, and the 140 hole cores rest on the flat surface of the core beneath, practically eliminating the kin of metal and ensuring a perfectly circular casting. The upper ection of the box contains the baked mould for the dished bottom f the casting, which in the case of the inner contains no core rint hole.

In casting, not only every tray is gated, but the large flange at he bottom, obtaining a more uniform filling up of the mould. A rge head is cast on top, as usual.

This method of casting, together with the improvements in the sign already referred to, and a new alloy, has resulted in the production of excellent castings, sound as a bell and free from all rosity.

MATERIAL—LIMITATIONS DUE TO CONDITIONS—The range of aterial from which the catalysers could be constructed was limited by the many conditions laid down by the chemist, and the operating requirements. The material was required to contain no iron, lead, zinc or phosphorus, to be a good heat conductor, absolutely non-porous under repeated heatings and coolings and at a dull red heat and 15 lbs. pressure, and to be capable of withstanding a working temperature of 1,000° continuously for long periods. Because of difficulty of determining tightness at 1,000° F. it was decided that the castings should be subjected to an air pressure of 80 lbs. per sq. in. submerged in water. The conditions eliminated the use of cast iron, brass, phosphor bronze and aluminum, while the building up of a catalyser out of sheet copper was felt to offer too many risks of leaks or failure through faulty riveting or destruction of brazing. The field was thus narrowed down to castings of copper-tin bronze, and a bronze was specified containing as high a percentage of copper as possible, which appeared to be a 90.10 copper tin alloy.

PRELIMINARY TESTS—Before proceeding with the casting of th full-sized catalyser, two manufacturers submitted small sampl pots, 2" I.D. x 12" long, flanged at one end, closed at the other These were placed for testing inside an electrical heating element closed with a flange fitted with a thermometer, and connected t the compressed air line. They were first tested for porosity unde a pressure of 80 lbs. per sq. in. submerged, and were then heate to a temperature of 1,000° F. when sealed, bringing pressure insid up to about 240 lbs. per sq. in., and held at this temperature for a long as gaskets would hold, or ten minutes in the best case. The were then cooled and again subjected to the air test to see ho they were likely to stand up under the high temperature.

One manufacturer submitted pots of two different alloys, on 90.10 copper, and the other a Boron copper alloy, while the secon manufacturer prepared a 90.10 alloy sample only. The Boron co per pot proved decidedly porous, although the addition of Bor was said to make a dense casting. As a result of these tests 90.1 copper tin bronze was decided upon as the material for the catal ers. It was found practically impossible to secure non-porous cas ings with this alloy. The addition of 0.25% of phosphorous, intr duced in the form of phosphor copper, resulting in a final phosph content in the casting of 0.15 to 0.20%, reduced the porosity co siderably but not completely, and continued rejections of castin owing to porosity led to the undertaking of a research into the alloy question.

Alloys Research—Seven different alloys were tested, and in five of them seven test bars were tested of each alloy. The test bars were heated in an electrical furnace to various temperatures (indicated by both thermometers and pyrometers) and tensile strength tests made at these temperatures. The highest temperature was 1,000° F. or a dull red heat, which was assumed to be the highest temperature reached by the catalyser under operating conditions, and at this temperature three samples were tested as checks on each other.

The elongation was also taken in each test, and the fracture examined and studied under the microscope.

The results of the tensile strength and elongation tests are plotted on the accompanying sheet, and the compositions given. From these curves will be noticed the great reduction in strength and elasticity at the high temperatures. The crystalline formation and structure of the fracture was also found to undergo marked changes as the temperature rose. (See album, page 163).

From a careful consideration of the curves and the microscopic examination of the fractures, the No. 5 alloy 87 copper 10 tin 3 ead was recommended, and has been used with great success. he only modification was the introduction of a small percentage f phosphorus in the form of phosphor copper. This alloy is strong nd dense, giving a fracture very like steel, and flows readily, which s important for a casting of this form.

After the removal of the restriction against cast iron for the hird stage, a cast iron catalyser was ordered of the same design s bronze, but delivery was not made until after the closing down f the plant.

Machining—The machining on the catalysers has been reduced a minimum, as it has been proved that the removal of the outde skin of the casting uncovers the inner more porous metal and ads to leaks. The machining now consists of facing the grinding rip of each casting in a lathe, boring and tapping out the core int hole, where it exists, facing off connection flanges of outer, turning edges of trays of inner, and drilling the bolt holes. The re print plug is then screwed and brazed in. The two main nges are ground in separately, first using a cast iron ring, after which the two faces are carefully ground in together until all traces of porosity disappear, if any existed, and the faces assume a smooth finish, almost a polish.

The screen for the outlet is made up of 16 gauge sheet copper held in place in the recess provided for it by two small flat head screws tapped into the catalyser wall.

POROSITY—The large number of porous castings produced necessitated some endeavour being made to salvage these rejected castings. Various methods were tried of correcting the porosity, with varying degrees of success.

(a) Copper plating—The porous upper flange was machined all over, pickled and given a thick coating of copper plate deposited at a slow rate. The plating cracked off under heating and cooling.

(b) Tinning—The surfaces are thoroughly cleaned with acid and heavily tinned with a 50.50 tin lead solder, which is afterwards burned into the surface by gas flame, protecting the tin from the air by means of a coating of clay. This at first fills the holes, but the tin gradually burns out.

(c) Peaning—Where scattered pinholes occurs, these may be closed up by careful peaning. The hole is encircled with taps, gradually working into the hole itself, in order to force the metal into the hole.

(d) Where odd large holes occur, as in flange face, these may be drilled and tapped, and a plug inserted, afterwards refinishing in order to give gasket a smooth face to lie on.

(e) Silicate of soda is forced into the pores so as to pass through the castings and show on the outside. The casting is then exposed to the air on both sides and allowed to air dry for several hours; then gently heated so as to completely dry.

Where porosity occurs in the faced flange only soft gaskets of sheet asbestos, soaked in shellac and dipped in graphite, may be applied, but these have been found to dry out rapidly and shrink leaving joint open.

ESTIMATE OF PROBABLE DUTY OF CATALYSERS—In designing the large scale catalysers it will be apparent from the preceding that no attempt was made to design a catalyser to give a definite duty. Rather the catalyser was designed of such form and size as to permit of its being constructed with reasonable chance of success and at a fair cost, and the capacity of plant required secured by poviding a sufficient number of catalysers.

PERFORMANCE OF EXPERIMENTAL CATALYSERS—The performance of the catalysers was estimated on a basis of known test results from the small experimental catalyser. The small catalyser on the first stage had a 152 hour run, producing 30 gals. with a conversion of 98% or at the rate of .19 g.p.h., approximately 1/5. Running on the third stage, during a 90 hour run, 21 gals. with 64% conversion resulted, giving a yield of about .15 g.p.h., or approximately 1/6 or 1/7. In these tests, however, leakage losses were excessive, and more probably the figures for first and third stage duties of the small catalysers should be taken at ½ and 1/5 g.p.h. respectively.

There are two bases upon which the probable duty or production of the full-sized catalysers may be estimated from the above experimental results; one is a catalyst volume basis, and the other heat-receiving basis.

ESTIMATE ON VOLUME BASIS—The volume of the three small atalysers in series is 111 cu. inches, and the volume of catalyst the large catalyser is 3,390 cu. inches, so that the pro rata duty f the large catalyser in first stage should be 15 gals. per hour, and third stage 6 gals. per hour.

HEAT RECEIVING BASIS—The heat-receiving area in the experimental catalyser is 97.2 sq. ins., or a total of 292 sq. ins. for three series, while the heat-receiving area of the full-sized catalyser 2,263 cu. ins.; so that the large catalysers should, on this basis, able to take care of 4 g.p.h. on first stage, and 1½ g.p.h. on third ge operation. It should be remembered, however, that the heatg system in the small catalyser was very crude. The wire was und on mica, an excellent electrical insulator but a splendid heat ulator as well, through which the heat had to pass, be absorbed a smooth rolled plate surface, a very poor heat absorber, and diate from the same surface across an air gap between outer tube spacers before reaching the catalyst. In addition, in the eximental plant the catalysers did the preheating. Under the cirnstances, an estimate on the heat receiving area basis is of little ue and probably explains the great difference in estimate obned on this basis and on the volume basis.

Estimated Number—Hence it was estimated that from 16 to 17 first stage, and 42 third stage catalysers might be required for the 250 g.p.h. plant, with the probabilities all favouring a smaller figure owing to improved construction and heat transfer conditions. This would mean six first stage batteries of three catalysers each, and fourteen third stage batteries.

Arrangements of Catalysers—The catalysers arranged in batteries of three in series have handled a maximum of 35 g.p.h. per battery with 80% conversion on first stage, and 25 g.p.h. with 36-86% conversion on third stage, meaning that 7-8 first stage batteries and 10 third stage are evidently required. However, this arrangement of three catalysers in series has been shown to result in the third catalyser doing practically no work, so that a rearrangement of the catalysers in the batteries in such a way that probably two are in parallel followed by two in series in each battery, one-half the gas passing through each of the first two catalysers and then all of the gas through the succeeding two, accompanied with higher preheating and probably heating between catalysers, may reduce this number still further.

REF. NO. 7. BUTYLENE LIQUIFICATION.

Problem—An examination of the butylene vapor pressure curve plotted from data supplied by the Chemical Department indicates that butylene can only be liquified at ordinary temperature by compression, and that to liquify by cooling alone would require a temperature below 32° F. or freezing. In view of these facts was decided to liquify the butylene by compression with a certain amount of cooling.

Production and Capacity Necessary—The production butylene is 6 lbs. per 8 lbs. of butyl alcohol fed at 100% conversion and at 60° F. and 15 lbs. of butylene has a volume of 6.74 c.f. per lb. (on a basis of 6.38 c.f. at N.P.T.=1 lb.) which means that practically 10,000 cf, hr. have to be dealt with or 168 c.f. min. by the compressor. Further, the compressor must be capable of dealing with possible condensation of the butylene in the cylinder.

An ammonia compressor was decided upon as being best suited for the purpose, and two belt driven 9 x 9 single acting compressors were ordered for the work. These at 100% volumetric efficiency could deal with the 160 c.f.m. at 120 r.p.m.

COMPRESSORS—The compressors are of the vertical, totally enclosed, self-contained type. The piston is of the double trunk pattern in which the suction gas enters through ports between upper nd lower sections, and passes through suction valve in ead of piston into cylinder. The discharge valve is in the safety ead of the cylinder which protects the machine in case of liquifaction.

The compressors are installed direct connected to two vertical team engines as previously described. (See Drawing A287).

The butylene is compressed to 60 lbs. pressure in the compresor, and is delivered through a vertical pipe into the top of a oler (interchanger) where the heat of compression is removed, nd the butylene liquified by cooling water. The liquid butylene rops into the liquid butylene storage tanks, where it is stored nder pressure.

EF. NO. 8. PIPING SYSTEMS.

VALVES—There are a number of different types of valves emoyed for various services in the M.E.K. plant and the providing valves suitable for the services of widely different natures contuted quite a problem. These services may be briefly outlined as lows:

CATALYSER SYSTEM—Control of feed lines to catalysers and inchangers, comprising all valves in system from the R.N.B. tank the butylene tanks, and in third stage from R.S.B. tank to crude E.K. This service requires a valve capable of remaining tight easily adjustable at high temperatures, coupled with absolute tness against penetrating liquids and gases such as butylene hydrogen, which are also explosive. The seats of the valve t be of a material not acted upon by the various liquids of the ess.

During the experimental working of the small plant, different s of plug cock were tried without success. It was found quite ssible to make or keep a plug cock absolutely tight under the itions existing in the small plant. This fact was also demonstrated from a bacteriological standpoint in the Fermentation Department. From the working of the small plant the conclusion had been drawn that the only practicable valve was one with a metal to metal contact, and hence when the construction of the large plant was started, this type of valve was installed.

REGRINDING VALVE—A standard regrinding valve was fixed upon but it was found impossible to secure them in the size wanted with flanges. Screwed valves were therefore bought and flanges screwed and brazed to them while patterns, etc., were being made for the manufacture of flanged valves.

These valves have been extensively used throughout the plant and have given complete satisfaction.

BUTYLENE TANKS—The builders supplied the butylene tanks initially with gauge fittings and valves of brass, tinned inside The valves were of the cone, metal to metal seat type, but being tinned after grinding to a seat, globules of tin and irregularities o the surface were introduced sufficient to allow the penetratin butylene to escape. These have now been replaced with standar metal seated (iron) ammonia valves which have quite overcome th trouble.

ACID VALVES—Acid resistant valves of several types have bee used throughout the plant.

Plug Gate Type—The builders of the acid equipment suppli with their installation lead lined valves of the plug gate (P.G type (see album, page 161 right hand), that is, the valve is in th form of a frustrum of a cone which drops into a similarly shap recess. The gate instead of being of flat disk form is conical. T valve is of cast iron lined with lead. Difficulty was experienc with the valve due first to sediment settling in the gate pocket p venting proper closing of gate, and further the plugs after bei closed a few times became too loose a fit to prevent leakage, t bottom of the valve resting on bottom of plug recess before va was properly closed.

Angle Seat Type—A second type of valve, the angle s (A.S.) newly put on the market was then tried. (See album, p

161 centre). This valve is of lead, except handwheel, yoke, etc., and the body is divided at 45° by a flange joint between which is inserted a reversible lead seat disk. The valve spindle is at right angles to the seat and is heavily covered with lead and carries a conical valve having line contact on the sharp edge of the seat. The valve operates a great deal more easily than former valve, is absolutely acid proof and possesses the added advantage that it may be employed as a straightway valve or angle valve. The valve however, is not made with standard flanges rendering placing in existing lines difficult, and while the seat is renewable, the valve speedily wears a groove in its surface since there is no device to restrain valve from twisting. Further, the valve is so arranged that the handwheel touches the yoke just as valve touches seat, and slightest wear, etc., results in a leaky valve.

Globe Type—The most recently tried type of valve, some f which were in process of installation when plant was closed down, s in effect a lead globe valve (see album, page 161, left hand). The body of the valve is a lead casting similar to a flanged globe alve, the valve is conical in form operated through gland and rising pindle provided with indicator and handled wheel. The spindle is ivided into two halves, one lead covered from valve itself and the ther brass, threaded and carrying wheel, the two halves being inted by the recessed indicator. The packing thus holds the valve d prevents it turning. The contact between valve and seat is er a conical surface. No extended trial of these valves had been ade up to closing down of plant.

Plug and Seat—In the acid concentrating plant, anti- onial lead plugs and seats are largely used for controlling empty- g lines of tanks, troughs, etc. The sizes used are 2, 2½ and 4". e cone of the plug has a 28° angle, and a depth of from 2¾" to . The plugs are cast around a ¾" rod with nut threaded and etted on one end, a length of lead tubing being afterwards burn- around the rod. The seat is shaped to fit around the plug, which ground into the seat, and is provided with a flange for burning the lead lining of the trough or tank. Both plugs and seats are t of 5% antimonial lead.

In use these showed marked signs of sulphating within a month h the 60° Be acid, resulting in leakage due to sulphate cracking . After scraping off the sulphate the plug was readily ground in again to a tight fit. The leakage caused was not sufficiently serious to make trouble.

Duriron Plug Cocks—Plug cocks of duriron have been installed at one or two points in the acid system but because of their brittleness and the care necessary in connecting them and in operating them, they have not been extensively used. The cocks are of standard plug cock type, standard flange sizes but in the smaller sizes slots are provided instead of bolt holes. The flanges are provided with a raised ground face around opening for making the joint on.

Asbestos Packed Plug Cocks—In odd cases where a valve was urgently required and none available for acid work, standard asbestos packed iron plug cocks have been used on the concentrated acid lines. These cocks are of standard type flanged body, plug inserted from top with no bottom opening and a bolted on gland surrounding the stem of the plug. The gland is packed with asbestos and the cock is of cast iron throughout. One of these has been in use on the drain of the concentrated acid tank continuously for six months with no signs of leakage.

PIPE—The piping employed in the plant has been mostly standard wrought iron pipe except where nature of liquid or gas to be carried necessitated the use of another metal. For acid lines the W.I. pipe was lead lined and for first stage piping from R.N.B. feed tank to storage for liquid butylene, the chemist insisted on copper or bronze being used.

Iron—With the W.I. pipe screwed cast iron or malleabl iron fittings have been largely used, and where an extra degree o tightness was required, or for convenience in erecting or takin down, flanged joints and fittings have been to some extent used.

Copper—For the copper piping flanged, joints have bee almost exclusively used. Flange joints only have been used f the high temperature piping in connection with the catalyse employing bronze flanges, brazed to the tubing. The piping insta ed has been mostly 1½" x No. 16 gauge copper tubing, with 1½ iron pipe size copper tubing used in some places during experime tal work.

Expansion Joints—For the high temperature catalyser and interchanger piping, expansion and contraction was provided for with either regular expansion bonds or offsets. In the case of the vertical outlet line from catalysers to interchangers, it was thought expansion would be taken care of by the freedom of the connection above to the interchanging system. This proved incorrect, however, as the bend at connection to the catalyser eventually cracked and was replaced by a ram's horn expansion bend.

Fittings for the copper piping in the majority of cases have been made up of copper tubing. A limited number of cast bronze tees have been used.

Lead—For acid carriage other than concentrated acid (above 60° Be) lead or lead lined piping is used. Ordinary iron pipe fails within a month, the point of failure being the threads. In temporary work the lead tubing alone was used, but for permanent installations lead lined W.I. pipe was used. This was made up on the premises by drawing lead tubing of the size required through W.I. pipe of the nearest size to the O.D. of the lead tubing. The ends of the W.I. pipe carry screwed flanges and the lead lining is expanded nd peaned over the faces of the flanges.

Fittings on permanent piping is of the standard lead lined, cast ron flanged type. The lead lining is bonded to the cast iron and s spread over a portion of the flange face on which the joint is ade. For temporary work, or where cast iron lined fittings were ot available, fittings such as elbows or tees are made up of lead bing, with cast iron flanges loosely slipped over the ends and the ad peaned over.

Gaskets, Copper—A great deal of difficulty has been ex- ienced in securing a gasket that would stand up against the vere service in the high temperature piping in connection with e first stage catalysers and interchanging system. Several types ve been tried (see album, page 162), including a corrugated sheet pper gasket (centre of photo) a corrugated sheet copper gasket th asbestos cord inserts (left hand side of photo), asbestos sheet d asbestos sheet dipped in shellac and graphite. None of these, wever, proved entirely satisfactory and after a great deal of ex- imenting a gasket made of copper wire (No. 8 or smaller) zed into a ring and annealed was fixed upon as being the best and has proved successful in practice (right hand side of photo). A full account of the gasket problem is given in the section of the report dealing with the catalyser operation.

Gaskets, Lead—In connection with acid lines or apparatus lead gaskets are used exclusively. The gaskets are made up of either 3/8" or 1/4" lead wire, or 3/8" tubing burned into a ring slightly smaller than the bolt circle. The gasket is bolted between the two peaned over ends of the lead lining of the pipe or fitting. Initially the joints were made on the peaned over lead lining only but joints thus made proved unsatisfactory in practice.

In some few cases, for low temperatures lead gaskets either cut from sheet lead or as above have been employed on the copper pipe lines also.

REF. NO. 9. ACID HANDLING EQUIPMENT.

PUMP PROPOSED—The original layout of the acid equipment for the second stage called for a duriron belt driven reciprocating pump to elevate the acid from the dilute acid storage to the feed or measuring tank. Doubts were entertained by the Chemical Department as to the durability of the duriron under the conditions of working and objections raised to any traces of iron getting into the acid. On this account the question was reconsidered and a lead centrifugal pump supplied. In the meantime, however, compressed air had been used to force acid up, as well as to force acid from concentrated acid tank in acid plant into diluting tank, and worked so satisfactorily that the pump was not used.

COMPRESSED AIR—The compressed air piping for elevating the acid is arranged in each case with the control valve near the tank into which the acid is delivered, so that the gauge glass can be watched and the tank not flooded. On the tank side of the control valve is located a vent, relief valve set for the maximum safe pressure the tank is good for, and a pressure gauge. These enable the operator to see at all times what pressure he has in the tank, protect the tank from bursting through too great a pressure, and to relieve the pressure as soon as the charge has been sent up (see right hand side of album page 148).

ACID EGGS—In the acid concentrating plant, acid eggs are used for elevating the acid, using compressed air on a similar plan (see Acid Plant). Due to the fact that the acid likely to be handled by the eggs was dilute and hot, the usual 8 lb. lead lining of the eggs was replaced by 16 lb. lead. The hot acid tends to make the lead creep and the heavier lining was therefore put in.

Air pressure is also used for emptying the tank cars of sulphuric acid delivered to the plant.

REF. NO. 10. LEAD STILL.

DIFFICULTIES OF PROBLEM—The design and construction of the lead still for the hydrolysing distillation of the butyl hydrogen sulphate in the second stage, capable of handling the full quantities for the 250 g.p.h. plant, was a new departure in chemical engineering and one about which little was known, and about which little data was furnished by the Chemical Department. The chemical manufacturers who designed and built the still pointed this out as follows:—

"The lead lined still has been designed by us to comply with your requirements so far as we can ascertain them, but you will realise that your own information as regards large scale operation is somewhat indefinite and that the problem is a peculiar one. It is obvious therefore that we cannot assume responsibility for the exact capa- ity or operation, although we will co-operate with you in every re- pect to make the operation as successful as possible, and if any odifications are required to make them promptly at reasonable xpense."

The actual operation of the lead still brought out several difficul- es and lead to a number of alterations and improvements being ade. These were as follows:—

FEEDING ARRANGEMENTS—The 500 gals. per hr. of butyl ydrogen sulphate at full rated capacity of the plant (250 gals. tylene plus 250 gals. 75% sulphuric acid) are diluted with 1,100 ls. of water before entering the column of the lead still. The di- ting device for mixing the B.H.S and water preparatory to ding into the still was left in the hands of the British Acetones r design, and was laid out as already described. In addition to e diluting device some means of measuring and indicating the rate of flow of both B.H.S. and water to the device and of keeping a constant head on both was necessary. A constant head could not be maintained on the B.H.S. tank due to the charges from the sulphator coming up at intervals, while the outflow is constant. Constant level tanks were therefore decided upon, containing float valves or means of controlling rate of inflow, a measuring device and observation windows (see album, page 145).

Control of Flow—For controlling the inflow several methods were discussed:—

1. Using a duriron plug cock, operated by hydraulic pressure through a float controlled pilot valve. This was abandoned after designing due to its complicated nature.

2. Using a duriron float valve of globe type, having a large pitch threaded spindle, opening valve in fraction of a revolution and operated by the float. This had to be abandoned due to impossibility of obtaining the valve.

3. Using a lead float valve. Delays in securing delivery of valve necessitated rejection of this plan.

4. Design lead float valve and have it made up locally. This was done resulting in the arrangement already described, which has worked well.

Feed Measurement—The measurement of the flow of the B.H.S. also resulted in a number of proposals, including:—

1. Lead tester similar to testers of stills. It was found impossible to secure one large enough.

2. Lead venturi meter. This while accurate proved difficult to incorporate in proposed arrangements.

3. V notch of lead. This offered the most advantages, indicating a wide range of flows accurately, being easily and cheaply made and readily incorporated in the constant level tanks.

This was installed as previously described.

The installation of the constant level tank and diluting device between the B.H.S. storage tank and lead still inlet necessitated the raising of the B.H.S. tank as far as possible (18") to secure sufficient head to operate at all. The difficulty of operation encountered with the still and described later were at one time considered due to lack of feed head, and it was proposed to instal a lead centrifugal pump on the feed line to secure a greater margin of pressure.

DILUTING DEVICE—The diluting device gave some trouble due to impinging of jets of water and B.H.S. head on and one backing up the other, and further due to lack of a vent, to relieve the device of gases (sulphur dioxide, butylene, di-butylene, etc.), released during the diluting. To overcome these difficulties, a length of 6" lead lined W.I. pipe sufficiently long to extend above level of liquid in constant level feed tanks, was bolted to the top of the device to provide a space for the gases to accumulate, and from the top of this a 2" water jacketted vent was carried to condense and return the condensable portions of the vapors escaping. The vent was of lead pipe, with lead pipe jacket, about 4 ft. long fed by ½" water pipe and above this a 2" W.I. vent led straight through roof.

The second difficulty was to have been overcome by changing entrance lines to diluting device so that they entered parallel to each other.

FAULTS OF CONSTRUCTION AND IMPROVEMENTS—*Lead Column* –A serious fault in the construction of the lead still was that due to the method of making the lead boiling plates of the column (see Drawing 8684 and 8684-2). These were of cast 5% antimonial lead ¾" thick with 1⅛" faced thickness where bolted between the sections of column. Cast in the plates were four 2½" x 3" tee bars, with the bottom of tee cut off at the edges permitting remainder to project into flange between sections of column.

As soon as the still was started up, the plates developed leaks around the points where the tee bars projected through to the outside. Apparently in cooling the lead had pulled away from steel ee bar and being also porous permitted acid to work into the steel nd along between steel and lead to the outside.

This was rectified by dismantling the column, cutting back the ee bars inside the bolt holes with oxy-acetylene flame and filling p the space again by burning in lead, using a sheet metal mound lamped to the plate to form the bolt holes. To provide for support acrificed through cutting off the tee bars, six posts of 3" x 2" ad pipe were placed between each pair of plates, burned to bot-om one, and the posts between bottom plate and bottom of still ere provided with standard 3" W.I. size lead flanges to distribute essure over bottom. The posts were cut of such a length as to low for settling of column as erected due to crushing of gaskets.

Kettle—The kettle of the still has two defects of a serious nature, one being the small vapor or boiling space provided, and the other the arrangement of the boiling coils (See Drawing 8683 and album, page 144). The level of the liquid in the kettle is carried close to the upper flange level which leaves little space for vapor or boiling. The coils are arranged in three concentric coils around the circumferance of the kettle, which does not permit of a proper boiling action. Better results would have been obtained, had the coils been distributed over or near the bottom of the kettle. In addition, the coils do not drain from bottom, but from top which means that the coils form a pocket for condensate until blown out by the steam.

Seal—Considerable trouble was experienced for some time after the initial run with the still due to its blowing the seal on the acid outlet. Three to four pounds pressure built up in the kettle although seal on each plate was at most ½" so that a pressure of 6" should have sufficed. The seal as originally installed was only 30" deep, which was insufficient under these conditions, and it was deepened to 58 inches. The trouble still persisted, however, the still would operate all right at beginning but apparently gradually choked and finally blew the seal. Difficulty was also caused with the vent of the seal which was first carried through wall, but when seal blew acid was sprayed about so that the seal was altered and carried; lead lined, through roof and provided with a drain below into the acid line to acid plant so that condensate dropping back is returned to the acid plant. The still operated a longer time on the inner coil only, but even then would eventually blow the seal. It was at first considered that the trouble was due to the long acid delivery pipe to the acid tank house not permitting acid to flow away readily enough. This was disproved, however, by the same thing happening when running on water only, with overflow direct to the sewer.

Defective Elbow—The trouble was finally located in an elbow in the reflux line from column to kettle, the lead lining of which had blistered away from iron partially closing the passage so that the reflux could not pass to kettle as fast as fed in, the column filled up and blew the seal.

Minor Defects—Minor defects in the still were the sigh glasses provided on the kettle top which were useless because level of liquid in kettle was too high to permit observation of any kind, and the small vent on the regulating bottle, only 1" dia. The sight glass holes were blanked off, and from one a connection taken to a slop tester and pressure gauge. A new cap was made for regulating bottle providing a 2" dia. vent. The latter trouble was not so serious after the vent was placed on the diluting device permitting the gases to escape there.

IMPROVEMENTS TO FACILITATE OPERATION—The improvements applied to the still to make operation more convenient include the following (See Drawings A 396 and A 397).

A recording thermometer in the vapor pipe leaving the dephlegmator with dial on operating floor (see photos album, pages 141 and 145).

A pressure gauge and vapor tester on the kettle.

These were connected to one of the disused sight glass openings. The 15 lb. gauge is mounted on wall at operating floor, and the vapor condenser, of simple copper coil construction is also placed on operating floor and from it the condensed vapors run through a testing and sampling cup to the sewer.

TEMPORARY LEAD STILL—While awaiting completion of the arge lead still, a small temporary one was made up to permit experiments and operation in a small way to be carried on. The ettle of this still consisted of a 30" dia. x 45" deep copper tank ned with 8 lb. lead, and fitted with coils of 1½" lead pipe. The ondenser was a small feed water heater, passing vapor through he tubes and from it the condensed distillate passed through a mall improvised tester to a second 30" x 45" copper receiving ank. This still dealt with 25 gals. per hour nicely on actual orking.

EF. NO. 11. RECOVERY OF SECONDARY BUTYL ALCOHOL FROM THE BRINE FROM SALTING.

SOURCE AND QUANTITIES—The crude secondary butyl alcohol om the lead still passes to a settling tank where it settles out into o layers, a lower, aqueous layer which is returned to the lead ll as diluting water for the feed, and an upper crude butyl layer, containing a varying percentage of water, according to amount of other impurities present.

The secondary butyl alcohol produced at 100% conversion is 250 gals. per hour which may after settling, contain from 15—25% of water. Salting in the Toronto type of continuous salting plant will reduce this water content down to 8—10% or 22 to 28 gals. per hour; meaning that a maximum of approximately 30 gals. per hour of water is removed as brine in the salting. The brine may contain a maximum of 100 lbs. of salt per 30 gals. In addition, the brine contains a small percentage of secondary butyl alcohol which it is desirable to recover. At full rated capacity, and allowing for excess salt necessary to insure proper salting, 2,500-3,000 lbs. of salt will be used daily, of which from 2,000 to 2,400 will actually become brine, and the remainder remain undissolved or in suspension, and be recovered from the salt settling tank of the salting plant.

Two proposals were under consideration for the recovery of the butyl alcohol from the brine, and for using the salt solution over and over again.

INTERCHANGER METHOD OF RECOVERY—The first proposal was based on the use of the Shaw Interchanger. The brine is forced by a pump through a preheater (interchanger) where it is heated against hot, concentrated brine leaving, and is then pumped through a second interchanger acting as an evaporator (using steam) in which steam is generated from the brine. The mixture is discharged into a separating chamber from the top of which the steam and secondary butyl vapors pass off and are condensed, while th brine settles in one-half of the bottom. The weaker solution collects on the top and overflows into the other half of the chambe from which it is drawn by a float controlled pump, and forced int the steam evaporator with the fresh brine. Part of the brine i thus re-circulated. The concentrated hot brine is withdrawn fron the bottom of the separation chamber by the pump and force through the preheater where it is cooled, becoming a super saturated solution, and thence into a mixing tube having a passag similar in shape to the interchanger passage. A second pump i at the same time forcing the crude secondary butyl into the mixin interchanger. The two are violently mixed passing through th tortuous passage, and the water takes up the salt from the supe saturated brine solution. The mixture then passes into the settling tank where the brine settles out as a lower layer, and the salted secondary butyl as the upper layer.

Ordinary Evaporation—The second proposal was to instal a system similar to that of the scrubber. The brine is passed through a preheater to an evaporating kettle from which the steam and butyl vapors pass to a condenser, while the concentrated brine is withdrawn through the preheater by pump, and elevated to storage to be used in salting either in a mixing drum (Toronto type) or mixing tank with propeller and cylinder device.

SULPHURIC ACID CONCENTRATING PLANT.

Source of Acid in M.E.K. Plant—In the second stage of the M.E.K. process 75% sulphuric acid (58.4 Beaume, 1.6744 sp. gr.) is used to sulphate the butylene, producing butylene hydrogen sulphate (B.H.S.), which in the hydrolysing distillation in the lead still yields crude secondary butyl alcohol and dilute 25% sulphuric acid (22.3 Be, 1.182 sp. gr.). The strength of strong and weak acid used and rejected from the above process have up to the present varied considerably, due to the experiments being carried out on the operation of the M.E.K. plant. Weak acids varying from 20 to 30% sulphuric have been rejected to the acid plant.

The Acid Problem—The rated capacity of the M.E.K. plant is 250 gals per hour. This means that 252 gals. of butylene per hour have to be sulphated (assuming 100% conversion), requiring 250 gals. of 75% sulphuric acid, which when rejected from the lead still have become approximately 1,062 gals. of 25% sulphuric acid. The problem was thus one of delivering to the M.E.K. plant 6,000 gals. per day of 75% sulphuric acid, and removing 5,500 gals. per 24 hours of 25% acid from the plant.

Solutions of Problem—There were several solutions of this problem:—

(a) Buying fresh acid continuously, and running to waste the spent weak acid. This method involved the loss, at rated capacity of M.E.K., of 25,500 gals. of 25% acid, or 6,000 gals (100,440 lbs.) of 75% (costing at $20.00 per ton for 60 Be $1,004.40), or 80,967 lbs. of 93% acid (costing at $1.65 per 100 lbs. for 66 Be $1,335.86), or a loss per day of at least $1,000, which corresponds to 2.1 cents per pound of solvent produced. It further involved the securing of this quantity of acid, which under war conditions was an impossibility, and finally the disposal of the 25,500 gals. of weak acid had to be provided for, which was a serious problem when the nature of the waste is considered.

(b) Buying fresh acid continuously, using the spent acid or selling it for use in some other industry requiring acid of this strength. Inquiries were received dealing with propositions of this nature, one for the manufacture of a fertiliser, the other of a chemical in connection with water filtration, but in no case were the quantities required more than a fraction of the waste acid available, and in addition there were the difficulties of transportation. For acid of this strength lead lined tank cars or waggons are necessary, or the plant using the acid must be erected close by and a lead pipe line used. There is in this method still the difficulty regarding available supply of fresh acid.

(c) Buying fresh acid only initially and at long intervals to make up for losses, and to concentrate the spent acid, using it over and over again. This method involves a large initial expenditure for the concentrating plant, and an operation charge for wages, fuel, wastage, etc.

Under the circumstances it will be apparent that only one decision could be made, and that was concentrate.

RESEARCH—Considerable original research work was carried out under Mr. E. Metcalfe Shaw's direction with a view to the discovery of a method of concentrating the acid on the lines of his film evaporators. Difficulties were, however, encountered in trying to secure a metal capable of withstanding the severe service in such an apparatus working with sulphuric acid, which led to the temporary abandonment of the idea. Recent investigations carried out with a new type of apparatus (interchanger) indicate that a metal has been found which is amply resistant. The apparatus itself on test gave excellent results, from which it is apparent that had the plant continued in operation, the use of one of the present acid towers could have been discontinued, and the initial concentration carried out in the new apparatus at a great saving in capital expenditure and operating cost and space, using the second tower to do the final concentrating only (see another section of report).

Recourse was then had to some standard form of acid concentrating equipment which could be secured without delay and which would do the work. After carefully investigating the field, it was decided to instal a standard tower type of plant, as built by the Chemical Construction Company, of Charlotte, N.C.

CONSTRUCTION OF PLANT.

(See Drawings A 405 and A 406.)

ESSENTIAL ELEMENTS—The plant for the concentration of the spent sulphuric acid from the M.E.K. plant consists of two 30-ton acid concentrating units. Each unit consists essentially of a combustion chamber, concentrating flue, concentrating tower, filter tower and scrubbing tower. These elements with the exception of the scrubbing tower are of heavy masonry construction, built of acid proof brick, lined where necessary with firebrick, and are carried on heavy concrete footings.

FOOTINGS—The footings (see album, page 97) are of massive reinforced concrete, carried on a reinforced concrete slab under whole building; and in order to provide gravity flow through the plant and from towers to tanks the tops of the footings are 9 ft. above grade. The footing of each unit is in two sections, the main ne supporting the combustion chamber, concentrating flue and ower, and the other a lighter footing supporting the filter and rubbing towers.

The combustion chamber concentrating flue and tower are built s a single masonry unit (see album, pages 93, 94 and 95). A cape f 6 lb. lead is laid on top of the towers, over a layer of heavy uilding paper to protect the lead from irregularities of concrete, nd on top of the cape a pan of 30 lb. lead, made up inside a steel rame of 12 in. channels, surrounding the top of the footings. he inside of the pan is protected by three layers of roofing felt, id in a thin silicate of soda cement. Three courses of acid proof rick are laid on the felt, and on top of these a layer of 1" tile. On is base at one end is built the concentrating tower, at the other e combustion chamber, with the concentrating flue between. The mbustion chamber and concentrating flue are braced and rein- ced by steel frames, buckstays and tie rods connecting with the ain base frame around top of footings.

COMBUSTION CHAMBER—The combustion chamber (see album, pages 99 and 100) is 7' 6" x 9' 8" x 9' 4" high outside, built of an 8" outside casing of acid-proof masonry, and a 9" lining of special firebrick, with a 2" insulating layer of mineral wool between. The inside of the chamber is finished with a ½" layer of high temperature cement. The combustion chamber is 6' 6" x 4' 4" inside, and is provided with a baffle wall 2' 9" from burner wall, and from the combustion chamber a 2' 0" x 4' 4" opening leads into the top of the concentrating flue.

In the centre of the front of the combustion chamber is a 19" diameter opening in the brickwork for the oil burner, and bolted over the opening is a 4' x 2' x ⅜" steel plate with a corresponding 10" diameter hole. On each side of the central hole, and above and below, are built in four 2 ft. lengths of 3" W.I. pipe, loosely capped at outer ends, providing peepholes or admission ports to combustion chamber. The caps of the upper two are provided with small rotating dampers, and a manometer connection is tapped into one of the lower ones.

The 19" diameter hole is lined with fireclay arch brick, leaving a 10¾" clear opening for the burner. This opening at the inside end is lined for 6" of its length with a fireclay cylinder, with a slightly coned inner end, part of the oil burning equipment.

OIL BURNING EQUIPMFNT—The oil burning equipment installed is of the Schutte & Koerting mechanical type, consisting of burner, air register, strainers and oil pumps (see album, page 100).

The air register is conical in form, bolted directly to steel plate in front of combustion chamber, and carries at its outer end the holder socket which is provided with the handle operating the register and also an interlocking clamping device and oil inlet valve which holds the oil burner proper in place and prevents withdrawal of burner without first shutting off the oil.

The burner proper consists of a goose neck held in the socket burner pipe protected by the guard tube projecting forward into the opening in the combustion chamber wall, carrying at the inner end the burner tip screwed into the burner socket. The burner tip are of the centrifugal spray type, fitted with spirals, and variou sizes are used, depending upon the heat required (1½ and 1 m.m.

FUEL OIL PUMPS—The oil pumps, two in number, are the rotary motor-driven type, and are arranged in duplicate in ca of accidents. The pumps are gear driven by means of two 2 h.p. 750 r.p.m motors (Nos. 15 and 16), and are located on ground in north-east corner of acid building under the firing platform. The pump draws through a 1" suction line fitted with a duplex suction strainer, and discharges through a ¾" pipe vertically through platform to an air chamber supplied with compressed air connection at bottom from which a ¾" pipe rises to the steam oil heater (12" interchanger type), and thence the oil pressure line passes horizontally through ¾" duplex discharge strainer, pressure gauge, and thermometer connections to the burners. A ¾" 250 lb. relief valve is placed in the pressure line between air chamber and heater from which a ¾" return line runs to oil tank.

CONCENTRATING FLUE—The concentrating flue (see album, pages 93, 94, 95 and 96), extends from the front of the tower under the combustion chamber to the concentrating tower and is 7' 6" wide x 27' 0" long x 4' 7" high outside, with arched top, and is 4' wide inside x 2' 3½" maximum height, with a total length inside from front to inside wall of concentrating tower of 27' 6". The top and sides of flue are lined above acid level with 9 in. of firebrick. Below the acid level the lining is of acid-proof brick and 1" tile. Three 4½" deflecting baffles of firebrick project down from roof arch at 7' 6" intervals to throw the hot combustion gases down upon the pool of acid. The roof of the combustion chamber and concentrating flue are provided with expansion joints. The bottom of the flue forms a pan or basin for the acid which trickles down through tower to pan against the hot gases going up, and in the pan is exposed to the hot flue gases passing through the concentrating flue and thrown down upon surface of acid by means of the roof baffles. The acid in the pan is at the same time boiled up or agitated by means of air blown in through a 1" I.D. perforated duriron pipe connected to the compressed air at the front of the combustion chamber. The perforations are on top ⅛" diameter, 6" apart, and the pipe has a total length of about 20 ft. The end of the pipe is plugged.

ACID PORTS AND TROUGHS—At both ends of the concentrating flue are located acid overflows. At the end under the concentrating tower there are three 8" wide x 5" high ports through base of wall of tower into a 7½" wide, washout trough of tile-lined chemical brick leading to the side, where there is located a duriron water cooled outlet and plug.

At the furnace end of the flue there are three 8" x 9¼" ports leading to a similar acid outlet trough and water cooled outlet casting. The troughs are in both cases covered with 6" x 9" x 1" tile.

CONCENTRATING TOWER—The acid or concentrating tower (see album, pages 93, 94, 95, 96 and 98), is 10' 6" square outside by 42' high from top of footing to roof of tower, and at the bottom has an interior opening 6' 8" square up to a height of 20 ft., and 7' 4" square for remainder of height. At the bottom are four arches, 4 ft. span and 2 ft. radius, which support the packing of the tower.

The concentrating tower is braced and reinforced by means of 6 lb. lead-covered 3" x 3" x ⅜" angles at the corners, cross-braced with 1¼" diameter tie rods, every 39" from corner washers at the angles, and sprung over a tee bar midway between corners on each face, made up of 2½" x 2" x ¼" angles (lead covered) with notched plates riveted between them, in which the tie rods rest.

The top of the concentrating tower is covered with an arch of chemical brick, and the side walls are carried up 3 ft. above to support distributor tank (see album, page 102). A frame of buck stays and tie rods surrounds the tower at top to take thrust of arch.

PACKING—The acid concentrating towers are packed with brick, quartz and spiral rings. Built up from the four arches a the bottom of the tower to a height of 16 ft. above the arches is checkerwork of chemical brick on edge 4½" centre to centre Above this is a depth of 13 ft. of 6" to 8" quartz packing, and o top of the latter 4 ft. of 3" spiral rings.

The latter are of terra cotta or earthenware, 3" O.D. x 2½ I.D. x 3" long, with a one-turn helical baffle ¾" wide formed insid

The top of the packing is about 3 ft. from top of arch of towe

From the back of the tower just under the arch cover and abov packing is a 22" diameter opening from which a 22" diameter lea pipe passes to top of filter tower.

DISTRIBUTING TANK—An 8' x 8' x 3' 6" deep distributin tank of wood, lined with 8 lb. lead, is carried on 4" x 10" joists o

12" centres on the projecting walls of the tower at the top (see album, page 102). The tank is built of 2" x 10" planks, with 8" x 10" bracing around top and bottom, and tie rod. The distributing tank contains the acid regulator, blow box and float.

Blow Box—The 1½" lead delivery pipes, one for each unit, from the acid egg pass up the south wall of the building and across to the distributing tanks, where each one enters, at 60° to horizontal, the domed cover of a blow box. The blow box is used to prevent splashing of the acid when sending up a charge from the egg. It is a 24" diameter by 3' 9" high lead cylinder (12 lb. lead) provided with 3' 0" diameter domed lead cover. The top of the cylinder is serrated with 3" x 4" serrations, and at bottom it is slotted with 1" x 3" slots. The box is burned to lead lining of the bottom of the tank.

Acid Regulator—The acid regulator consists of floats, float cylinders, acid siphon, outlet cylinder, etc. The float cylinders, two in number, are 22" diameter by 3' 6" high, of 12 lb. lead, open at top, provided with slots at bottom similarly to blow box, and burned to bottom of distributor tank 48" apart. In the float cylinders are suspended two 18" diameter spherical lead floats from a wooden float yoke. The float yoke is in turn suspended by chain which passes over two pulleys at peak of roof and down to counterweights at the wall. Suspended from the middle of the float yoke by means of an adjusting rod and wing nut is a 1¼" lead pipe siphon (see album, page 102), five feet deep, The builders called for a 2½" lead pipe siphon, but this was found to give trouble in maintaining a steady flow and was reduced to 1½" and then to 1¼", and even the latter has the flow restricted by inserting a piece of glass tubing. One leg of the siphon is suspended inside an " diameter by 3' 0" high lead siphon cylinder burned to tank botom around the 2" outlet pipe, while the other leg is simply in the ank.

By this regulating device the counter-balanced floats always aintain the siphon suspended in the acid in the tank to the roper depth, thus giving a constant outflow of acid as the tank mpties, and feed is regulated by raising or lowering the siphon y means of the wing nut.

In the bottom of the distributing tank there is also a 2½" x 3" washout plug and seat, from which a 2" lead pipe leads to distributor. The plug is controlled by lever and wing nut adjustment, similarly to those of acid storage tank.

In the corner of each distributing tank is an 18" diameter by 6" float, from which a chain passes over pulleys and drops down side of tower to an indicator on a graduated scale on the side of the tower, visible from firing platform. There is a second indicator on the chain, in front of a gauge board on the side of the distributing tank. The quantity of acid in the tank is thus indicated.

A runway is built over the distributing tanks giving access to various pulleys and gear above them.

DISTRIBUTOR—Suspended over the top arch of the tower by tie rods from joists supporting acid distributing tank is a timber platform carrying two concentric rectangular lead (8 lb.) trays, the inner one 4 ft. square, with 6" sides, and the outer 5' 8" square, with 4½" sides. In the centre of the inner one is a 10" diameter x 10" high domed cover splash bell, into the top of which enters 2" lines from distributing tank washout, and from acid gauging box. The bottom of this bell is serrated to permit outflow of acid to inner tray.

There are also burned to the bottom of the inner tray four 8" I.D. by 6" high cylinders, each of which surrounds the outlet opening to a lute. In the side of each of these cylinders is a 1" hole, whose bottom edge is 4" above tray bottom through which acid flows from tray to pipe to lute. In the sides of the inner tray ar twelve similar 1" holes fitted with spouts (see album, page 102) directing acid to twelve corresponding holes in the bottom of oute tray, between sides of inner and outer tray. From the latter holes 2" x 2½" lead tube spouts direct acid to the respective lutes.

Cemented in the brick arch cover of top of tower are sixtee equally spaced 2" diameter by 12" long stoneware pipes, projectin through arch, with bell upward. There are four extra pipes, two a each side, for washing down purposes, etc., which normally ar plugged with rubber corks.

Lead lutes (see album, page 102), are inserted in the sixtee stoneware pipes. The lutes are of lead throughout 4" I.D. x 5 deep, of cup shape, through the bottom of which a 6" length o 1" A A Lead pipe projects 1½". A small bell 3" I.D. x 2½" dee with serrated bottom edge and ring handle on top, is placed ove the upward projecting 1" pipe, thus providing an acid seal against escape of fumes. The spouts from the distributor feed the acid to the cup, from which it flows under bell and into 1" pipe, and thus into the tower.

GAUGING BOX—Between the distributing tank and the distributor, suspended from the edge of the distributor, tank platform, is a lead gauging box 20" x 24" deep at back and 6" at front (bottom horizontal—see album, page 102). Three division plates, of decreasing height, extending the length of the box divide it into four compartments. The 2" I.D. lead pipe from the siphon cylinder of the distributing tank enters the rear (deepest) compartment of the box and from this compartment the acid flows through eleven 1" holes at bottom of dividing plate, or two overflows at top, into the second compartment. The centre division plate is provided with eleven ½" holes, at increasing heights from bottom of box, and two overflows at top. The rate of feed is then gauged or measured by the number of these holes running full of acid. This provides a very simple, accurate and ready means of regulating the flow of acid to the towers.

The third division plate is provided with holes similar to first, and acid from fourth compartment flows through bottom opening and 2" I.D. pipe to splash bell in distributor.

GAS FLUE—From the opening in the top of the concentrating tower to a similar opening in top of the filter tower, a 22" diameter lead (6 lb.) gas flue extends. The flue is supported by two vertical steel angles, to which are bolted the steel bands burned around the flue. The vertical angles are steadied at the top, and supported at the bottom by steel beams between lower and roof steel and between filter and concentrating towers respectively. The pipe is fitted with a hard lead spray at the bend where it leaves the concentrating tower, projecting into pipe through a lute or seal.

FILTER TOWER—The filter tower is of similar construction to the concentrating tower, of chemical brick laid in acid-proof cement throughout. It rests on the smaller of the two parts of the footing on a 20 lb. lead pan and two layers of roofing felt. Two courses of chemical brick are laid on the felt, on which the tower is built. The tower is 16' 0" x 10' 6" wide by 21' 0" high outside, and 12' 10" x 7' 4" inside up to a height of 10 ft.; and 13' 9" x 8' 3" for rest of distance to the arched brick roof. Across the tower at the base are nine 8" thick arches, 3' 6" span, 3' 9" to highest point, on which rests the packing of the tower.

The tower stands in a base frame at top of footing of 8" channels, and is re-inforced and braced by means of 4" x 4" x 3/8" lead-covered angles at the corners, cross-tied with 1¼" tie rods, sprung over tee bars made up similarly to those of concentrating tower, and a buckstay and tie rod frame surrounds tower at top taking thrust of arches. The side walls are carried above the arches to support the fan platform.

PACKING—The towers are packed with 2" to 4" quartz on top of 7½" (three courses) of acid-proof brick checkerwork, on top of arches. The depth of quartz packing is 12' 6".

The 22" diameter lead pipe from top of concentrating tower enters front of filter tower at top, and a 22" diameter outlet leads from back of tower at bottom (end of archway under packing arches). From the front of the tower 2½" high by 8" wide ports lead to an acid trough and elevated lead overflow at side.

LEAD SPRAYS—Inserted through two 4 in. square holes and a luted cover on the centre line of the roof arch of the filter tower are three 3/8" hard lead sprays with 2½ mm. orifice. The luted cover is over a 20" diameter opening in centre of roof for examination purposes, etc. The sprays are mounted on the end of a length of lead pipe which is fitted with a bell, and the latter drops into an annular chamber surrounding the lead tube projecting through the roof, forming a seal or lute when filled with acid. Each spray is supplied by a ¾" W.I. pipe. with water from municipal system. Between the end of the W.I. pipe and lead pipe attached to the spray a length of rubber hose is inserted to enabl spray to be withdrawn for examination.

SCRUBBING TOWER—The scrubbing tower stands behind th filter tower, between the latter and west wall of building, on a narrow portion of the filter tower footing. The scrubber stands on 3' 9" x 2' 6" x 9" deep lead pan, of 11 lb. lead, the sides of whic are supported by a 4" brick wall around the outside. The scrubbin tower is encased in a rectangular 10 lb. lead casing 3' x 2' x 2 high. The casing is supported by 4" x 4" timber at the corne with 2" x 4" cross-braces, to which casing is attached, and the whole is supported on 4" x 8" beams between filter tower and wall of building. The casing is so suspended that the escape ports are not covered. From the top of the scrubber to one side leads an 18" lead pipe, and beside the latter is a 3/8" hard lead spray inserted through lute as in filter tower. Inside the casing at the bottom is built a 4" lining of brick extending to a height of 4' 6", with a 4" arch between walls. In the side walls, between the arches at the bottom are 1" x 2" openings for escape of scrubbing water to pan outside. A three course checkerwork of brick rests on the top of the arch and casing, on top of which are packed 6" spiral rings for remainder of height of scrubber. The 6" spiral rings are similar to the 3".

From the pan under the scrubber a 2½" lead drain pipe leads to the sewer.

FANS AND FAN PLATFORM—Between the filter towers of the two units and on top of them is built a fan platform. On this platform are placed the two No. 7-16" Special Regulus Metal Exhausters with flanged inlets and outlets and right-hand upblast discharge (see album, page 101). Each exhauster has a 27" diameter four-bladed Regulus metal cast impeller. The 18" lead pipe from top of scrubber passes direct to suction of the fan through an 18" lead regulating gate damper, the gate of which is sealed against leakage and provided with counterbalance weight. The fans each discharge through an angle-type lead damper (to prevent backflow from the other fan) and 16" lead pipes to a Y, and thence through a single 22" diameter lead exhaust pipe suspended from the steel of sloping roof by tie rods and steel bands, and passes thence vertically up the monitor wall and through the roof to a lead exhaust head.

The fans are each driven by 7½ h.p. 720 r.p.m. induction motor through 7" rubber belt at 920 r.p.m. The entrance box, fuse box and auto starter for the motors are on the wall between and behind the fans.

OVERFLOWS—CONCENTRATING TOWER—The overflows from the front (acid outlet to coolers) and rear (washout) troughs of the concentrating unit are arranged as follows:

Set in the top of the concrete footing flush with top at the corners are cast iron "floor plates" or brackets projecting out from footing, in which is a 10" diameter hole. The steel tower frame extends around these, and the flooring, lead pans, etc., are laid over them also. The trough in each case extends into these pockets, which are lined with a 11½" high brick wall. The lead pan is hammered down through the hole in the floor plate to form a gasket against which the duriron water cooled outlet pipe is bolted. This consists of a 3½" I.D. pipe, some 14" long, surrounded by an annular cooling jacket. The jacketted portion projects through hole in floor plate, and the top of the inner pipe is turned to give a cone seat. The cooling space is closed by bolting a flange to the bottom, into which the ⅜" water inlet is tapped, projecting up inside the annular space 6", from which the ⅜" water outlet leads. The water supply to this is controlled from the cooler manifold.

The washout outlet is provided with a 3½" duriron plug fitting into the coned top of the outlet pipe, and from the bottom a short 2½" I.D. lead pipe leads to the weak acid trough. In the acid trough, between the acid ports from the tower and the outlet pipe, a dam of chemical brick is built, to raise acid level in pan to a depth of 9 in., thus sealing ports.

The strong acid outlet to the coolers is fitted with a vertical length of 3½" duriron pipe, tapered at bottom to fit into cone seat of outlet casting, thus raising level of acid in trough to height of 9 in. above floor before outflows occurs. In addition to this a dam is built in trough similarly to washout trough. From the bottom of the outlet casting a 3½" I.D. duriron delivery pipe (see album, page 103), 3' 9" long, leads to top of central duriron pipe of the acid coolers. The joint between outlet and delivery pipe is of bell and spigot type, made with acid-proof cement.

OVERFLOW FILTER TOWER—The overflow from the acid trough of the filter tower is similarly arranged with a floor plate, in which in this case is a 6½" hole only. A 2½" lead seat is placed in bottom of trough, from which a 2½" lead pipe passes through hole in floor plate to the weak acid trough. The seat is provided with a lead plug, and is surrounded by a brick dam to raise overflow height 9" above bottom, sealing ports and providing a 9 in. deep pool of acid in bottom of tower.

WEAK ACID TROUGH—The weak acid trough placed between the two units and leading to the weak acid tanks, between concentrating and filter towers, is divided into two troughs of the same size as the main trough. Three feet from the end of each is a 3" high dam across each trough, and into this section in each comes the outlet pipe from the filter tower, and in the bottom of it is a 2½" plug and seat from which a 2½" I.D. drain leads to the sewer. It is possible by means of this arrangement to consign the washings from filter tower, if too weak to be profitably concentrated, to the sewer without interfering with rest of trough.

Beyond the first dam is a second section of about 3 ft. of trough with a second dam. Into this section the outlet from the washout trough at the back of the concentrating tower enters, and the section is also fitted with a 3½" plug and seat and drain to sewer. This arrangement enables the washings from this end of the pan to be consigned either to sewer or weak acid tanks. Beyond the second dams, the two troughs unite and the single trough leads with a gentle slope to the weak acid tanks Nos. 1 and 2.

COOLERS—There are two acid coolers, one for each unit (see album, page 103). Each cooler is contained in a 4' 2" diameter by 4' 0" deep cylindrical outer jacket of 16 lb. lead. Concentrically inside the outer jacket resting on acid-proof bricks on edge, is a second lead cylinder, 3' 8" diameter by 3' 10" deep. Again, concenrically inside the latter is placed a 30" diameter by 24" long sewer ipe (with bell cut-off) covered on outside with ¼" of acid-proof ement, and covered with 10 lb. lead, burned at bottom to last menioned lead cylinder. The top of the pipe is serrated. In the centre f the pipe is placed a 6" I.D. x 7" O.D. x 36" duriron pipe, open t both ends, placed on top of a 9" x 9" x 12" high checkerwork f acid-proof brick.

Inside the sewer pipe cylinder is an inner coil of 1½" I.D. x 2" D. lead pipe, 2' 2" diameter, and between sewer pipe and inside ad jacket is a second coil of similar pipe 3' 4" diameter. The two ils contain 280 ft. of pipe, and are made up with a spacer of 1" ad pipe burned in place every ¼ turn.

The two coils and the outer annular space between outer and ner jackets are supplied at the bottom through 1½" lead pipes om a water manifold over the coolers. The flow is controlled by obe valves, with extension handles reaching to the firing platrm. The coils and outer water jacket overflow into an outlet cup side of cooler, from which a 2" x 3" lead pipe drops vertically the sewer.

From the bottom of the inner lead jacket a 3" I.D. lead pipe passes through outer jacket and from it a vertical acid riser passes up side of cooler to top, and also a 2" I.D. lead washout drain drops to sewer through a 2" lead valve (globe pattern). This washout is drilled for a 1" observation hole (corked) to permit detection of leaks.

From the riser 3" from the top a short 3" lead pipe and discharge line runs to the strong acid trough, running parallel to the weak acid trough, delivering strong acid to the strong acid tanks, Nos. 3 and 4.

The coolers are placed side by side, between combustion chambers, on a lead tray carried on a concrete base 4 ft. high.

CONTINUOUS SAMPLING DEVICE—Inserted in the top of the vertical acid riser from the cooler is a small continuous acid sampling device (see album, page 100). This is essentially an air lift, and is a great improvement upon the old sampling method of dipping a sample from the riser.

Two 5/8" by 3/8" lead tubes project down to bottom of the riser, where one is constricted to form a 1/8" diameter nozzle pointing upward into the enlarged coned bottom of the other pipe. The nozzle tube is connected to the compressed air supply (to agitating pipe), and the other rises to a vertical cylindrical 2" diameter by 6" long lead separator, clamped on railing of firing platform. The tube from the riser enters the side of this separator at top on a tangent, giving a swirl, thus separating the air and acid, the former escaping from centre of top through a 3/4" pipe bent over the lead instrument tray, also clamped to railing, to catch any acid not separated, and the latter from bottom to a lead hydrometer cup. From both tray and cup the acid runs back to the strong acid trough.

The amount of air required is infinitesimal, the 1/2" valve on the air line being barely cracked. It is lightly closed, and the little air seeping through keeps a steady stream of acid flowing. The device has given great satisfaction.

INSTRUMENTS—The instruments employed in operating the tower include water manometers or draft gauges connected at exit from fan scrubber, filter tower and concentrating tower, in combustion chamber and on agitating pipe in pan. These manometers are all of the simple glass U tube type filled with coloured water.

Temperatures are taken by means of 500° recording thermometers, fitted with long capillaries, enabling the instruments to be all mounted in a case on the wall at firing platform. The bulbs of these instruments are inserted to measure temperature at exit from concentrating tower, at exit from fan, and of acid in pan (bulb in a duriron casing).

The conditions of the oil is taken by means of 160 lb. pressure gauge and 220° indicating mercury thermometer.

The temperature in the combustion chamber is recorded on a recording pyrometer with platinum thermocouple.

Hydrometers and lead dippers are used to take strength of the acid.

ACID TANK HOUSE.

ACID DELIVERY LINE FROM M.E.K.—The weak acid line from the lead still kettle passes through the wall into the acid plant. The line is of 3" x 2" lead, and inside the acid plant is encased in 3½" W.I. pipe. The elbows are simply made of bent lead pipe. The line has a length of 128 ft. with a fall of 9 in. from the lead kettle trap, and passes under the west end of the tower foundations, and thence east under north tower foundations to the acid tank room.

The straight length (68 ft.) under the north tower is encased in 12" x 12" wooden trough, through which water flows for cooling the acid from a supply at the east end, overflowing through a 2" W.I. pipe to sewer at the west end. The pipe is carried from hangers in the foundation, and the trough rests on 2" pipes across from side to side of footing.

The weak acid line in the tank room passes over the top of the two west of four lead-lined wooden acid tanks. From a tee in the line just before the first tank is reached a 3½" vent is carried vertically through the roof to carry off the steam. The outlet into the first tank is from a tee in the line, to which is bolted a 3½" acid valve (P. G. type) with a lead spout. The line ends over the second tank in a 3½" acid valve (P. G. type), and a spout directing acid into this tank.

STORAGE TANKS—In connection with the acid plant and in the acid tank house there are five acid storage tanks (see album, pages 104 and 105). Four of these are of wood, lead lined, 5' x

17' x 4' deep, with a capacity of 2,125 gallons, and placed side by side. The tanks are built of 9" x 2" lumber, braced with 10" x 6", and reinforced with 4" channel buckstays and tie rods, and lined with 8 lb. lead. The tanks are built on 10" x 3" joists, on 16" centres carried on concrete footings, the bottoms of the tanks being 21" above the floor.

OUTLETS—Each tank at the south end is provided with two outlets of the plug and seat type; one, a 2" washout, leads to the sewer through 3" x 2½" lead pipe, and the other, a 2½" drain, to either of the two acid eggs through a 3" x 2½" lead pipe. Each washout to sewer where it bends down is drilled with a 1" hole in which a cork is inserted. By means of this any leaking of the plugs can be detected readily. The plugs are operated through a plug lift consisting of a pivoted lever at the top of the tank, one end of which is pinned to the plug rod (¾" iron encased in ¾" x ⅞" lead tubing), and the other end pinned to a threaded rod passing through a bracket on the tank side, with a wing nut on either side of the latter, permitting the plug to be held in any position whatever. (See album, pages 104 and 105.)

INLETS—The inlets to the tanks, besides that already described into tanks Nos. 1 and 2 from the weak acid line from the lead still, are from the two lead-lined wooden troughs from the acid towers. These troughs are 6" x 9" inside, of 2" x 12" lumber (dressed) sides, with 6" x 10" bottom, lined with 8 lb. lead: one extends over tanks Nos. 1 and 2, and the other over all four. These troughs are provided, one over Nos. 1 and 2 tanks, and the other over Nos. 3 and 4 tanks, with 2" plugs and seats, from which 2" I.D. lead pipes drop vertically about 12 inches or 9 inches below top of tank. The plugs are inserted or withdrawn from the seats by hand, using a T handle attached to them, and access is had to them by means of a wooden runway built over the tanks. The filling pipes from the troughs project down into a lead splash tube of 10 lb. lead, 9" diameter at bottom, 6" at top, open at both ends, simply standing on tank bottom. The lower half of the length is perforated with ⅜" holes. The boxes prevent splashing of the acid.

FLOAT GAUGE—The tanks are also provided in one corner with a float gauge, consisting of a lead cylinder 6" I.D. and extending the full depth of the tank, perforated at top and bottom, in which a glass bottle float is placed. A chain is attached to the bottle, and runs up over a pulley at the top of the graduated gauge board, and extends down behind to a weight. An indicator is placed on the chain in front of the board.

SCUM TROUGH—Owing to the quantity of an oily, tarry substance (carbides) which is delivered from the lead still in the acid, and which gradually rises to the surface as the acid cools, the cooling box was placed around the acid line from the lead still (also to reduce steam liberated), and in addition two 6" x 6" lead troughs were placed at the ends of Nos. 1 and 2 tanks, about 6" below the top, into which this scum was drawn when the acid level was up to the trough level by lead rakes, and washed down the sewer through a 1½" I.D. lead pipe.

ELEVATED OUTLET (SLUDGE)—In the strong acid tanks (Nos. 3 and 4) there was found to settle out in the bottom of the tanks a heavy sludge, apparently disintegrated brick or cement from the towers, which was returned to the M.E.K. plant through the bottom outlet of the tanks and caused trouble there by blocking the pipes, valves, etc. To overcome this, these two tanks were provided with a raised outlet by burning to the seat surrounding the plug a 12" length of 4" I.D. lead pipe, from which a 3" x 2½" lead pipe was laid along bottom of tank to about two-thirds of tank length from outlet, and there turned up so that inlet was about 9" above bottom of tank. This to some extent secured acid free from the sludge for the M.E.K. plant. The tanks were periodically emptied, and the sludge washed down the sewer.

In transferring acid from one of these tanks to another (when this is necessary) a lead siphon of 2" pipe is used.

ACID EGGS—The acid eggs used for elevating the weak acid to the tops of the towers, or for returning the weak acid to the M.E.K. plant are placed in a concrete pit just in front of the four wooden tanks (see album, pages 104 and 105). The eggs are heavy cast iron, spherical vessels, 5' 6" outside diameter, with a capacity of 465 gals, lined with 16 lb. lead, with a 16" opening at the top, to which is bolted a cover, on which there are three flanged openings. On one of these flanges, the acid inlet is bolted a 2½" angle type Pratt Sulphuric Acid valve. Into the other a 2½" x

1½" air inlet is connected, and from the other the acid delivery pipe leads. The latter has a 1½" pipe extending down inside the egg to the bottom.

The west egg is the weak acid egg used to elevate weak acid to the tops of the towers, and the east egg is the strong acid egg for delivering strong acid to the M.E.K. plant. From the outlets of the weak acid tanks Nos. 1 and 2 (and if necessary No. 3) the three 3" x 2½" lead lines lead and are burned to a single lead pipe connecting to the acid inlet valve on the top of the west egg. The delivery line from this egg is of 2½" x 2" lead pipe, and divides just above the egg into two branches, each controlled by a 2" lead valve (P. G. type), from which 1½" lead pipe lines (A A weight pipe) pass through wall into acid building and up to tops of towers.

Two 3" x 2½" lead outlet lines from strong acid tanks Nos. 3 and 4 unite, and the single line connects with the acid inlet valve on top of the strong acid egg. The strong acid delivery line from this egg is of 3" W.I. lead lined pipe, which passes up and over a steel concentrated acid tank to the delivery line to M.E.K. plant. The line is made up with standard lead lined cast iron fittings, and is provided over the steel tank with a 3" lead lined valve (P. G. type) just before a tee is reached, into which the branch from the steel tank enters.

The compressed air is supplied to each egg through a ¾" W.I. pipe, controlled by brass gate valve; this pipe is fitted with ½" drain valve (downwards), and a vertical outlet to a 1" I.D. lead pipe (see album, page 105). A 160 lb. pressure gauge is also connected into the line. The lead pipe leads from the air connection to egg through an inverted U extending some 2 ft. above tops of acid tanks, and from the egg leg, of which a 1" I.D. lead pipe air release line (fitted with 1" lead valve, P. G. type) slopes to tops of tanks. (No. 2 in case of weak acid egg, No. 3 for strong). The latter line is used to release the air pressure on the egg, so that any acid in the line is blown into the tank.

The concrete acid egg pit is provided with a 1½" acid lead siphon, with a capacity of 1,400 gals. per hour, operated with compressed air (1" pipe) for pumping out purposes. Lime is kept in the pit at all times to neutralise acid drips, and the eggs are given a lime wash occasionally.

CONCENTRATED ACID STORAGE—The strong acid tank is of steel, 10' diameter by 20' long on straight, 10,000 gal. capacity of horizontal cylindrical type, with dished heads. The tank is of 3/8" steel, built to withstand 10 lbs. pressure. It is provided with manhole and various filling and emptying nipples. It is carried on three cast iron saddles on concrete footings about 12 in. above the floor. Strong acid, 60° or 66° Be is purchased to make up wastage in concentrating and other losses, and is stored in this steel storage tank.

Strong acid from the railroad tank cars is delivered through a 2" extra heavy W.I. line over the roofs from the railroad siding, some 250 ft. at a maximum elevation of 40 ft. and drops through the roof of the tank house vertically into a 3" flange on top of the steel tank. The line is provided with a 2" asbestos-packed, iron plug cock at the tank, and between tank and cock a 2" horizontal W.I. pipe is taken off to the gauge glasses. Air is supplied to the tank through a 1" line, entering top of tank through a 1" flange. This line is controlled from a valve on the second floor of the M.E.K. section at the acid diluting tank, in order that the correct mount of acid may be sent up. The air line here is provided on the tank side of the control valve with a 50 lb. pressure gauge, 1" ent to the outside and relief valve. This shows operator pressure n tank, and he can vent the tank after sending up a charge.

There is provided a 3/4" ammonia valved vent on top of the tank, nd a 2" drain flange on the bottom. The latter is fitted with a 2" sbestos-packed plug cock, from which a 2" drain also fitted with a lug cock passes through wall to the outside, and also a 2" line eads horizontally out beyond tank through a 2" lead valve (A. S. ype). Between this latter line and the branch from the filling ne referred to above is a vertical 2" W.I. pipe, on which three verlapping 5/8" gauge glasses are connected. Ammonia type iron auge glass fittings are used.

DELIVERY LINE STRONG ACID TO M.E.K.—The outlet from he tank is through a 2" flange on top, from which a 2" iron pipe tends down inside tank to bottom. Above the flange the line is nlarged and fitted with a 3" lead-lined valve (P. G. type), and en- rs the acid delivery line from the strong acid egg which passes rough a 3" lead-lined (P. G. type) valve and a 3" W.I. lead lined id line horizontally and then vertically to the top of the acid luting tank in the M.E.K. section. The line is some 75 ft. long, ith a rise of 27 ft. from bottom of strong acid tank, or 35 ft. from ttom of egg.

Fuel Oil Storage—The oil storage consists of a 12,000 gal. steel tank, 9' diameter by 30' 2½" on the straight, with dished heads. The tank is placed underground outside the acid tank house on a concrete-lined bed, and since it is beneath water level it is held down by means of steel cables anchored in the concrete bed. The top of the tank is some three feet underground and the various flanges and manholes are rendered accessible by wooden well to top of tanks.

Oil is received in tank car lots, and unloaded by air pressure through a long 2" W.I. line, parallel to the acid line to the acid tank house, thence underground about 20 ft. to the top of the tank. A valve is located in the line here, as well as a connection for the return line from the oil pressure line of the burners. The outlet is through a 1" pipe projecting downward through tank to bottom, and leads underground through tank house to oil pumps. The entrance to the outlet pipe is arranged with a steam-heating coil, supplied with ¾" steam and returns lines, to render oil more fluid in cold weather. A 2" vent pipe projects from top of tank, and through it the chain of the float passes up to the gauge board on the cover of the well.

OPERATION OF ACID PLANT.

Starting up New Towers—The towers on completion are dried out, using a wood fire or preferably an oil flame (¾ mm. tip at 60 lbs. pressure). A six-hour run is first made with flame half-hour on and half-hour off, followed by a nine-hour run, one hour on half-hour off. The towers are then closed up tight and allowed to cool, or if so desired after two hours' cooling the burner is lighted and constant fire kept.

Setting Cement—The acid-proof cement with which the masonry is laid is very soluble in water, but is supposed to be set absolutely hard and insoluble with sulphuric acid. Strong doubts are entertained on this point. To do this a slow stream, 1 to 2 holes, of 25% acid is run through the tower till pan is full. The filter towe is similarly set by means of lead siphon from distributor box, acid being allowed to run through for four days. The cement must b set with acid before water is allowed to get on masonry.

The action of the acid in setting the cement is slow, graduall penetrating through, forming white incrustations on the outsid of the tower, which are allowed to form. If liquid seeps through, however, the joints are pointed up, first clearing out old mortar and washing joint with water, so that fresh mortar may be properly packed before acid acts on it. After one or two months, the whole of the tower becomes set, and the incrustations are washed off with a hose and the towers re-pointed where necessary.

STARTING—In starting operation, the distributors tank is filled and a flow of 1½ holes started. The fan is started, steam turned on oil heater, and the oil pump started. The oil pressure is regulated to 40 lbs., and by means of drain valves near burner oil is run into a bucket until it comes through hot. If this is not convenient, and the tower is cold, a burner without tip may be inserted in the furnace, and the cold oil forced into the firebox, then the tip put on and lighted, keeping face back from furnace.

When hot oil comes, the burner with a 1mm. tip is inserted, valve opened, and using a 4 ft. torch and keeping face back from furnace, the burner is lighted. The damper at the fan is kept only about one quarter open until oil is burning steadily.

At the beginning the acid comes through black owing to the debris of construction left in towers. After three weeks' operation, the towers are allowed to cool, acid siphoned off, and the tower cleaned out by running water through in large quantities for two days. The dams at front and back troughs are removed when washing out. The tower is then re-started.

HEATING UP—The heating up of the towers should be done slowly, maintaining oil pressures at 40 to 45 lbs. and a flow of 1½ to 2 holes. In the initial starting up the pan temperature rises during 24 to 36 hours to 365° F. for 75% acid, for subsequent startings the period may be reduced to 15 to 24 hours. If the temperature rises too fast, the oil pressure is reduced, oil cut off for an hour. The flow from cooler is slight, but there must be some flow maintained from cooler at all times.

In normal concentration from 25% to 75% acid a 1 m/m tip is used, with an oil pressure of 60 to 100 lbs., with an oil temperature of 230° F. (above flash point).

OIL—The oil recommended for use by the builders was an Oklahoma distillate oil 30 to 32 Be., .873 specific gravity, flash point

225° F., and viscosity 1.5 to 1.7. The oil contracted for conformed to the above specification with a specific gravity of .875 and heat content of 18,000 to 20,000 B.T.U. The oil pressure should not be sufficient to produce a smoky or visible flame when viewed from peephole in back of tower.

The pan temperature is maintained at 365° F. by regulating the number of holes of feed. About five holes being correct.

The longest burner that proved satisfactory was 26½" overall. The burners must be changed at intervals (once or at most twice) each eight hours' shift when tips become carbonized. The tips are cleaned as soon as cool enough, and the burner strainer is cleaned every two days.

With the strainers in the oil line, one on pump inlet and other on pressure oil line, as soon as one side becomes clogged the flow is changed and the clogged strainer removed and cleaned.

TEMPERATURES AND PRESSURES—The normal operating temperature and pressures are as follows:

Pressures.	Temperatures.
Exit from scrubber tower 2½-3¼ inches,	
In pan	365°
Exit from filter ¾-⅞ inches,	
In exit from concentrator tower	200-220°
Exit from concentrating tower ¼-¾ inches,	
In exhaust	150°
In combustion chamber ¼-½ inches.	
Air agitation, acid pool 8½-10½ inches.	

Too high a pressure indicates a choke in line between them, and combustion chamber, too low, an air leakage or a choke between them and fan.

FLOW REGULATION—The flow is regulated by changing level o siphon in distributing tank by means of winged nut on suspensio bolt, and measured by number of holes through which acid flows i gauging box. The flow is regulated to keep a proper temperatur in pan (365°) and should never be changed more than half a hol at a time. The effect of a change is noticeable in the strength o the strong acid from the cooler, two to three hours after chang is made.

SPRAYS—The spray in scrubber and centre one of filter tower is kept on full while concentrator is running end ones of filter tower are not required on full unless sulphur fumes can be detected in the exhaust. In the case of these towers it was found unnecessary to save washings from filter towers, as acid content was too small; they were therefore run to sewer. The spray in the flue from the concentrating tower is not used except in emergency, when temperature at that point becomes 400°, which in concentrating to 75% is unlikely.

FANS—The fan must be kept running while tower is in operation. If the fan stops, the burner must be immediately shut off.

OIL PUMPS—The oil pumps are arranged in duplicate so that in case of trouble with one the other may be started and the disabled one immediately repaired. The air chamber on the pump discharge line dampens out the pulsations caused by the pump. When they become excessive (10 lbs. on pressure gauge) it means air is exhausted from chamber, which must be replenished by reducing oil line pressure to 25 lbs. and blowing in compressed air until guage shows 45 to 50 lbs. The air is then shut off and that in chamber expands feeding oil, until pressure has dropped to 25 lbs. again when the oil pressure is restored to its former value.

COOLERS—The coolers installed have very little margin of capacity and if a rush of acid is forced into them by flushing the towers, penetrating acid vapors will be given off from coolers. To remedy such a condition the flow in the tower and pressure on oil line are reduced, thus lowering pan temperature. The acids should leave the coolers at 80 to 90° and should never exceed 110°. If fumes persist, the cooler cover is fastened down and joint made tight. A flow of acid must be kept going from coolers at all times.

All moving gear, siphon in distributing tank, level indicator, etc., are kept properly oiled, outlets from distributor clear and unchoked, water sprays running properly and seals around them filled with water or preferable strong acid, and the outlet to sewer kept dry, as observed through holes provided for that purpose.

OBSERVATIONS—The following readings are recorded by the operators on printed forms Nos. 1 and 2 (Form 108) every hour:

Oil pressure and temperature, air pressuse in agitator and pan temperature, strong acid discharge Baume and temperature, weak acid feed, Baume, temperature and rate (number of holes), draught in combustion chamber, at exit from concentrating tower, filter tower, and at exhaust, and temperatures at exit from concentrating tower, and at exhaust.

The foreman records daily observations as outlined on pink sheet (Form 111) of the sulphuric acid in storage or received, in various tanks, strength, number of eggs elevated and delivered, oil consumption, and fresh acid and oil received.

From these observations the foreman calculates the data for the daily acid report (Blue Form 109) which are checked by the Engineer. This form shows the quantities of acid handled, strengths, oil consumed, acid losses, etc.

From the latter sheet a monthly summary of the acid plant operation is filled out, as in sheet 109 (yellow).

SHUTTING DOWN PLANT—In shutting down a tower, the oil i turned off, pump stopped, and steam shut off oil heater. The burne is removed, and all openings in front of combustion chamber plugged, and the fan damper lowered until a quarter open only. A fee of 1½ holes of acid is left on for 2 hours and after 4 hours th damper is completely lowered, all sprays shut off, cooling wate turned off coolers, and the windows at the top of the tower opene

STAFF—The plant is in general charge of an Engineer, th actual plant operation being under direction of a Superintenden who makes out reports and under whom are three shifts of tw operators each.

TOWER PERFORMANCE—On a test run (acceptance trial) lastin five days, on one tower only (since towers are exact duplicates during which the tower was operated on fresh acid continuousl re-diluted and re-concentrated, 5,852 gals. (68,730 lbs.) of 24.67% acid were concentrated per day to 1,370 gal. (16,909 lbs.) of 74.33% acid.

The corresponding oil consumption averaged 319 gals. per da equivalent to 13.3 gals. per hour and 11.8 gals. per ton of 75% acid produced. The oil consumption was determined by measurin each day the decreasing level in the 12,000 gal. oil tank, a metho not permitting of great accuracy.

OPERATION DIFFICULTIES.

A number of difficulties of a serious nature have been encountered in running the acid plant.

DISINTEGRATION OF TOWERS—FORMATION OF SLUDGE—In several cases the shutting down of a tower has been necessitated for washing down through the choking up of the cooler, and the ports from pan in front of tower with the so-called "sulphate mix." On opening the tower it was found in each case that the bottom of pan was covered with a 4" to 6" layer of a white clay-like substance (presumably sulphate silicate mixture) covered with a hard black scale. Water and washing removed a great deal of this, but the remainder had to be removed with buckets. The cooler was completely choked up with the sludge.

The sulphate also settled out in the strong acid tanks in the form of sand, which collected very rapidly. In one case noted a depth of three inches collected in the bottom of No. 4 tank in one day, and a depth of four inches has several times been washed out of the tanks. The sand is almost completely soluble in water, which renders cleaning of tanks, etc., comparatively easy, but the sludge causes a great deal of trouble in the M.E.K. plant, choking pipes, preventing closing of valves, etc.

Stalactites were also formed in the towers presumably of sulphates, formed by dissolving of the masonry or from silicate of soda. On one occasion three were observed through peepholes at back of towers, hanging from the bottom of the tower.

Apparently the chemical brick which is highly resistant to strong 60 Baume acid is not nearly so resistant to 25 Baume acid, which is borne out by evidence that the sulphates are not soluble in the 60 Baume acid since they are found in the strong acid pipes and tanks, coolers, etc. The case is a parallel one to the action of strong and dilute sulphuric acid on iron, the former having no effect while the latter corrodes rapidly.

It was at first considered that the disintegration of the towers by the acid was due to certain organic compounds contained in the acid rejected from the M.E.K., but this was disproved by the fact that on the acceptance trials the towers were run on clean fresh acid newly purchased, which was diluted and reconcentrated over and over again, with sludge or sulphates forming as before when operating on the acid from the M.E.K. plant.

Such acid towers as those built at Toronto are normally employed in the concentration of strong acid, 50 Baume to 66° Baume, and under these circumstances no disintegration occurs. The M.E.K. proposition however, was an unusual one, and one on which the towers had never before been employed. From the evidence cited, it is apparent that the masonry was rapidly disintegrating under the action of the weak acid, and that the life of the towers on such a concentration process (25% to 75% acid) was strictly limited, and that the towers would soon have become unserviceable under continued working at full capacity.

ADVANTAGE OF INTERCHANGER—Under these circumstances, the Shaw Interchanger referred to above was particularly advantageous and invaluable in that the Interchanger could handle successfully the lower concentration, leaving the towers to deal only with the higher concentration; although from later information secured it appears that the interchangers themselves may possibly be able to take care of the full concentration.

DESTRUCTION OF LINING—While the corosion and disintegration in the towers themselves was not observable without breaking into towers, the effects were readily observable when the combustion chamber and the concentrating flue were entered through the manholes, when it became necessary to clear out the accumulation of sludge and to repair the lining. The lining of the combustion chamber and concentration flue of the towers after a few weeks' operation was found on examination to be in bad shape. The high temperature cement lining had cracked off the interior of combustion chamber, the brick at top of acid level was corroded very badly, and the tile lining had broken away from the wall. On examination, these troubles were all stated to be due to bad materials, which were replaced at the builder's expense. The tiling at base of tower was replaced by chemical brick on edge, the five lower courses in flue (three of acid proof and two of firebrick) were removed, and replaced by five courses of chemical brick, and the high temperature cement lining of combustion chamber was replaced with a layer of Hytempite. The latter was found on operation to blister and run. The towers received no extensive run after the other alterations, so that no data is available as to effect of these alterations.

While this breaking up of the tower lining may have been largely due to the use of poor materials, it appears that it is simply part of the general disintegration of the towers due to the nature of the service in this plant.

ORGANIC MATTER IN SPENT ACID—It was noticed in concentrating spent acid from M.E.K. that a black, oily, tarry mass rose to the surface in the weak acid tank and in distributor tank as the acid cooled, and that acid was black in cooler. It was found on concentrating a sample of the same acid in the laboratory, that quite a heavy deposit or scum of some organic matter formed on the top, and that the 75% acid was quite black. The tarry matter was apparently carbides resulting from polymerisation of the butylene in the M.E.K. process and is unavoidable. That this is so is proved by the fact that during the acceptance trials the towers were operated on fresh sulphuric acid, and the acid produced was a light coffee color, but the sludge was produced as with M.E.K. acid.

In this connection it was at first considered that the tarry matter and blackening of the acid was due to imperfect burning of the oil, resulting in the formation of soot. Doubtless, at the beginning this was to some extent true, owing to the trouble experienced with the charcoal oil heater provided as part of the oil burning equipment. With the substitution of the Shaw Interchanger as steam oil heater, this trouble ceased, and it was subsequently shown by investigating in the laboratory the spent acid from the M.E.K., that as described above, the scum was formed and the acid turned black on concentration and that the acid contained a number of high boiling oils.

To prevent as much as possible of this scum collecting on the top of the acid from being sent up to the distributing tanks, and so into towers, the cooling trough was installed around the acid delivery pipe from the M.E.K., and raking-off troughs placed at the ends of the weak acid tanks into which the scum is raked as it collects on the surface. Up to the time of closing down the tarry matter had not gummed up the towers as no marked increase of draught gauge readings were observable. Had this occurred, it would have been necessary to repack the towers more openly.

LOSS OF ACID—During the initial operating of the towers, a loss of acid by absorption by the brickwork and packing material of from ten to fifteen tons is expected, which should all occur within the first month. In the case of these towers, the loss of acid continued up to shutting down of plant at a serious rate. Various explanations were offered. Undoubtedly some of the lost acid went into the production of the sludge, while some more was lost in the exhaust, said by makers to be ½ to 1%. Leaking washouts or drains were also suggested and led to drilling holes in all drains to permit observation of interior. The leaks of this nature were found to be negligible.

The losses varied from 800 to 4,000 lbs. per day, with an average of about 1,500 lbs. or 10% of acid handled. An investigation was made of acid present in gases at outlets from various towers and from the wash water discharged from filter tower. The results were as follows:

Date.	Pounds per cu. ft. of H2SO4 in outlet gases from Concentrator.	Filter tower.	Scrubber.	%H2SO4 in filter tower discharge.	Strength of acid discharge.
August					
7	—	—	.000306	0.913	58.3 Be.
9	.000512	—	.000143	1.02	62.0 Be.
10	.000287	—	.000112	0.47	57.7 Be.

From these figures, assuming the fan handles 2,000 cu. ft. of exhaust gases (rating is 2,260 c.f.m. at 719 r.p.m.) the losses in lbs. of sulphuric acid per day will be as given in the following table, together with the actual loss as shown by the daily report for that day.

Date.	Calculated loss in exhaust gases.	Actual loss as shown by reports.	Calculated losses in gases from concentrating tower.
August 7	594	2,751	1,475
9	412	6.585	1,475
10	321	2,031	826

From these, while the loss in the exhaust gases is large, it does not account for the great absolute loss as shown by the tank records. Nor is this loss one through acid going to sewer in scrubber and filter tower wash water, since as is shown by the last column the acid leaving the concentrator in the gases, which represents the loss in this cases where neither filter nor scrubber tower wash waters are concentrated, is not nearly equal to the actual loss.

Fumes from Coolers—Considerable trouble was experienced through coolers giving off penetrating and disagreeable fumes. It was learned, however, that all coolers fume more or less, and that if keeping the temperature of acid within proper limits is not effective, all that can be done is to fasten down the covers and make the joints tight.

J. H. Parkin,
Mechanical Engineer.

Approved:
E. Metcalfe Shaw,
Engineer-in-Chief.

CONSTANTS FOR M.E.K. PROCESS
French and English Units

No.	Constant	Normal Butyl		Secondary Butyl		Butylene		M.E.K.	
		French	English	French	English	French	English	French	English
1	Molecular Weight.....	74.08	74.08	74.08	74.08	56.06	56.06	72.06	72.06
2	Specific Gravity—								
	Liquid..........	.81	.81	.819	.819	0.607	0.607	0.8036	0.8036
	Vapour Air = 1..	2.56	2.56	2.56	2.56	1.94	1.94	2.49	2.49
3	Density—Liquid.....	.81 gm.-cc.	50.46 lb.-c.ft.	.819 gm.-cc.	51.02 lbs.-c.ft.				
	Vapour.....	3.31 gm.-lit.	.2066 lb.-c.ft.	3.31 gm.-lit.	.2066 lb.-c.ft.	2.51 gm.-lit.	.157 lb-c.ft.	3.22 gm.-lit.	.2073 lb.-c.ft.
4	Specific Volume......	303 lit.-kg.	4.84 c.ft.-lb.	303 lit.-kg.	4.84 c.ft.-lb.	398 lit.-kg.	6.38 c.ft.-lb.	310.5 lit.-kg.	4.82 c.ft.-lb.
5	Temperature—								
	Vaporization.....	116.8°C	242°F.	90-100°C	210-212 °F.	-5°C. 1-2.5°C.	23°F. 33.8-365 °F.	79-81°C.	174-178 °F.
	Critical....	......	....	....	....	....	....	....	....
6	Specific Heat—Liquid	.5	.5	.5	.5	....	....	.5	.5
	Vapour	....	....	....	....	....	....	.4	.4
7	Latent Heat of Vap...	143 cal.	257.37 B.T.U.	136 cal.	244.77 B.T.U.	....	....	103.4 cal.	186.1 B.T.U.
8	Vapour Pressure.....	....	....	....	....	92.56 mm-0°C	17.9 lbs.-sq.in	76. mm.-21°	1.47 lbs.-sqin.
10	Solubility............	1 in 8	1 in 8	1 in 29	1 in 29	....	....	....	....
11	Temp. of Reaction ...	....	....	....	....	400–420 °C.	752–788 °F.	150–250 °C.	300–480 °F.
12	Heat of Form (Endo. Heat)	....	....	....	....	56.6 cal.-gm.	102 B.T.U.-lb.	166 cal. gm.	299 B.T.U.-lb.

DRAWINGS.

Drawing. No.	Title.
A184	Variable Stroke Pump.
A236	Butyl Salting Plant.
A251	Alterations to Scrubbing System.
A264	Interchanger Piping.
A287	Arrangement of Butylene System.
B295	Catalyst Furnace—First Stage.
B307	B.H.S. Constant Level Feed Control.
B310	Measuring Tank.
A343	Catalyst Furnace—Third Stage.
A365	Sulphating Mixer.
A396	Lead Still—Elevation.
A397	Lead Still—Plans.
A405	Acid Concentrating Plant—Plan.
A406	Acid Concentrating Plant—Sections.
A407	Diagrammatic Layout Mill St. Stills and Tanks.
A409	Proposed and Ideal Interchanger Layouts.
A410.	Revised Catalyser.

E. B. Badger Sons & Co.'s Drawings.

8675	B-2-6' 0" ID x 7' 0" Sulphuric acid Diluting Tank.
8678	36" ID Tinned Copper Storage Tank A-1.
8679	3' 0" Lead Lined Mixing Tank "C."
8683	10' 0" ID x 6' 0" Lead Lined Boiling Kettle (Stage "E.")
8684	72" ID-12 Plate Column lined with ¼" thk. CP. Stage E.
8684-2	Detail of Boiling Cap Plate for 6' 0 Lead Lined Column.
8685	37½" ID Condenser Stage "E."
8686	24" ID Dephlegmator (Copper) Stage "E."
8688	Stage "E" Elevation of General Arrangement of Lead Lined Still
8688-1	Plan of General Arrangement of Lead Lined Still, Stage "E."
8703	Stage "F" (Revised) Elevation Preliminary Arrangement Scrubbing and Recovery System.
8705	Plan of General Arrangement of Interconnecting Piping.
8706	Elevation of General Arrangement of Interconnecting Piping.
8709	Digrammatic Arrangement showing Apparatus from "B-1" to Stage "E" inclusive.
8887	10' 0" x 16' 0" Kettle with 250' 0" Steam Coil.
8888	60" ID-36 Plate Steel Exhausting Column.
8899-1	Steel Shell for Kettle 10' 0 x 24' 0".
8899	Steel Kettle 10' 0" ID x 24' 0".
8892	General Arrangement of M.E.K. Refining Still.
8901	60" ID-24 Plates Exhausting Column.
8906	General Arrangement of Secondary Butyl Alcohol Still.
8911	Caustic Washer (proposed).
8921	40" ID-40 Plate Column (Stage "F").
8924	21-⅝" ID Preheater to Recovery Still.

8925	60"-12 Plate C. I. Column (Stage "F.")
8926	3' ID-12 Plate Column (Stage "F."
8297	22" ID Condenser (Stage "F").
8928	18¼" ID Oil Decanter.
8930	4' 0" ID Evaporator (Kettle).
8933	36" ID Salt Solution Storage Tank.
8937	Stage "F" Elevation of General Arrangement of Scrubbing and Recovery Systems.
8938	Stage "F" Plan of General Arrangement, Scrubbing and Recovery System.
8939	Stage "F" Diagrammatic Arrangement of Scrubbing and Recovery System.

M

EDWAR

TORONTO

BRITISH ACETONES TORONTO, LIMITED.

REPORT
ON THE
ELECTRICAL ENERGY REQUIRED
BY THE
BRITISH ACETONES TORONTO, LIMITED
AND THE
OPERATION AND CARE
OF THE
MECHANICAL AND ELECTRICAL EQUIPMENT
OF THE
METHYL ETHYL KETONE PLANT
AT TORONTO.

EDWARD METCALFE SHAW, WH.SC., ASSOC. M. INST., C. E.
Engineer-in-Chief.
BY
D. J. THOMSON, B.A.SC.,
Electrical Engineer.

TORONTO, CANADA, February 15th, 1919.

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SECTION NO. 1.

GENERAL INTRODUCTION.

USES OF ELECTRICAL POWER—Electrical energy is used throughout the plant of the British Acetones Toronto, Limited, for three purposes:

(1) Power for motor drives in both the Acetone and the M.E.K. plants.

(2) Lighting of both plants.

(3) Electric heating of the catalysers in the M.E.K. plant.

The acetone plant uses no electrical energy save for lighting and power, hence no description of the process will be here necessary. But as the M.E.K. plant employs electric power directly in part of the process, it seems advisable to give a brief description of the method of manufacture of Methyl Ethyl Ketone.

BRIEF DESCRIPTION OF M.E.K. PROCESS.

FIRST STAGE—The first step is to change the rectified butyl alcohol obtained as a by-product in the manufacture of acetone into butylene, a gas easily liquified. This is done by first evaporating the alcohol, and then passing it through heated chambers or catalysers containing the catalyst. These catalysers are heated by electrical means owing to the delicate control possible with this method, as an excessive rise of temperature may destroy the active qualities of the catalyst. After the gas is passed through the first stage catalysers it is cooled, compressed, and then collected as a liquid in the butylene storage tanks.

SECOND STAGE—This stage is purely chemical, consisting of mixing sulphuric acid and butylene by agitating them strongly in sulphator. The resultant compound is Butyl Hydrogen Sulphate, from which on the addition of water in the lead lined still, Secondary Butyl Alcohol is obtained. The extra water is removed by salting, and the crude secondary butyl is rectified.

Third Stage—The rectified secondary butyl alcohol is evaporated and once again led through the catalysers containing another catalysing agent. Here it is converted into crude M.E.K. and hydrogen. A scrubbing system recovers the M.E.K. carried away by the hydrogen.

It is to heat these catalysers that the large supply of electric energy was required, and although heat derived by this means is more expensive than that derived by the combustion of coal gas, yet the delicacy of control more than offsets this disadvantage.

ECONOMIC CONSIDERATIONS.

Before the erection of the M.E.K. plant, the British Acetones Toronto, Limited, was supplied with 550 volt, 25 cycle, 3 phase alternating current by the Toronto Electric Light Co.

When the M.E.K. plant was authorized, the load already contracted for with the Power Company was seen to be insufficien for future needs, so that it was necessary to secure a new supply. The Power Company could allow us only a small increase at 55 volts, but they could supply us with current at 12,500 volts fro their substation on Cherry Street, which is about 1,000 feet fro our catalyser room. It was decided for the following reasons utilize the 550 volt service for lighting and power loads throug out the whole plant, and to use the 12,500 volt service for heati the catalysers.

(1) The 550 volt service rate had been fixed before the pow shortage became acute, and was considerably lower in price tha that for the new 12,500 volt power.

(2) By utilising the 550 volt service for power and lighti the M.E.K. plant was made standard with the Acetone plant, th necessitating keeping fewer spare motors in stock.

(3) Transformers were available for immediate delivery at reasonable cost, for stepping down from 12,500 to 200, 140, 100, or 50 volts—220 volts was decided on as the highest voltage p missable for use on the heater elements with safety to the op ators.

(4) Owing to the high cost of electric power, oil heating of catalysers was being considered, and should this latter prove ada able to the needs here, the electric heating could be dispensed wi and the contract for current at 12,500 volts allowed to expire wi out in any way affecting the lighting or power loads.

This report, therefore, resolves itself into two parts; first, that dealing with electric lighting and power throughout the whole plant, which can be considered as standard practice, and second, that dealing with the supply of heat to the catalysers, which up to the present we believe to be new work, and consequently unknown.

SECTION NO. 2.

LIGHTING AND POWER.

ORIGINAL POWER SUPPLY—The original power suppy at 550 olts, 3 phase, 25 cycle to the Gooderham & Worts and the General Distilleries Limited was first brought into the Pump House on Trinity Street, where it was metered and then distributed to the arious buildings. When the General Distilleries was taken over y the British Acetones Toronto Limited, the old arrangement was dhered to, the addition of a meter to divide the current consumed y the Gooderham & Worts Company from that used by the British cetones Toronto Limited, being the only change.

CHANGES—As the latter company gradually extended, more and ore power was required, both for lighting and for motor load. he old distributing board in the pump house and the main over- ad lines from it to the General Distillery building became over- aded. Heavier lines were put in, and a new switchboard was set p in a small brick building built against the south wall of the eneral Distillery Building, which also housed the transformers epping down the voltage from 550 volts to 220-110 three wire. is new switchboard divides both the power and lighting among e various buildings.

While the work of wiring the buildings for both light and power nformed to standard practice, there were several precautions ken, owing to the inflammable nature of the gases, in some of e buildings. The following methods were followed:

GENERAL SPECIFICATIONS FOR POWER AND LIGHTING WIRING—

(1) All wires whether for lighting or power were run in con- it.

(2) No fuses or switches which permitted arcing at the contacts re allowed inside the buildings where inflammable gases could sibly be present in explosive quantities.

(3) All motor starters operated in oil, and where possible were protected by an overload coil which operated by opening the main contacts under the oil.

(4) All lighting fixtures were of the vapor-proof variety, and the conduit pipe leading thereto, throughout the whole length was vapor-proof. This was accomplished by using condulets instead of junction boxes, and making up every screwed joint with oil and red lead.

(5) Every portable lamp socket was of the vapor-proof variety heavily protected, and the extension cord thereof was provided at the other end with a "push-in" plug. Sockets for these extension cords were located in the outside air within convenient reach of window or doors, and were suitably enclosed for protection in cast iron condulets. By equipping every extension with a push-in plug, the workmen could not unscrew a lamp from its socket, and there attach an extension cord.

(6) All bells for signalling purposes were of the non-arcing type, or mechanical pull type.

Motors Used—The motors used throughout the plant are as follows:

C.W. Represents—Crocker Wheeler.
West. Represents—Westinghouse.
C.G.E. Represents—Canadian General Electric.

No.	Location.	Duty	Manufacture.	Speed.	H.P.	Serial No.
1.	West B. House,	Draft Fan	C.W.	750	30	63-
2.	Trinity St. B. House,	Draft Fan	C.W.	750	15	Q-118
3.	East B. House,	Draft Fan	C.W.	750	20	118-A
4.	Machine Shop,	Ventilating Fan	West	720	7½	599
5.	Machine Shop,	Machine Tools	C.G.E	1500	7½	227
6.	Shipping Room.	Salting Machine	C.G.E.	750	3	125
7.	Shipping Room,	Hoisting Outfit	Lincoln	variable	1¾	Z-111
8.	Main Floor, Gen.	Ventilating Fan	West	700	3	293
A9.	Fermenting Floor,	Ventilating Fan	C.G.E.	750	2	238
B9.	Fermenting Floor,	Ventilating Fan	C.G.E.	750	2	238
10.	Seed Tanks F.,	Seed Tanks	C.W.	1500	5	145
11.	Top Floor Gen,,	Inoculators	C.W.	1500	3	45
12.	2nd Floor Gen.,	Ventilating Fan	C.G.E.	1500	7½	227
13.	Research Lab.			500	½	
14.	Mr. Shaw's Office	Lathe	C.W.	1500		34
15.	Concentrator,	Crude Oil Pump		750	2	L333
16.	Concentrator,	Crude Oil Pump	Roth Bros.	750	2	L333

17. Concentrator, Fan Motor	West	720	15	59966
18. Concentrator, Fan Motor	West	720	15	59966
19. Catalysers, Driving Pumps	West	700	3	58854
20. M.E.K., Driving Kettle	West	1400	3	60070
21. M.E.K., Sulphator	West	730	15	59190
22. M.E.K., Salting Machine	West	700	3	58853
23. M.E.K., Running Mixer	West	700	3	55251
24. 2nd. Floor Mill, Running Blower	West	720	10	48677
25. Elevator, Running Conveyor	C.W.	750	10	1592
26. Elevator, Running Conveyor	C.W.	750	25	1136
27. Elevator, Running Winch	C.W.	750	10	15008
28. M.E.K. 1st Floor, Blower Fan	West	700	3	37998

SECTION NO. 3.

DESCRIPTION OF ELECTRICAL INSTALLATION IN THE M.E.K. PLANT.

Power Line—Electrical power for this plant is supplied to us at 12,500 volts, 3 phase 25 cycles, from the Toronto Electric Light Company's Cherry Street substation. This line, of wooden pole onstruction, passes across the Gooderham & Worts property, over Trinity Street and the Workmen's Lunch Room, and enters our ubstation, a distance of approximately 1,000 feet.

Transformer House—The transformer house of brick and ement construction, and absolutely fireproofed, is shown in Dwg. No. 350A, but a brief description will be given.

The wires enter the south wall of the building through three 5,000 volt porcelain entrance bushings and pass to the top of three 5,000 volt disconnecting knife switches. From the bottom of these witches, the leads run to the oil switch, two of them passing rough the meter current transformers, and jumpers from all ree passing over to the two meter potential transformers hung n the south wall under the entrance bushings. The meter is a estinghouse Polyphase Curve Drawing Watt meter, and is fast- ed to the panel in front of the oil switch. This whole section, in- uding disconnecting switches, current and voltage transformers, switch and meter, is the property of the Toronto Electric Light mpany.

The three wires lead from the Power Company's oil switch rough our oil switch, and pass overhead to connect with the wer transformers. Of these we have 3-300 Kva. single phase

25 cycle O.I.W.C. 12,000 volts primary to 200, 140, 100, 75, 70 and 50 volts on the secondary. For our present requirements we have connected in only two in open-delta thus saving the cost of the exciting current for the third. Provision was made that the third transformer could be connected in a few minutes for both primary and secondary in case of an accident to either of the other two.

In this building, all insulators, switches, etc., are mounted on pipe frames, making a clear open construction, and all high tension wires, save where they enter the oil switches, are carried about ten feet above the floor. To prevent the water cooling supply to the transformers freezing in winter, it is brought into the building across the open space from the switch house parallel with and close to the exhaust steam pipe for heating, both pipes being lagged.

The three low tension lines carrying current at 200 volts 3 phase 25 cycle pass out through the west wall close to the north west corner of the Transformer House and enter the Switch House.

SWITCH HOUSE OR CONTROL ROOM—This building was originally intended to be only temporary until the needs were fully known, and is hence of a cheap wooden construction. The interior layout is shown in drawing No. 330A.

SWITCHBOARD—The lines from the transformer station enter the switch house and, turning at right angles, pass along the top of the skeleton switchboard to form its main buses. The switchboard is designed to handle 36 catalysers with a separate switch for inner and outer heaters. The outer heaters are either on or off, but the input to the inner heaters can be varied by a water rheostat from almost zero to full capacity.

Current from the main buses to supply the outer heaters is led to the top terminals of 36-60 amp. D.P.S.T. fused knife switches mounted in a row along the top of the board. From the lower terminals of these switches the No. 6 wires pass to the condulets on the 1" conduit line to the catalyser room.

For the inner heaters, two No. 2 wires from the main buses are lead to the top terminals of each of the 36-100 amp. D.P.S.T. fused knife switches which are placed immediately below those for the outer heaters. From one of the lower terminals one wire passes through a barrel rheostat to the conduit pipe leading to the catalyser room. From the other terminal the wire leads to a 100 amp

S.P.S.T. knife switch mounted horizontally, and provided with taps on each terminal to facilitate connecting in an ammeter. From here this second wire passes to the conduit line.

METERING ARRANGEMENTS—Just before these two feed lines enter the conduit, a voltage tap is brought back from each, connecting into a push-in plug receptacle which facilitates voltage readings by the operator. Thus with one voltmeter and one ammeter, the input to each inner heater can be quickly and conveniently ascertained. The meters, mounted on a platform, slide along a shelf on the front of the board.

RHEOSTATS—The water rheostats are of the barrel type with one stationary plate in the bottom, and a movable "V" shaped plate dipping into the brine from above. This "V" plate is suspended by a rope carried on pulleys to the front of the board where it is counterweighted by a 28 lb. sash weight. In order to prevent leakage from one barrel to another, or to ground, as well as to protect the operators from shocks, each barrel is set on porcelain cleats and the whole frame work of the floor, sustaining rheostats and switchboard, is supported on glass insulators. These details are fully covered in Dwg. No. 330A.

CONDUIT LINES—The conduit lines at the back of the board are rranged in three groups, each group supplying four batteries of atalysers and containing 12-1" lines for the outer and 12-1½" ines for the inner heaters.

Referring to the end elevation of drawing No. 330A, it is seen hat each of these groups passes downward through the floor and nto a pit. This pit was constructed and the conduit was installed ith the idea that should automatic controls be later installed, the onduit could be broken just before it leaves the switch house to nter the catalyser room without disturbing the floor of the latter. ach pipe, therefore, was joined at this point by means of a running thread, made water tight by painting with tar, the joints in ach tier being successively moved nearer the wall than those in e layer immediately beneath.

In the catalyser room (Dwg. 414B) the conduit passes under e floor, being distributed so that one 1½" riser for the inner eater and one 1" riser for the outer is supplied to each catalyser.

These uprights, each terminating in a Type "B" condulet with a 2 hole porcelain cover, are securely bolted to a 2½" pipe railing set in concrete footings.

Electric Heaters—The wires projecting from the condulets are attached by heavy connecting clamps to the electric heaters. Of these there are two types inner and outer heaters, but as these heaters are manufactured on the premises a full description of them would be long. A detailed report of their design, construction and installation is given under a separate heading.

SECTION NO. 4.

ELECTRIC HEATERS, THEIR DEVELOPMENT, DESIGN, CONSTRUCTION AND INSTALLATION.

DEVELOPMENT OF HEATERS.

Experimental Stage—Early in the experimental work on the M.E.K. process, attempts to use gas heating for the catalysers proved unsuccessful, owing to its imperfect control causing rapid and wide fluctuations of temperature.

Electric heating was then employed, the resistance wire being wound directly on the catalyser. A Nichrome resistance ribbon of a suitable length was first braided with Asbestos Twine to prevent short circuiting between the adjacent turns. The catalyser tube was then covered with pieces of Mica, and the nichrome was then wound over the mica, thus holding it in place. To hold the wire in place and to secure the ends, successive wrappings of asbestos twine were used.

Defects—While this type gave very good results as far as experimental work was concerned, yet serious defects had shown themselves which can be here noted.

(1) When all the heat is forced into the catalyst from one direction, if the mean temperature of the gas is correct, it is most probable that part of the catalyst is underheated and part overheated resulting in its shortened life.

(2) Mica is a splendid heat insulator, and, although this heat insulating quality falls off at high temperature, yet a high resist

ance is inserted to the flow of heat causing an excessive temperature on the resistor for a moderate output.

(3) The mica, under the expanding and contracting nichrome, is always shifting, giving rise to grounds.

(4) The mica is expensive, particularly when purchased in the large size sheets that would be required for a working plant.

(5) Asbestos rapidly deteriorates causing repeated overhauling of the heaters.

(6) In making any repair all the lagging had to be taken down, the resistance wire taken off, and the whole installation built up again before operation could be resumed.

IMPROVEMENTS DESIRED—For these reasons it was decided to alter the design of the heaters so that the following points would be obtained:

(1) The heat should be supplied from two sources, thus necessitating an inner and an outer heater.

(2) Each heater should be a complete unit in itself facilitating easy removal and quick replacement should an accident or burn out occur, subsequent repairs to the damaged heater being affected away from the catalyser.

(3) All insulating material separating the conductors should not deteriorate under the extreme temperatures dealt with.

MANUFACTURERS CONSULTED—The General Electric Company of Schnectady, and the Canadian Westinghouse Company of Hamilton were approached with the idea of having either of them supply the needed equipment. In the meantime experimental work was begun in the plant. The Westinghouse Company stated plainly that they were in no better position to supply our requirements han we were ourselves, and that their cost for special apparatus f that kind would be as high or higher than if we built it ourselves.

The General Electric Company sent in a quotation accompanied y blue prints and a specification which did not appear to meet our eeds. Further their time of delivery was 4½ to 5 months, and t seemed a hazardous undertaking to delay that length of time to ecure apparatus which might or might not suit our requirements. Therefore their offer was refused, and our own heaters were developed as per dwg. B404.

CONSTRUCTION OF INNER HEATERS.

Forming the Wire—The resistance wire is received in coils of approximately 1,000 feet for Kromore, but much less for Chromel. These coils are placed on a winding drum and then a sufficient length for an element is pulled through a wire straightener (see Dwg. No. B308) to remove all coiling tendencies. The piece of wire after passing through an adjustable tension block with copper jaws is led to the coil former (see dwg. No. C311). Here it is inserted between two of the removable strips, leaving 20 inches projecting for one of the leads. The coil former is then revolved half a turn against the drag of the tension block bending the wire about the end of the strip. Owing to the springy nature of these resistance materials, the bend is still not sharp enough and must be closed up by means of gas pliers and a hammer and copper drift. Another strip is inserted, the coil former is given a half turn in the opposite direction, and the resultant bend in the wire again made sharp. This is repeated until the whole coil is formed in a horizontal plane.

Double Leads—In order to prevent overheating of the leads when they pass through the heat insulation, a piece of the same resistance wire 22 inches long is bound to each lead and welded to the last turns about two inches below the top of the coil. Considerable care must be exercised in this welding to prevent burning the metal, making it exceedingly weak and brittle. The best results have been obtained by using a reducing oxyacetylene flame with borax as a flux.

Alundum Covering—The formed coil is now bound about a central alundum tube 8½" bore x ½" wall x 24" long, made specially for us by the Norton Company of Worcester, Mass., and is covered with a ⅜" layer of alundum cement trowelled to place, leaving the loops of the wire exposed at the top to provide for expansion. The heater is then set aside to dry for 24 hours, and then dried for 24 hours in a steam heated kiln.

Firing—After coming from the drier, band wires are wrapped around the heater, and then it is fired in an electric furnace of the resistance type. This furnace is gradually heated from room temperature to about 2,000° F. held at that temperature for several hours and then allowed to cool gradually. In the manufacture of alundum ware, the firing is usually carried on for about two weeks with a steady improvement in quality, but in making these heaters we found that baking for 24 hours in the furnace was sufficient, as it was completed by the heaters themselves in operation.

BANDING—After the heaters are baked, three permanent band wires as shown in Dwg. No. B404 are put on, and, since the alundum cement has now hardened, they can be brought up tight, the old ones being removed.

SHAPING THE LEADS—The two leads from the heater are then bent through two slots in the top of the Alundum tube. Immediately inside the tube they are secured by a short block of transite to prevent any movement of the leads being carried down and cracking off the alundum cement. Then each lead is bent to a template to give the required spacing as per Dwg. B404. No difficulty will be met in this bending unless the metal has been overheated while welding on the double lead.

CONSTRUCTION OF OUTER HEATERS.

Drawing No. C246 shows the cast iron mould used in making these heaters. As alundum cement contracts in drying it is necessary to make provision that the flanges will not crack off. This is accomplished by putting metal strips ⅛" x 1" x 26" long, along the side of the flange the surplus 2" projecting through the slot in the end plate of the mould. To prevent the cement sticking to the mould it is thoroughly lined with tar paper.

The mould is now filled half full of alundum cement mixed with water, and a coil formed in the same manner as for the inner heaters is placed in position being held there by three transite strips (Dwg. No. 404B, Item 6). The mould is then completely filled with alundum cement with the exception of a space at the top where the loops are left bare. The two metal strips at the side of the flange are now removed, and the cast set away to partially harden. The remainder of the drying and baking is the same as for the inner heaters.

ELECTRICAL DESIGN OF INNER HEATERS.

The only factors limiting the maximum capacity of heaters of the type used by the British Acetones Toronto Limited are the area of the radiating surface and the temperature attained by the resistor.

TEMPERATURE RISE—In this plant the size of the heater was fixed by the design of the catalyser and therefore any increase in input to the heaters caused a corresponding temperature rise. Curve No. 411C shows the radiation in kilowatts of a heater 10¼" dia. and 24" long at various temperatures of the heater itself, and of the gas passing through the catalyser. The temperature of the heater was obtained by using a platinum thermo-couple, the thermo-couple being suspended in the air inside the tube. Since the flow of heat is outwards from the heater to the catalyser, the temperature of the air inside the tube has been considered as the temperature of the heater.

RESISTANCE WIRE USED—The resistance wires employed by the British Acetones Toronto Limited were the Driver Harris Company's Kromore and Nichrome, and the Canadian Hoskins Company's Chromel "A" cold rolled. The maximum safe working temperature of Nichrome consistent with long life is about 1,700° F., and a small supply of this was bought owing to our being unable to secure delivery of either of the other varieties. Kromore and Chromel, according to the manufacturers will withstand at least 1,800° F. and, in our heaters made from these materials and continually operating at this temperature, no deterioration has been apparent. In one heater element of Chromel designed for baking the catalyser heaters the temperature often attains 2,000 ° F., and no trouble has resulted. We cannot state therefore what is the maximum operating temperatures for Chromel or Kromore, or which is the better, since both have stood up admirably, and we have not had one failure from overheating or oxidation. Indeed the only failures were due to gas leakage completely carbonizing the whole heater and short circuiting the winding between adjacent turns.

CURRENT CARRYING CAPACITY OF WIRE—The current carrying capacity of the resistance wires themselves was limited to that value which would cause a wire stretched horizontally in free air to attain a temperature of 1,112° F. as shown in Dwg. No. C212. This value was chosen after an analysis of different muffle annealing furnaces, where a temperature of 1,450° F. was attained in 30 minutes by the metal being heated, had been made.

PITCH OF WIRES—It has been found that the closest spacing that should be employed in these wires is about 7/16" which provides for a maximum of 32 double turns of wire on the coil. Any closer spacing is apt to deform the wire at the point of bending, tending to cause a burn out.

RESISTANCE AND TEMPERATURE COEFFICIENT—According to the Driver Harris Company's booklet "Resistance Materials" the specific resistance of Kromore is 570 ohms per circular mil foot at 75° F. with a temperature coefficient of resistance approximately that of Nichrome (see Dwg. No. C415). The manufacturers of Chromel state that it has a resistance of 20% lower than that of Nichrome, but we found in the first lot received that the resistance was about 5% higher, and in the second lot about 10% higher than Kromore. The average rise in resistance due to increase in temperature in both Kromore and Chromel was found to be approximately 16% at 1,800° F., but this value is low as the wire heated slightly in performing the cold resistance test. Our meters were not sensitive enough to permit working with a low current and voltage.

The Driver Harris Company also published a "Nichrome Sheet" giving the temperature attained and the current which will flow at 110 volts through various lengths of Nichrome stretched horizontally in free air. This chart is extremely useful, being compiled for every size of the B&S wire gauge and for various shapes of each size, although the results published do not exactly agree with corresponding data given in their booklet "Resistance Materials."

CAPACITY OF INNER HEATERS—In the design of the first of these heaters we had no data on the duty that would be required from any heater. Therefore they were designed for the maximum load that could be carried by the wires. This method was permissable because, with the barrel rheostats, the power input to any unit could be varied from almost zero to the full capacity of the heater.

But with the information gained from actual operation of the plant (for data see section on Catalyser Operation) it was seen that the quantity of heat required for the different catalysers in the battery was not the same, being greatest for No. 1 and least for No. 3.

As the continued use of these heaters was very wasteful of power in units 2 and 3, designs of the heaters were begun to proportion the capacity of each unit to the work in hand.

It was not possible to increase the capacity of the heater in Catalyser No. 1 of a battery because the present input of approximately 14 Kw. was causing excessive oxidation of the catalyser. But work was done to design heaters for 7½ and 5 Kw. for units Nos. 2 and 3 respectively. These would then supply the average load when nearly operated at full voltage, but should additional heat be required the outer heaters could be put on, bringing up the total input to 13½ and 11 Kw. respectively for units 2 and 3. This latter arrangement would also be of great service in warming up the catalysers preparatory to beginning on a new run after the catalyst had been renewed.

TYPICAL DESIGN—A typical design is as follows:

Heater No. 12—Rating 15 Kw. at 200 volts. Wire—No. 6 B&S gauge Driver Harris "Kromore." No. of double turns, 29. Average length of turn, 23". Length of Wire, 117 feet. Resistance (cold) 2.315 ohms; (hot) 2.64 ohms.

DESIGN OF OUTER HEATERS.

In these heaters the duty per unit of area was greatly reduce from that of the inners owing to the fact that the gas heating are of the outer part of the catalyser is in the ratio of 1 to 5 to that o the inner tube of the catalyser. These heaters were therefor designed for a duty, per set of six units, sufficient to supply al radiation losses and about 1/5 of the heat generated by the inne heater, or for about 6 kilowatts in all. Therefore each unit of Kw. capacity at 1/6 of 200 or 33 volts, was constructed of 7 doubl turns of No. 8 B&S gauge resistance wire, six of these units i series making one complete outer heater.

ASSEMBLY OF HEATERS AND LAGGING OF CATALYSERS.

Owing to the high cost of heat generated by electrical means, it was necessary that the non-conducting covering or lagging surrounding heaters and catalysers should be efficient. At the same time, until data on the life of the outer heaters was secured, it was felt that the lagging surrounding them should be capable of being easily taken down and replaced, should a heater burn out. For this reason a type of assembly and insulation of heaters and catalysers was decided on as shown in Dwg. No. C334.

SETTINGS—The lower pans are placed on the channel iron support and then the catalysers are set in position with a 2" layer of Asbestos Fire Felt between them and the pan. The heads of the bolts holding the catalysers down are welded to a piece of iron plate, triangular in shape which permit tightening down of the holding bolts from the outside after the heaters are completely assembled.

To insulate the bottom of the catalyser the space between the channels is filled with broken pieces of Nonpareil H.P. block, and scrap Nonpareil Cement, and this lagging is carried up in the pan to a height of 1" from the top being finished with a smooth layer of Nonpareil cement. The outer heaters are then placed in position, connected in series with heavy clamps, and retained by a band passing completely about them.

CONNECTORS—These connecting clamps are shown in Dwg. No. B413 and it is seen that they can be used either for connecting two units of the outer heaters in series, or for connecting either the outer or inner heaters to the supply lines. For the former service the clamp requires two steel pieces (Item No. 1) and two copper liners (Item No. 2), and for the latter, two steel pieces (Item No. 1) one copper piece (Item No. 2) and one copper piece (Item No. 3) are required, the latter being welded to the supply wire. In either case the leads from the heaters are clamped between pieces of soft copper which is backed up by the steel to give it the requisite strength.

HEAT INSULATION—After the heaters are connected in, and the lundum tops placed in position, the whole is carefully covered with a layer of 3" x 1½" x 18" Nonpareil H.P. block, the spaces between the blocks being filled with Nonpareil H.P. cement. To give the outside a smooth finished appearance, a ½" thickness of this cement is trowelled to a smooth surface over the blocks and the whole is then covered with cotton. The guard rail, to prevent accidental shocks to the operators, is then put in place and the assembly of the outer heaters and catalyser is complete.

ASSEMBLY OF INNER HEATER—To prevent the direct transfer of heat by contact from the heater to the bottom of the inner part of the catalyser, a 3" layer of insulating block and cement is formed in the bottom of the tube. On this rests the alundum base which is larger in diameter than the inner heater, thus centering the latter and preventing direct contact between it and the shell. The cap, which is also larger than the heater, is then put on. The space above this cap is filled with Nonpareil block and cement moistened with water which forms a hard core, and the catalyser is ready for filling with catalyst.

After the catalyst has been filled and the joint made on a No. 8 copper wire gasket, the sheet metal top is put on, filled with broken block and loose insulating material and the transite cover installed. The heater is connected to the supply wires as above, and the catalyser is ready for operation.

SECTION NO 5.

TEMPERATURE CONTROLS.

In the description of the electrical installation, mention has been made of the barrel rheostats for controlling the amount of power supplied to the heaters and, as a consequence, the temperature of the gases in the catalysers. The use of barrel rheostats may seem a rather crude method, but, when account is taken of the novel nature of the process, and a survey made of the types of control at our disposal, the reasons for this type will be readily seen.

METHODS OF CONTROL—When the subject first came up for consideration, a review of the whole field showed three general methods:

(a) By the use of variable voltage transformers.

(b) By interruption of the power going to a heater when the temperature of the gases rose too high, and closing in the circuit when it fell too low.

(c) By a variation in the voltage supplied to the heaters by the insertion of a resistance in the supply wires.

These different methods will be considered in detail with the advantages and limitations of each type shown. And in considering this problem it is to be born in mind that the maximum variation above or below the temperatures desired must not exceed 10° F.

By Variable Voltage Transformers—This method is successfully used for the control of the temperature of annealing furnaces where an auto transformer is mounted close to the furnace. Then by the manipulation of a single handle any voltage, within the range of the design, may be impressed on the heaters. And had we been concerned with only one catalyser heater such a method would have been very seriously considered owing to its high efficiency.

To consider a separate auto transformer for each catalyser was out of the question owing to the excessive cost and delay in delivery, as these transformers would have been built to suit our special requirements. And had this method been finally adopted, some data on the nature of the process would be necessary before it would have been safe to specify the capacity of each unit, and the variation in voltage required.

To make use of the variable voltage feature of the 3-300 Kva. ansformers installed to bring the voltage from 12,500 to 200, 140, 00, 75, 70 or 50 volts would certainly not suit our needs. Leaving t of the question the switching difficulties to be overcome to in- all a "fool proof" arrangement so that even three different volt- es could be impressed on any heater, with its multiplicity of iring and operating difficulties, it is seen that if a voltage of 200 considered as the rated voltage per heater, that to impress 140 d 100 volts on that heater, would give an input of only ½ and ¼ spectively of the rated load. This arrangement would therefore altogether too coarse for accurate control. Therefore this whole heme was abandoned.

By Interrupting the Circuit—This method has much to mmend it. It is cheap, compact, and leads itself to automatic control. But from knowledge gained from the experimental work as well as from general information, where this type of control is used, the power input to the heaters must be very little in excess of the heat required by the process. Indeed the best results are obtained by having the capacity of the main heating coil slightly below that demanded by the work, and to insert a second heater operated by the control, the combined output of the two coils to be in excess of the demand. This gives very stable operation.

But since we had no idea of the quantities of heat that would be required and above all things else desired that an accurate control could be obtained no matter what the demand might be it was felt that for the moment, the third type had more attractions

It was considered probable that after full data on catalyser oper ation and the demands of the process had been obtained, that auto matic controls would be installed for all new work going in, and i they proved more efficient as viewed from a commercial standpoint that they would gradually supplant the barrel rheostats.

AUTOMATIC CONTROLS—These automatic controls essentiall consisted of two parts, the magnetic switches which automaticall opened and closed the circuit to each heater as the temperatu of the gases in the corresponding catalyser rose or fell, and th actuating part of mechanism which operated from the temperatur of the gases.

The actuating part consists of a thermometer bulb or a pyr meter couple which causes a needle to swing between two conta points, which contact points can independently be moved to a part of the scale of the instrument. If it is desired therefore maintain the temperature between 800° and 810° the lower a upper contacts can be set respectively to these points on the sca If the temperature of the gases is lower than 800°, the needle, necessity being hinged, would rest against the lower contact. Th allows a small current to flow through these contacts and to t switchboard, which current, acting through a relay, magneti the coils of the main magnetic switch causing it to close. T operation of this relay then breaks the circuit through the nee and lower contact which action prevents any arcing or overheati in the instrument. But as the temperature of the gas rises, needle point is carried to the upper contact and a current set up actuate the relay, and through it to demagnetise the switch. T latter flies open under spring tension and the pointer gradually falls back to the lower contact when the operation is repeated.

The use of these automatic controls could not be considered for the first installation because the time of delivery was approximately six months, and we could not afford to wait. They were moreover subject to the same objections for the first installation as all other types of control which operated by the interruption of the current to the heaters.

By Insertion of Resistance in the Circuit—As it was necessary that each separate unit be controlled independent of every ther unit, the number of rheostats required was equal to the umber of heaters employed. The barrel type of rheostat gave ood results and was therefore chosen for the following reasons:

(1) It was cheap and compact, and work could immediately be egun on the installation from material on hand or easily available.

(2) Each rheostat could be made to operate by remote control nsuring safety to the operators, and since it was impossible to amage the installation by any mistake on the part of the oper- tors, it was not necessary to secure skilled men.

(3) The installation secured the most flexible and sensitive rrangement possible, as the input to the heaters could be con- olled anywhere from practically zero to full rated capacity.

(4) As a direct consequence of this great flexibility, it was t necessary to absolutely know the radiating power of a heater t any temperature, and had the heaters exceeded the maximum orking temperature, the input could be cut down, and full data the heaters thus obtained.

For these reasons a skeleton switch board was set up as seen photos, on pages 114 and 115 of album, capable of handling 6 ner and 6 outer heaters. Only six were installed at first, this ing treated as a temporary installation with the intention that battery of six catalysers would be set up in series and full data the most efficient method of arrangement and setting of the cata- sers secured, as well as data on the electrical problems. How- er, owing to delay in obtaining tight catalysers, this informa- n was slow in forthcoming. Also the measurements during first empts to operate the third stage were too unreliable to consider ing them as a basis for the final layout of the catalysing equip- nt complete. Therefore, so that operation of a greater number of units could be proceeded with as soon as satisfactory catalysers were secured, the skeleton switch board was extended to accommodate 36 catalysers, as already described in the text and shown in album, pages 116-117, and dwg. No. A330.

By preparing to operate 36 catalysers on barrel rheostats we were assured plenty of time to consider fully every aspect of the case without holding up development of the process. Further, by setting the rheostats so that the power supplied to any heater would be slightly in excess of what was judged to be the average duty required and leaving the rheostat at that setting, and then by opening or closing the supply switch to the heater, thus controlling the temperature by interrupting the supply, a complete study of that method was possible. This would check up our final design and ensure its complying successfully with every condition before the order would be placed. And while awaiting the delivery of the apparatus that best suited our needs, operation of the plan could be proceeded with.

SECTION NO 6.

OPERATION OF M.E.K. PLANT.

GENERAL.

ORGANIZATION—In the M.E.K. plant, the process of makin methyl ethyl ketone from butyl alcohol was under the direction c the chemist, Mr. Legg. Previous to September first last, M Barron was mechanical superintendent of both the acetone, an the M.E.K. plants, while all electrical equipment was under th direction of the writer. But after that date, largely at the wis of Mr. Barron, the electrical and mechanical departments we combined for the M.E.K. plant, and the writer with this assistan Mr. Baldwin were made responsible for all equipments electric and mechanical, the operating staff, save switchboard attendan and engineers, being under Mr. Legg.

WORKMEN—Previous to September the first Mr. Barron h at his disposal in the British Acetones a force of mechanics, incl ing steam fitters, carpenters, etc., sufficient to handle the mecha cal work in both the Acetone and M.E.K. plants, the foreman the electrical staff being directly responsible to the writer. Although on that date the supervision of the two plants was assigned to two different men, yet the closest cooperation remained, and, it was therefore possible to assign to the payroll of the M.E.K. plant only those workmen who were steadily employed there. When additional help was required, the mechanics needed were transferred temporarily from the Acetone to the M.E.K. plant, the cost of the work being charged to the proper department by means of Works Orders. This system has worked very satisfactorily and without friction.

The mechanical staff on the payroll of the M.E.K. plant consisted of three shift engineers with their three helpers, one coppersmith and helper, one steam fitter and helper, and the erecting gang of six men under a foreman.

The electrical department consisted of a foreman, six switchboard attendants, two for each shift, one electrician and helper, and one man engaged in making heaters. When the operators were not engaged in regular duties they were employed in either construction work or building heaters. This staff, in the near future, would not have been able to handle its work as delivery of the catalysers was rapidly increasing. But up to November the 15th, they had all equipment installed to handle thirty-six catalysers while 27 heaters had been constructed. Also up to that date we had received only enough gas tight catalysers to set up four batteries, so that the switchboard attendants were frequently free for ther duties.

Since Mr. Legg was in charge of the actual operation of the plant while the writer was responsible for the operation of the catalysers and the upkeep and installation of the mechanical equipment and since the electrical and mechanical construction as they and at the present have been fully reported on, this section of this report naturally divides itself into two headings.

(a) Mechanical difficulties and changes necessary in the M.E.K. ant.

(b) The electrical operation of the catalysers.

These two headings should be considered separately.

ART "A"—MECHANICAL DIFFICULTIES IN THE M.E.K. PLANT.

As the M.E.K. plant was, to our knowledge the first of its kind in existence, it is not to be wondered at, that very serious difficultits presented themselves at the outset. These troubles began with the feed pumps to the catalysers, and as each part of the apparatus came into use, minor changes were necessary in almost every part, from the catalysers down to the lead valves and piping. The most important of these will be here listed under their separate headings.

It is to be regretted that from the first an accurate record had not been kept of each cause of trouble with the type, and name of manufacturer of each part at fault. Such a trouble sheet had been prepared, and is enclosed with the drawings accompanying this report, but the printer only delivered the blanks two days before the shut down of the plant. Therefore, while no definite table can be given showing the exact number of times defects were met with in each part of the equipment, the main causes of trouble will be listed.

VARIABLE STROKE FEED PUMPS.

The variable stroke feed pumps at first gave considerable annoyance by leakage about the plungers. The trouble seemed to b caused by the butyl alcohol attacking any grease or rubber presen in regular piston rod packings, candle wick was too soft, and asbestos packing caused scoring of the plungers. They are now packe with Ova-hole hollow centre packing 9/16" square, and have bee operating satisfactorily.

PIPING FOR HOT GASES.

For batteries 1 and 2 all connections between the interchan ers and the catalysers were made up with copper pipe screwed an then brazed into copper flanges. This system gave considerab trouble both with the joints between the flanges and the pipe itsel The copper pipe at the high temperatures oxidised to such an exte that it burst in two instances, closing down the catalysers; t gasket problem is treated under a separate heading in this sectio (See Index).

Batteries 3 and 4 were connected with ordinary wrought ir piping, and it stood up well. One or two small leaks occurr where the pipe was screwed into the flanges but these were eas caulked. The joints gave no trouble at all as it is an easy matter to make a joint between hard iron faces with a copper gasket.

Therefore it was recommended that in all future piping for this class of work, flanged iron piping should be used, such flanges being secured by threading and welding. Where bends were to be made, the material employed should be drawn seamless tubing except where short radius bends were necessary, when standard malleable fittings could be welded to the necessary length of pipe. This recommendation was adopted by the mechanical engineering department.

INTERCHANGERS.

The heat interchangers used were of the old type where the packing space between the outer case and the inner tube was too short. It was therefore impossible to keep these joints tight. Also leaks of gas occurred where the short copper nipples were screwed into the body, the copper being altogether too soft for such service. These details were taken care of in the new design.

CATALYSERS.

The troubles encountered in securing gas tight catalysers will e fully covered in Mr. Parkin's report, but as satisfactory cata- ysers began to be delivered just before the plant was shut down brief description of the methods employed in fitting the first efective ones so that they could be used, will be of interest.

In these early catalysers which were porous both throughout e body of the metal and in the flange, the main difficulties experi- nced were:

(1) Closing up the pores in the body.

(2) Closing the pores and getting rid of the blow holes in the rface of the flanges.

(3) Securing a suitable gasket to withstand the high tempera- res and the penetrating nature of the gases.

(4) Prevention of oxidation of the catalysers.

These difficulties will be dealt with in separate sub-sections.

Testing for Leaks—When a catalyser was received, it was t tested for porosity. This was done by closing the end with a blank flange with a ¾" supply to the high pressure air line, and immersing the whole in a vat of water. Bubbles of air arising showed the most minute leak if the eye was placed at an angle of about 30° with the water, and directed so that light from a window fell on the surface of the water and was reflected into the eye.

When all defects were noted the catalyser was gradually withdrawn from the tank and each porous spot as it came from the water was clearly marked. Since the work of closing the pores was done on the floor, it would have wasted valuable time, as this work progressed, to have returned the catalyser to the tank to examine the progress made. By painting the open spots, which had previously been marked, with soap and water, the most minute leak could be observed and the work of closing them up carried on until they were tight.

CLOSING THE PORES—The pores in the body of the catalysers were closed up by peening with a ball headed hammer and small drift. This method was quite satisfactory in most cases, but in others the metal was so open that nothing could be done, any attempt to peen the metal only resulting in a larger leak.

Learning from Col. Gooderham that by forcing sodium silicate into the pores of the castings, that these castings would then retain gas at high pressures, an attempt was made to reclaim those catalysers already scrapped. They were filled with a solution of sodium silicate, a cover bolted to the flange and an air pressure of 100 pds. per sq. in. was used to force this solution into the pores. After being thoroughly dried out, these catalysers were found to be absolutely tight while cold, but on being heated the old leaks developed to their original extent.

GASKETS—The gasket first used between the flanges of the catalysers was a No. 00 B&S Gauge copper wire carefully bent in a circle and welded. This was placed between the flanges of the inner and outer tubes of the catalyser and these flanges pulled down with bolts made of the same material as the catalysers. But the first flanges were left as they came from the lathe with the marks of the tool still in them, and the pressure required to make a tight joint also caused the gasket to sink into the soft catalyser and to buckle the flange. Gaskets of corrugated copper with and without asbestos rings were then employed, but after being heated up, th joints leaked. Plain asbestos packing and asbestos packing used with oil and graphite or used with shellac all failed, the smoke from the latter two poisoning the catalyst.

Therefore six units were put in series and a different style of packing inserted in each. It was found that the only joint that would stand up to the service was made by carefully grinding in the two flanges to a smooth finish, and an accurate fit. A No. 8 B&S Gauge copper wire gasket very carefully brazed at the joint and annealed, made an absolutely tight joint, and at first caused no indentation in the metal of the flange (see section on catalyser flanges). Other gaskets tried were asbestos, corrugated copper without asbestos lining and corrugated copper with asbestos lining (see album, page 162). Also it was attempted to make a joint without a gasket by turning a raised strip $\frac{1}{4}$ of an inch wide on the face of the flange of a very porous inner tube and grinding it to a smooth surface on the lower flange. While the joint appeared to be tight the metal was so porous that leakage occurred directly through the metal of the raised strip, and since the copper gasket was satisfactory, work in this direction ceased.

Therefore all joints whether between catalyser or pipe flanges were made with No. 8 B&S Gauge copper wire gaskets, the flanges being first carefully machined flat and then ground to a smooth surface.

CATALYSER FLANGES—The flanges of these first catalysers were full of blow holes and extremely porous. When the body of a catalyser had been made tight the flange was carefully examined, and if a clear course for the gasket at least $\frac{1}{2}$" wide could not be traced completely around it without encountering blow holes, the catalyser was set up in a lathe and the flange turned down until it was either too thin for use, or the large cavities had all been cut out.

The flange was then pickled in a solution of nitric, and sulphuric acid, and dipped in a bath of melted half and half solder. After being removed from this bath and the surplus solder wiped off, the flange and upper part of the catalyser was burnt at a red hot heat to drive this solder in the pores and cause it to combine with the catalyser metal. This method was very effectual in closing small pores and gave an exceedingly hard surface to the metal similar to that given by case hardening in steel, though not to the same extent.

It has been noted in the discussion on gaskets that No. 8 copper wire ring inserted between the flanges did not cause indentation. In that test the flanges had been previously tinned. But as the thin hard surface was eaten away by grinding and oxidation, once more the gaskets began to cut into the flanges, although at the time of shut down it had not become serious.

It is quite possible however, with the soft metal of the first catalysers, that the tinning process might have to be repeated from time to time.

A more serious trouble now began to make itself shown. It will be remembered that nearly all these flanges had been turned down and hence were very thin. The upper one had been reinforced by placing above it a cast iron ring drilled to the same template as the flange, but the lower one had no such strengthening. Also due to the blow holes in the surface of the flange, and to faulty drilling, the gaskets could not be brought out close to the bolts. Consequently the lower flange began to crimp between the bolts and to buckle upwards.

Fortunately this trouble developed only slightly and had not, to the date of closing, caused any great trouble. The slight raise after each run was removed by scraping to a smooth surface by hand and then regrinding the joint. Had it been necessary to use these old soft metal catalysers for any considerable time, we would have welded "V" pieces of copper to the bottom of the lower flange and to the body of the catalyser between the bolts to withstand the upward draw.

But in the new type of catalysers employing the new metal, the flanges were thick, and as hard as steel with absolutely perfect surfaces and the drilling for the flanges had been accurately done to template. Thus the gasket could be brought out close to the bolts and little trouble was expected from any buckling. Had however this distortion taken place it would have been a simple matter to weld in ribs to support the flange for those already made and to have cast these supports to the flange on any new ones being ordered.

OXIDATION—Besides the oxidation of the copper piping already noted, a serious oxidation occurred in the catalyser. This was first apparent on the surface of the inner part of the catalyser next the inner heater. However, it was largely overcome by paint ing that surface with sodium silicate before the heater was installed. But a more serious oxidation in the flanges of the catalyser developed in the last long runs. The flanges from the outside edge right up to the bearing surface of the gasket were eaten away and pitted in some places to a depth of 1/16 of an inch. It was considered that in future the joint should first be made as usual on a wire gasket and then the space external to the gasket filled with oil and graphite, and if necessary the outside plugged up with asbestos soaked in shellac. The joint being made before the oil and graphite was put on would prevent the poisoning of the catalyst by the heavy smoke generated from the heating of the oil. Unfortunately, the plant was closed down before this method could be put to the test.

THERMOMETER POCKETS—It was noticed that when the catalysers were in operation, that if a small flow were maintained (10 gals. or less liquid butyl alcohol per hour) that a certain reading of the thermometers placed in the gas leaving the catalysers was obtained. If the feed were increased to 20 gals. per hour, almost immediately a rise of temperature was recorded by the thermometers. Also in performing tests to determine the radiation losses, steam was led into the catalysers, thermometers being placed in the pockets in the catalysers, and also in a pocket in the steam line leading to the catalysers. The latter thermometer steadily read lower than the one in the entering thermometer pocket of the catalyser. We are therefore led to the conclusion that these thermometer pockets are not sensitive enough to give the temperature of the gas at low rates of flow and that they are influenced by the temperature of the catalyser.

In the next battery set up, it was therefore decided to discard the pockets cast into the catalysers and to bring the outlet from each catalyser into a "T" placed "bull-head". By this means the thermometer pocket could be any length, would be swept by the gases ensuring a more correct reading, and would not be influenced by the temperature of the catalyser itself.

BUTYLENE COMPRESSORS.

No operating troubles were experienced with these machines as long as they were kept running. But after even a very short shut down on opening up the cylinders, the valves, pistons and cylinders walls were found to be very badly rusted and corroded with a hard scale. These machines were never opened immediately after a shut down to see if the corrosion occurred during operation, but the writer is of the opinion that the butylene gas with perhaps some butyl alcohol in suspension dissolved off all the oil, leaving the metallic surfaces exposed and unlubricated. While not serious, this matter has been considered worth noting because had the compressors been run in this heavily scaled condition, the cylinder walls would speedily be cut and scored beyond repair.

SULPHATORS.

TYPE—The sulphator as originally furnished by E. B. Badger and Sons of Boston, is shown in drawings of the Badger equipment (Badger Assembly No. 8679), and was designed to run at a speed of from 600 to 1,000 r.p.m.

PACKING TROUBLE—It was set up exactly as furnished and run at a speed of 600 r.p.m. which gave no mixing action. On its being speeded up to 1,000 r.p.m. the packing burned up, so the packing gland was altered to the form shown in Dwg. No. C 359. The oil now being forced into the centre of the packing no further trouble was experienced from that source.

SPLITTING OFF OF LINING—While this work was being carried on, it was noticed that the lead lining had left the iron shell at the top, and the lining had also split circumferentally on the central shaft. Repairs were effected by riveting the lead lining to the shaft and then burning lead over the heads of the rivets. The central shaft was repaired by simply burning over the cracks.

WHIPPING OF SHAFT—After running a couple of days the propellor jammed, and on removing the cover it was found that the long unsupported shaft had begun to whip and had knocked out the supports under the central tube. A bottom bearing was designed using 8% antimonial lead bushings, and an 8" two blade propellor lead covered was substituted for the old one, details of which are given in Dwg. No. B 345.

STUDY OF MIXING ACTION AND NEW DESIGN—The sulphator was assembled complete save that the cover was omitted so that if filled with water and the machine started, some idea of its action could be obtained. Starting with a water level about 4 inches below the top of the central tube, it was observed that the water inside this tube was violently rotated and that there was only a very slight mixing action caused by the centrifugal force coning up the water to the outside of this tube and making it slop over. The lifting power of the propellor was practically nil for this height of water in the tank and it increased only slightly as water was added, although a height of 8" above the inner tube was reached. At once a new design was begun to use a larger propellor with a larger central tube with spiral fins within this tube to limit the rotation of the liquid and increase the lifting power of the propellor. This desing is shown in Dwgs. No. C 368 and No. B 365.

As it would require some time to make drawings, patterns and castings for these changes, the sulphator was put into operation in the form described in the experiment with the water and the speed increased from 580 to 870. At this speed the driving gears were excessively noisy so rawhide pinions were ordered.

The sulphator operated very satisfactorily for two weeks except that cuttings from the bearing destroyed the seat of the valve on the outlet, permitting a charge of acid to be blown up into the B.H.S. tanks.

FAILURE OF LINING—But at the end of that time, the propellor shaft refused to turn, and on opening the cover it was found that the lead lining of the tank had bulged outward in several places, completely upsetting the lining up of the shaft between the top and bottom bearing. The apparent causes of this bulging and all particulars on the subject are fully covered in a report by Mr. H. J. Roast, an expert, a copy of which report is appended. Besides the imperfections noted in this statement a split had occurred in the lead lining at the outlet base of the sulphator, fully exposing the iron to the action of the acid.

FINAL CHANGES—Fortunately we had on hand, two more sulphators, one 12 inch, 3 blade propellor and a central bearing with cast iron bushings. Work was immediately rushed on one of the casings and it was given a most minute and careful inspection for flaws and imperfections. As the central antimonial lead castings (Dwg. No. C 368) were not ready, a central tube was made from sheet lead and three vanes of 3" x 1½" angles were lead covered and burnt on to the inside to form the fins. This sulphator running at only 350 r.p.m. has been giving a splendid mix even with an acid more diluted than that formerly used. The iron bushings in the bottom bearing showed not the slightest sign of deterioration or wear, although it was considered probable that duriron bushings would have to be used. But this sulphator was in operation continuously for over a month, without noise even with the iron gears, and when the plant shut down it was in perfect condition.

REPORT

ON

VISIT TO BRITISH ACETONES PLANT IN TORONTO

OCTOBER 25TH, 1918.

The writer, Mr. R. J. Roast, upon instructions from the Imperial Munitions Board, visited the British Acetone plant with a view to solving the difficulty that they were experiencing with a lead lined mixing tank constructed according to blueprints of the Badger Company, No. 8679.

TROUBLE—The lead lining of the tank in question swelled away from the casting in certain places and gave evidence of the lead having been perforated, allowing the acid contents of the tank to get in between the lead lining and the steel casing, resulting i the tank having to be opened and emptied, and either patched o relined.

HISTORY—This tank is being used for the production o butylene hydrogen sulphate by the reaction of butylene and su phuric acid. The acid liquor in the tank is 72% sulphuric acid an 28% water. As a result of the chemical reaction the temperatu of the contents rise to probably between 100 and 200 degre Fahrenheit, while at the same time the pressure increases to fro 100 to 150 pounds per square inch.

The use of this tank for this reaction is believed to be uniqu comparative data in this connection is not therefore obtainabl There are three tanks at the Plant, one of which has been in use i termittently for three or four weeks, during which period of operation it has had to be repaired three or four times, and each time that it has been repaired the swelling out of the lead lining has become more noticeable, and has developed at more than one point. The second tank has just been installed, but has not yet been used, the third tank is still in stock.

Construction of Tanks—The tank is three feet in diameter and four feet deep essentially of cylindrical construction with a view to being half filled with sulphuric acid which must be violently agitated to hasten the reaction. For this reason the inside of the tank is fitted with a central shaft carrying a small propeller which is surrounded for half the height of the tank with an antimonial lead pipe about twelve inches in diameter. To keep this lead pipe in place it is braced at four points against the sides of the tank about two-thirds from the bottom and at the bottom is braced again in a similar manner although with lighter braces.

Everything within the tank is covered with lead which in the case of the lead pipe surrounding the propellor is alloyed with ten per cent. antimony as is also the case in one or two small parts in connection with the bearing of the shaft.

The braces supporting the pipe against the sides of the tank are constructed of iron covered with lead.

The joints of the lead lining are burned with lead, there being one joint running round the circumference of the tank at the top, and one at the bottom, together with one joint running longitudinally, in addition to which are the various joints in connection with the braces, etc.

Investigation—It was reasonable to suppose that the trouble might be due to electrolysis, or, that if there was any other cause for the trouble, that electrolysis would be set up which would rapidly increase the destructive effect of the prime cause of the difficulty. With this in mind the following portions of the lead lining were cut out of the tank;

1. A bulge occurring in the top of the tank having a diameter roughly speaking of about nine inches. This bulge extended over the burned lead joint.

2. A smaller blister about one foot away from Number one, located on the head of the tank which did not include a burned lead joint.

3. A square piece cut out of the side of the tank from a portion which appeared to be in a thoroughly satisfactory condition.

4. A piece cut out of a large bulge occurring at the bottom of the tank which included a lead joint.

5. The four iron braces supporting the lead pipe.

RESULTS OF EXAMINATION OF THE EXPOSED PART OF THE TANK AND THE FIVE PIECES ABOVE DESCRIBED.

Where the casing of the tank was exposed underneath the bulge it was found to be wet with a strongly acid solution which it was reasonable to presume was sulphuric acid, the iron was also covered with a white deposit presumed to be essentially sulphate of iron, together with possibly some sulphate of lead.

When the casing of the tank was exposed by cutting out of the lead lining where no bulge occurred it was found that in the first place the lead was only removed with the greatest difficulty and that it had made a perfect physical bond with the lead lining and that no trace of solution of any kind had an opportunity of permeating lead.

The whole of the lead lining including the bulges that had been formed showed a surface which was smooth and practically unattacked by the chemical reaction developed in the tank. There was no sign of pitting or uneven corrosion, either on the main lining which was composed of C. P. Trail lead or on the antimonial lead parts.

Piece No. 1 contained two blow holes occurring at the juncture of the lead situated directly on the line where the lead was burned in. Looking at the side of the lead lining that was next to the casing it was observed that directly under the two blow holes the lead burning was very imperfect and that this imperfection extended for several inches on either side of the blow hole.

Piece No. 2 showed on its exterior surface no imperfection and no noticeable difference on the underneath surface, there was no lead burned joint in this piece.

Piece No. 3. This piece was in intimate contact with the casing and appeared sound in every respect.

Piece No. 4. The condition of the under surface of this piece particularly in regard to the lead burned joint was very similar to piece No. 1 with the exception that no large blow holes were evident on the outside surface, nevertheless, looked at from the underside the lead burned joint was very imperfect and the union of the two surfaces only extended a very small proportion of the thickness of the lead sheets which are being united.

Piece No. 5. One of the iron braces (which may be taken as typical) had a crack extending some three inches along the centre of one side which had exposed the iron beneath the lead with the result that the iron had been rapidly attacked and destruction of the material generally had progressed considerably.

CAUSE OF TROUBLE—In the opinion of the writer the cause of the trouble has been the imperfect burning of the lead joints in the tank which has left in some cases either minute cracks or holes through which the acid has obtained access to the iron casing beneath, the reaction between the acid and the iron has produced hydrogen which has (owing to the pressure of one hundred and fifty pounds in the tank and to the fact that the means of entry and therefore of exit are extremely minute while the amount of hydrogen produced is relatively great) produced considerable pressure beneath the lead lining which, upon the release of the pressure in the tank generally has been sufficient to bulge out the lead lining as observed. The detachment of the lead lining from the casing has also been assisted by the production of iron salts which occupied a greater space than the tight fitting lining permitted.

The writer is personally unfavorable to the use of iron reinforcement in lead supports used in acid tanks. This is not the first case in which lead covered iron supports have cracked at the lead burned junction exposing the iron beneath. It may be that in some cases the mechanical strength required makes the use of iron supports compulsory, but it is better to avoid the same whenever possible.

Another cause of destruction of lead in the tank (which, although not in evidence after the short term of service in the case referred to) which would develop in time is that of electrolysis which is set up wherever the iron and the lead are exposed to the action of the acid, once this electrolysis is started it is almost impossible to say where corrosion will next set in. Such corrosion may develop even in a perfectly sound sheet of lead coming under the influence of the electrolysis developed in the tank elsewhere.

Remedy—It was recommended that all the lead burned joints be gone over again with a view to covering up any imperfections that may exist in the present joints, further that the lead covered iron braces be replaced with ten per cent. antimonial lead braces, it being understood from the engineers on the Plant, that the strain upon these braces is not more than the antimonial lead brace referred to would meet successfully.

The above recommendations were being acted upon before the writer left the plant.

Summary—The lead lining and also the ten per cent, antimonial lead lining in the tank referred to give every evidence of being a suitable material to withstand the action occurring in the tank, and so long as any portions of the tank are perfectly protected by a covering of these materials there seems to be no reason to expect that any trouble will develop. To make such protection perfect, extreme care must be used in the mechanical details for the joining of the sheets of lead and the covering of all parts of the interior of the tank.

(Sgd). Harold J. Roast.

Note—Three samples submitted for inspection but retained by Mr. Roast.

LEAD VALVES.

Three types of lead valves were purchased for use in the M.E.K plant are are shown in the album, page 161. From right to lef in this photo, they will be called the plug type, the angle seat typ and the globe type.

Plug Type—The ordinary plug type was the first on used in the plant, and was open to the following defects.

1. It was extremely hard to turn, very often requiring a wrenc to move it.

2. A coating of lead sulphate seemed to form on the surfac which surface would scale off causing a leak.

3. The valve would last only a short time before the plug wou

seat on the bottom instead of on the walls, and then the valve would have to be removed and a cut taken off the bottom of the plug.

Angle Seat Type—To try to overcome these defects, the angle seat type was purchased and installed with very little improvement. While this valve was very easy to turn, it was defective for the following reasons:—

1. The flanges were not standard size.
2. The line contact of the seat rapidly cut the plug.
3. The valve spindle was so short that wear could not be taken up or a new surface turned on the seat or plug.

Globe Type—By inspection, this valve appeared to overcome some of the defects of the other two, but time was not available for a tryout.

B.H.S. FEED LINES TO THE CONSTANT LEVEL FEED TANK.

Owing to the faulty acid concentrating towers, sludge was being perpetually carried over with the acid into the Badger equipment. This sludge gave no trouble until the B.H.S. feed tanks were reached where it settled out as a heavy deposit which would completely block the feed lines to the constant level feed tank. As there seemed to be no way to get rid of this sludge from the acid towers, it was proposed to increase the size of the feed lines from 1½ inches to 2½ inches diameter and at each bend to insert "Y's" with a blank flange on the unused opening. Then in the event of the pipe plugging, the flange could be removed and the line flushed ut with water in which the sediment is extremely soluble.

FEED TO LEAD LINED STILL.

Drawing No. B 219 shows the acid diluting device as first used. his gave considerable trouble as the gases generated by the mixing of the B.H.S. and the water would back up through the feed es giving very irregular action. To remedy this, the top cover f the diluting device was removed and a 4 foot length of 6" lead ed pipe placed on top. On top of this was placed a 2" lead pipe urrounded with a water jacket leading to a vent on the roof.

Thus by providing a 4 foot stand pipe over the feed to the stills with a free gas vent to the roof, most of the trouble was got rid of. Another defect was bringing the two streams, one of water, and one of B.H.S., directly to oppose each other in the entering tee.

A work order had already been issued when the plant closed down, to place a 6 x 6 x 1½ tee between the acid diluting device and the 6" pipe above, and to bring the water supply into the 1½" opening. This would have further helped to remedy the fault, but it is to be regretted that it was not possible to have had a considerable hydraulic head on the feeding device.

CONCLUSION—While this whole section has been a continual record of troubles and difficulties encountered, the reader must bear in mind the novel nature of the process. Also the whole plant had been in operation before it was finally shut down, and each part had been fully tested out, and its imperfections here noted. And it will also be noted that of all the difficulties encountered, every one had been over come, except perhaps one or two where a remedy had been suggested, which the shut down prevented from being put to the test. Had the operation of the plant been continued, a very short time would have sufficed to eliminate each defective piece of apparatus through a close study of the trouble report sheets, and to bring the production of the plant to a point where it would utilize all the butyl alcohol produced by the acetone plant by converting it into M.E.K.

PART "B."

OPERATION OF THE CATALYSERS.

FIRST STAGE

FIRST INSTALLATION—When the layout of the first catalysing system came up for consideration, data from the comparison of the volumes of the small experimental catalysers with tha of the present type, gave an extremely close estimate of the amoun of butyl alcohol that could be converted in the latter. But information was not available to point out the effects of rapid feed wit a large number of catalysers in series as weighed against a slowe feed with a smaller number of units per battery. Further, it wa feared that poisoning of the catalyst might begin in one unit, and, if that unit were not immediately cut off from the others, that this contamination would spread rapidly through the whole battery and the conversion would fall off.

For these reasons it was decided that an experimental battery of full sized units should be set up, that the setting for this battery would provide for six units in series, and that there would be a pipe line passing down the side of the battery joined to the connecting pipes between each unit and suitably valved (see album, page 133) so that any catalyser of the row could be short circuited through this pipe line. It was further decided that the catalysing process should be begun as soon as three units could be got ready, and that additions should be made to the row as quickly as new catalysers were received and made tight. This battery was to be operated until sufficient data had been obtained to determine points of doubt when the final catalysing system would then be developed.

First Run—Three catalysers operating on this system were started on April 21st, 1918, and ran until April 25th, using Alumina Asbestos as a catalyst. The butyl alcohol was first evaporated in a Wriggle coil from which it passed direct to the first unit, which was not packed with catalyst and served as a preheater.

Measurements Taken—In order to obtain the necessary data, the following quantities were measured, readings being taken every hour.

(1) Feed of butyl alcohol in gals. per hour.
(2) Temperature of the gases entering the preheater.
(3) Temperature of the gases leaving each unit.
(4) Pressure of the gas entering and leaving each unit.
(5) Volts and amperes supplied to each inner heater.
(6) Temperature of each inner heater.
(7) Volts and amperes supplied to each outer heater.
(8) Gals. of liquid butylene formed per hour.

The rate of feed of butyl alcohol was obtained by watching the fall of the butyl alcohol in a gauge glass attached to a calibrated measuring tank. From the length of time required to draw off three gallons, the rate of feed in gals. per hour was obtained. All gas temperatures leaving the catalysers were obtained from thermometers placed in its upper pockets as seen in Dwg. No. 410 A, while that of the entering gases was obtained from the lower pocket of the first unit. The lower pockets of units 2 and 3 served as an outlet for the attachment of the pressure gauges, other readings of the pressure being obtained from openings in the pipe lines leading to and from the battery. A pyrometer couple placed successively in the air within the central heater gave a very close approximation to its temperature while the volts and amperes supplied to inner and outer heaters were measured as described under "metering arrangements," Section No. 3. The liquid butylene coming from the compressor and cooler was collected in storage tanks equipped with calibrated gauge glasses. From the difference between the readings at the beginning and end of the hour the gallons of liquid butylene formed were known. This data was carefully entered up each hour on sheets similar in form to the M.E.K. Daily Record Sheet for the Switch House, a copy of which is enclosed with the drawings accompanying this report.

RECORDS—These daily log sheets, while permitting a close check to be kept on the operators and securing all necessary data from day to day, became very bulky as operation continued. In order therefore to secure reliable data over appreciable periods, these records were condensed into workable form, the results being given in tables which are enclosed at the end of this section, and will now be described. While the arrangement of the catalysers as already described was adhered to until test No. 9 ended on June 18th, when a new grouping was made, the full list of all runs made are submitted on a single sheet and the considerations which led to the changes in arrangement of the catalysers will be taken up under the heading, "Examination of the Records (See index).

Table No. 1 gives a record of the number of times the catalysers were in operation converting primary butyl alcohol into butylene and secondary butyl alcohol into M.E.K. with the dates and duration of each run and the number of units to the battery.

Tables 2 and 3 were prepared from the Switch House Daily Reports and give the conditions of operation of the catalysers over definite specified durations of time chosen when these conditions were as uniform as possible. For purposes of identification later in this section each line is numbered in the first column while the numbers in the second column refer to the tests as listed in Table No. 1.

Table No. 4 gives a summary of the tests which were performed to estimate the radiation losses from the catalysers. These tests were made by passing steam through the catalysers, and adjusting its flow and the watts input to the catalysers so that the conditions of temperature or watts input were approximately the same as when butyl alcohol vapor was being converted. Then knowing the pressure and temperature of the superheated steam entering and leaving each catalyser and the quantity of heat supplied to each, the amount of heat lost in each unit or the Radiation Losses could be calculated. These values are all completely given in this Table.

CURVES SHOWING OPERATION—In addition to averages taken from periods out of each test when conditions were fairly constant which have been listed in tables 2 and 3, curves have been drawn where all the observations have been plotted on a time base. These curves (see index under "Drawings") fully show the full data at all times for tests 6, 7, 14 (a) and 14 (b) for the first stage and for runs 13 (a), 13 (b), 15 (a), 16 (b) and 16 (a), for the third stage. As readings were in nearly all cases taken every hour, and exactly plotted, a close study may be made of the effect of increased flow or rise in temperature of the gases.

TABLE NO. 1—Referring to Table No. 1 it is seen that runs 1 to 7 inclusive, were made with the catalysers arranged as described above. Test No. 1 served to instruct the workmen in the handling of the apparatus in their care, while test No. 5 lasted only a few hours owing to a large leakage having developed through the metal in catalyser No. 2. But very satisfactory information was obtained from tests 2, 6, and 7 which data is listed in Table No. 2. By examining this table we can study the beneficial results of substituting china clay for Alumina Asbestos as the catalyst and the limiting factors facing the whole catalyser layout.

TABLE NO. 2, TESTS 2, 6, AND 7—Examining Table No. 2 it is seen that the preheater was operated at its maximum capacity in tests 2, 6 and 7 where the feed of butyl alcohol was respectively ,30 and 36 gals. per hour. It is also evident that the preheater was overloaded because as the feed was increased the temperature of the gases leaving this unit was greatly reduced. This overloading was increased by the fact that the evaporator did not furnish completely dry butyl alcohol vapor in tests 6 and 7, slugs of liquid frequently coming over, although the reading of the thermometer measuring the temperature of the gas was higher than the boiling point corresponding to its pressure. This, however, was due to the defects of the thermometer pocket which had been noted in part A of this section. (See index).

Further it is seen that the efficiency of conversion had been steadily increased, the first large increase being due to the substitution of China clay as a catalyst in place of Alumina Asbestos. While unquestionably the addition of an extra catalyser helped considerably yet it is seen that with the alumina asbestos in test 2, the heat required for unit No. 3 was much greater than in test 6. Although in the latter case a greater quantity of butyl alcohol was fed to the catalysers and the temperature of the gases leaving the preheater was much reduced, yet the conversion in the first catalysers was unquestionably greater when china clay was used than when alumina asbestos was employed.

CONCLUSIONS BASED ON TESTS 2, 6, AND 7—Therefore at the conclusion of test No. 7 it was evident that a high percentage conversion could be obtained with a feed of 36 gals. of primary butyl alcohol per hour with three catalysers in series provided that the inlet temperature of the entering gas was not more than about 250° F. below that of the gas leaving the last unit.

CHANGES IN LAYOUT—At this time the heat interchangers had been constructed and tested, and it was thought possible by their use to preheat the gases entering the first catalyser to within 200° F. of their temperature leaving the last. It was then decided to set up a system of these heat interchangers to do all the preheating and then to pass these heated vapors directly to the catalysers. Also it was decided that the catalysers should be set up in batteries of three in series, the control of the amount of this heated gas coming from the preheaters to be divided between the different batteries by means of venturi meters and valves.

Accordingly two batterise of three units each were substituted in place of the old battery, and a system of interchangers installed as described by Mr. Parkin in his report. All future runs of the first stage were performed with these two batteries as listed in the tables. These two batteries were nearly always operated in parallel, the aim being by an adjustment of the valves on the pipes leading from the preheater to each battery to secure equ flow through each. While this equal flow to each battery was approximately attained, yet from the readings of the quantities of heat supplied to the catalysers it was apparent that such was not always the case. Also the discharge from both batteries led to a common header and hence when the quantity of butylene formed was obtained, it was the amount formed by the two batteries together nor was any data obtained on the quantity supplied by each catalyser separately. Therefore in preparing Table No. 2 showing the operation of this new installation the quantity of heat and the temperature of the gases for each catalyser in each battery were kept separate, but the quantity of butyl alcohol feed and the butylene formed is the amount for two batteries in parallel. The only exception to this occurs in lines 16 and 17 when battery No. 1 alone was working.

HEAT LOSSES IN INTERCHANGING SYSTEM—On examining Table No. 2 it will be noted that the temperature of the gases entering the first catalyser was not as high as had been expected, being almost 400° F. below that of the gas leaving the last. An analysis of this great drop showed it to be made up roughly as follows:—

(1) A drop in temperature in the pipe line from the exit of the last catalyser to the preheater.

(2) A drop in temperature between the gases being heated and those doing the heating.

(3) A drop in temperature in the pipe line from the preheater to the first catalyser.

These losses were divided and the following results obtained, all readings being in degrees fahrenheit.

Date	Pipe line Catalyser to Preheater	Gas to gas in preheater	Pipe line Preheater to catz.	Total
Sept. 10	190	100	195	485
Sept. 21	160	90	90	340
Sept. 26	150	85	150	385
Sept. 27	120	235	70	425
Sept. 28	155	100	100	355
Average	155	122	121	398

A great deal of this heat loss could have been prevented by more efficient lagging, but until perfect joints had been obtained in piping and interchangers, the lagging had to be easily removable for tightening of the flanges.

EFFECTS OF LOW PREHEATING—As a result of this low temperature of the inlet gases, the feed of butyl alcohol instead of being at 70 gals. per hour, as was expected from the result of test No. 7, could not efficiently be maintained above 60. When the feed was increased beyond this figure, the fall in the efficiency of conversion was too great to warrant operation at such a rate.

OPERATION OF THIRD STAGE.

In examining Table No. 1 it is seen that tests 3 and 9 were made with the same battery of catalysers as had been used for the first stage. While No. 3 was practically a failure, test No. 9 gave some very valuable information.

ATTEMPTS TO RE-OXIDIZE THE CATALYST IN PLACE—In this latter test the catalysers were packed with fused copper oxide and the temperature of the gases was maintained at approximately 550° F. At first the conversion efficiency was high (97% for a maximum) but this rapidly fell off until at the end of 36 hours it had fallen 50% owing to poisoning of the catalyst. Attempts were then made to re-oxidize and hence purify it by passing oxygen through the catalysers at a temperature of about 750° F., but, although, on starting up again the conversion efficiency rose to 55%, in a few hours it had fallen off to 35%. Re-oxidation with oxygen and air at a temperature of about 950° F. proved no better, for, although, at first the efficiency was 90% and over, inside of 10 hours it had fallen to 30%. Owing to these results, the re-oxidation of the catalyst in place in the catalysers was abandoned.

Further, in considering Test No. 9 it must be considered that the useful life of the catalyst in this run was only for about 42 hours, the remainder of the time listed in Table No. 1 being spent in re-oxidation of the catalyst and experiments to test its conversion.

LAST INSTALLATION—Turning to Table No. 3, it is seen that for Test No. 9 the fused copper oxide catalyst in the third stage was not nearly so active as was the china clay in the first. The conversion is much more evenly distributed among the three catalysers, as evidenced by the fact that the heat supplied to each is more nearly constant. However, at the conclusion of test No. 9 it was felt that the catalysers, having been used for the first stage, might have poisoned the catalyst causing its rapid destruction. Therefore, two batteries of three catalysers each for the third stage were set up on the same general lines as the batteries for the first stage already described. The only difference between the two sets were:

(1) That a single preheater and two wriggle coil evaporators were used in place of the extensive set of interchangers for the first stage.

(2) Provision was made to pass hydrogen gas from the M.E.K. scrubber system into either battery of catalysers and to vent the discharge therefrom to the roof.

(3) Sampling pipes were led off from the outlet of each battery so that the efficiency of conversion could be established for each separately.

(4) Iron piping was used.

It will be noticed that the conversion in the third stage is irregular, efficiencies as high as 86.6% and as low as 37.7 being recorded. This irregularity is also shown very well in the curves, where are plotted all readings of feed, temperature, conversion, etc., on a time base. Here it is seen that at any constant temperature when the catalysers are first started after being packed, the conversion is high, but that this efficiency gradually falls off. A rise in temperature rejuvenates it appreciably for a time, but in the third stage the range of temperature is very limited.

RECORD OF CATALYSER RUNS—Table 1

Test No.	Date.		Hours Run			Units in Use.	Catalyst in Use.
	Start.	End.	Gross	Shut down	Net		
	STAGE I.						
1	Apr.21 9.30 a.m.	Apr.25 5.30 p.m.	104	....	....	Old battery 3 units 1 preheater and 2 catalysers. Units Nos. 1 2 3.	Alumina—Asbestos
2	Apr.27 9 30 a m.	May 1 6 p.m.	104½	2	102½	Old battery 3 units 1 preheater and 2 catalysers. Units Nos. 1 2 3.	Alumina—Asbestos
5	May 16 1 p.m.	May 17 5.30 a.m	16½	....	....	Old battery. 5 units. Units Nos. 1 2 3 4 5.	
6	May 19 6 p.m.	May 24 7 a.m.	109	0	109	Old battery 4 units 1 preheater and 3 catalysers. Units Nos. 1 3 5 6.	H..B China Clay.
7	May 25 11 a.m.	June 4 2 a.m.	231	5	226	Old battery 4 units 1 preheater and 3 catalysers. Units Nos. 1 3 5 6.	H.B. China Clay.
11	Aug.23 6.30 p.m.	Aug.25 8.40 p.m.	38	....	....	Batteries 1 and 2 in parallel with interchanging system 6 catalysers.	
12a	Sept. 18, 8 a.m.	Sept. 27, 12 p.m.	232	0	232	Battery No. 1 with heat interchangers 3 catalysers.	Canadian China Clay
12b	Sept. 18, 8 a.m.	Sept. 28, 10 p.m.	230	18	212	Battery 2 with heat interchangers 3 catalysers.	" "
14a	Oct. 13, 3 p.m.	Nov. 8, 1.10 p.m.	477½	130½	*31, 316	Battery 2 with heat interchangers 3 catalysers.	" "
14b	Oct. 18, 3 p.m.	Nov.16, 9.15 a.m.	688	154½	*31, 502½	Battery 1 with heat interchangers 3 catalysers.	" "
17	Nov.14,10.15 a.m	Nov.16,9.15 a.m.	47	0	47	Battery 2 with heat interchangers 3 catalysers.	" "
	STAGE III.						
3	May 6, 12 a.m.	May 7, 7 a.m.	19	0	19	Old battery. 3 units 1 preheater and 2 catalysers. Units Nos. 1 2 3.	Fused Copper Oxide
9	June 10,9.30p.m.	June 18, 10 p.m.	190½	37	‡153½	Old battery 4 units 1 preheater 2 catalysers and heat interchangers. Units Nos. 1. 3 5 6.	" "
13a	Oct. 15, 10 a.m.	Oct. 24, 12 p.m.	218	39½	†54, 124½	Battery No. 4 3 units 3 catalysers and heat interchanger.	" "
13b	Oct. 16, 4 p.m.	Oct. 20, 1 p.m.	83	0	83	Battery 3 3 units 3 catalysers and heat interchanger.	" "
15a	Oct. 25, 9 p.m.	Oct. 27, 6 a.m.	57	0	57	Battery 3 3 units 3 catalysers and heat interchanger.	" "
16a	Nov. 2, 2 a.m.	Nov. 16,8.30a.m.	331	185	146	Battery 4 3 units 3 catalysers and heat interchanger	" "
16b	Nov. 2, 2 p.m.	Nov. 16,8.30 a.m	331	185	146	Battery 3 3 units 3 catalysers and heat interchanger	" "

NOTE—* Battery ran 31 hours and was then repacked with catalyst.

† Battery ran 54 hours and was then repacked with catalyst.

‡ 153½ hours includes time during which catalyst was being re-oxidized in place.

DUTY—STACK I (Table 2)

Number.	Test Number	Battery Number	Dates Considered.		Average Watts Input.													Temperatures degrees Fahr.					Pressure. lbs., sq. in., G.				Feed in B.A.	Conversion Butylene.	
					Unit No. 1			Unit No. 2			Unit No. 3			Unit No. 4			Battery												
			Start.	End.	Inner	Outer	Total	Inner	Outer	Total	Inner	Outer	Total	Inner	Outer	Total	Total	T0	T1	T2	T3	T4	P1	P2	P3	P4	Gals. pr.hr.	%	Gals. per.hr
1	2		Apr. 28, 10 a.m.	Apr. 29, 12 m.	14387	4500	18887	10171	4650	14821	8313	4400	12713	.....	.....	.....	46421	268.5	717	818.5	830	....	3	2½	2½	2	25.9	75	19.4
2	2		Apr. 30, 1 a.m.	May 1, 12 m.	13720	4600	18320	11018	4450	15468	8451	4100	12551	.....	.....	.....	46339	268.5	702	829	826	....	3	2½	2	....	25.6	63	16.1
3	6		May 19, 6 p.m.	May 21, 8 p.m.	14050	4000	18050	12768	3600	16368	4762	3625	8387	5882	0	5882	48687	262	632	775	798	799	5	3½	2½	2	30	80	24
4	6		May 22, 4 p.m.	May 23, 8 a.m.	14480	4100	18580	14723	3850	18573	4270	3780	8050	6717	0	6717	51920	260	630	821	827	835	5	3½	2½	2	30	68.3	20.5
5	7		May 26, 8 a.m.	May 26, 12 p.m.	14570	4000	18570	15414	3800	19214	5780	3850	9630	4190	0	4190	51604	264	543	700	695	704	5	3¾	2½	2	36	83.3	30
6	7		May 29, 8 a.m.	May 30, 4 a.m.	14425	4150	18575	15900	3950	19850	7083	4200	11283	4470	0	4470	54178	264	529	747	733	738	5	3¾	2½	2	36	83.3	30
7	7		June 2, 4 a.m.	June 3, 2 a.m.	13890	4000	17890	16384	4150	20534	9614	3800	13414	4273	0	4273	56111	264	548	760	792	770	5	3¾	2½	2	36	80.6	29
8	12a	1	Sept. 22, 4 a.m.	Sept. 23, 4 a.m.	14025	6620	20645	8032	0	8032	3645	0	3645	.....	.....	.....	32322	325	700	710	726	....	....	....	10½	....	60	83.	49.7
9	12b	2	Sept. 22, 4 a.m.	Sept. 23, 4 a.m.	14301	5170	19471	7841	0	7841	4597	0	4597	.....	.....	.....	32179	335	700	710	710	....	....	....	10	....			
10	12a	1	Sept. 26. 1 a.m.	Sept. 27, 6 p.m.	14598	6620	21218	7841	0	7841	2981	0	2981	.....	.....	.....	32040	386	720	760	762	....	....	....	10½	....	60	81.2	48.7
11	12b	2	Sept. 26, 1 a.m.	Sept. 27, 6 p.m.	14377	5170	19547	7957	0	7957	4609	0	4609	.....	.....	.....	32113	386	755	760	780	....	....	....	10½				
12	14b	1	Oct. 29, 8 p.m.	Oct. 30, 12 p.m.	13423	6620	20043	5796	0	5796	3609	0	3609	.....	.....	.....	29448	349	690	690	688	....	....	....	10½	....	60	84.8	50.9
13	14b	2	Oct. 29, 8 p.m.	Oct. 30, 12 p.m.	12129	5170	17299	6581	0	6581	4325	0	4325	.....	.....	.....	28205	351	685	685	689	....	....	....	10½	....			
14	14b	1	Nov. 4, 8 p.m.	Nov. 6, 4 a.m.	15410	6620	22030	6794	0	6794	3828	0	3828	.....	.....	.....	32652	359	720	725	727	....	....	....	10½	....	60	84	50.4
15	14b	2	Nov. 4, 8 p.m.	Nov. 6, 4 a.m.	14287	5170	19457	7408	0	7408	4743	0	4743	.....	.....	.....	31608	339½	720	723	724	....	....	....	10½	....			
16	14b	1	Nov. 12, 8 p.m.	Nov. 14, 12 m.	14235	6620	20855	6889	0	6889	4593	0	4593	.....	.....	.....	32337	438½	770	770	772	....	....	....	5	....	30	83.7	25.1
17	14b	1	Nov. 9, 11 a.m.	Nov. 10, 11 a.m.	12727	6620	19347	5238	0	5238	4210	0	4210	.....	.....	.....	28795	442	750	748	750	....	....	....	4½	....	30	73	21.9
18	14b	1	Oct. 28, 12 p.m.	Oct. 30, 12 m.	11070	6620	17690	5930	0	5930	4000	0	4000	.....	.....	.....	27620	383	608	680	690	....	....	....	10.5	....	60	85.7	51.4
19	14a	2	Oct. 28, 12 m.	Oct. 30, 12 m.	14078	5170	19248	6600	0	6600	4160	0	4160	.....	.....	.....	30008	392	680	686	687	....	....		10.5	....			
20	14b	1	Oct. 30, 12 m.	Oct. 31, 12 p.m	13290	6620	19910	5985	0	5985	3670	0	3670	.....	.....	.....	29565	386½	680	695	693	....	....	....	10.5	....	60	85	50.9
21	14a	2	Oct. 30, 12 m	Oct. 31, 12 p.m.	13818	5170	18988	6670	0	6670	4330	0	4330	.....	.....	.....	29988	382	677	695	693	....		....	10½	....			
22	14b	1	Oct. 31, 12 p.m.	Nov. 2, 12 m.	12600	6620	19220	5640	0	5640	3635	0	3635	.....	.....	.....	28495	386	702	703	703½	....	....	....	10½	....	60	78.7	47.2
23	14a	2	Oct. 31, 12 p.m.	Nov. 2, 12 m.	13525	5170	18695	6597	0	6597	3970	0	3970	.....	.....	.....	29262	393	703	702	703	....		....	10½	....			
24	14b	1	Nov. 2, 12m.	Nov. 3, 12 p.m.	13260	6620	19880	6190	0	6190	3710	0	3710	.....	.....	.....	29780	381	690	693	696	....		....	10½	....	60	81.	248.7
25	14a	2	Nov. 2, 12 p.m	Nov. 3, 12 p.m.	14075	5170	19245	6795	0	6795	3875	0	3875	.....	.....	.....	29915	390½	705	707	715½	....	....	....	10½	....			
26	14b	1	Nov. 3, 12 p.m.	Nov. 5, 12 m.	15120	6620	21740	6640	0	6640	3630	0	3630	.....	.....	.....	32010	364	720	726	728	....	....	....	10½	....	60	86	51.6
27	14a	2	Nov. 3, 12 p.m.	Nov. 5, 12 m.	15625	5170	20795	7260	0	7260	4320	0	4320	.....	.....	.....	32375	356	717	725	724	....	....	....	10½	....			
28	14b	1	Nov. 5, 12 m.	Nov. 6, 12 p.m.	15060	6620	21680	6760	0	6760	4185	0	4185	.....	.....	.....	32625	369	723	726	726	....	....	....	10½	....	60	82.7	49.6
29	14a	2	Nov. 5, 12 m.	Nov. 6, 12 p.m.	16175	5170	21345	7210	0	7210	4370	0	4370	.....	.....	.....	32925	364	721	722	725	....	....	....	10½	....			

RECORD OF CATALYSER DUTY—STAGE 3 (Table 3)

Note—Figures in brackets are assumed.

Number.	Test Number.	Battery Number	Dates Considered.		Average Watts Input.													Temperature degrees Fahr.					Pressure lbs. sq.in. gauge	Feed SBA	Conversion Crude M.E.K.	
					Unit No. 1			Unit No. 2			Unit No. 3			Unit No. 4			Battery									
			Start.	End.	Inner	Outer	Total	Inner	Outer	Total	Inner	Outer	Total	Inner	Outer	Total	Total	T0	T1	T2	T3	T4	P3	Gals. hr.	%	Gals. hr.
1	9		June 11, 4 p.m.	June 12, 8 p.m.	2500	.....	2500	4955	3945	8900	5580	1576	7156	4220	.....	4220	22776	384	454	548½	533	545	2½	23. 6	....	12.4
2	9		June 14, 4 a.m.	June 15, 2 a.m.	1770	679	2449	2138	3795	5933	1625	3745	5370	2722	.....	2722	16474	342	471	561½	552	576	....	11.24	41.1	
3	13a	4	Oct. 20, 6 p.m.	Oct. 21, 12 m.	11745	6430	18175	5623	.....	5623	5084	.....	5084	.....	.....	.....	28882	301	555	565	570	....	5	25	44.6	
4	13a	4	Oct. 23, 6 p.m.	Oct. 24, 12 m.	12341	6430	18771	5015	.....	5015	4543	.....	4543	.....	.....	.....	28329	247	580	585	585	....	5	25	36.4	
5	13b	3	Oct. 17, 10 p.m.	Oct. 19, 10 a.m.	10580	730	11310	6195	262	6457	5340	.....	5340	.....	.....	.....	23107	(275)	565	570	572	....	4.8	25	56.2	
6	13b	3	Oct. 16, 6 p.m.	Oct. 17, 2 p.m.	11710	6670	18380	6800	3435	10235	6365	.....	6365	.....	.....	.....	34980	(264)	550	550	555	....	15.3	50	71.6	
7	13a	4	Oct. 16, 6 p.m.	Oct. 17, 2 p.m.	5030	3830	8860	5013	2645	7658	9550	2142	11692	.....	.....	.....	28210	264	560	565	566	....	15.2		36.7	
8	15a	3	Oct. 26, 3 a.m.	Oct. 26, 11 p.m.	11920	6750	18670	5262	.....	5262	5230	.....	5230	.....	.....	.....	29162	(275)	550	550	553	....	5.8	25	50.7	
9	15a	3	Oct. 25, 3 a.m.	Oct. 25, 9 p.m.	11490	4975	16465	7020	759	7779	5780	.....	5780	.....	.....	.....	30024	(275)	538	546	547	....	6.7	25	72	
10	16b	3	Nov. 2, 8 p.m.	Nov. 3, 12 m.	12700	6750	19450	10495	.....	10495	4666	.....	4666	.....	.....	.....	34611	256	510	519	521	....	18.3	50	86.6	
11	16a	4	Nov. 2, 8 p.m.	Nov. 3, 12 m.	13850	6430	20280	10510	.....	10510	5695	.....	5695	.....	.....	.....	36485	256½	475	515	516	....	18.3		75.8	
12	16b	3	Nov. 13, 5 a.m.	Nov. 14, 3 a.m.	11460	6750	18210	6780	.....	6780	7540	.....	7540	.....	.....	.....	32530	258	540	540	545½	....	18.9	50	63.7	
13	16a	4	Nov. 13, 5 a.m.	Nov. 14, 3 a.m.	13270	6430	19700	6802	.....	6802	4645	.....	4645	.....	.....	.....	31147	257	530	570	575	....	19.0		37.7	
14	16b	3	Nov. 12, 1 p.m.	Nov. 16, 5 a.m.	10675	5806	16481	6748	.....	6748	6638	.....	6638	.....	.....	.....	29867	257	540	540	541½	....	18.6	50	67.3	
15	16a	4	Nov. 12, 1 p.m.	Nov. 16, 5 a.m.	13430	6430	19860	8360	.....	8360	4435	.....	4435	.....	.....	.....	32655	257	480	565	567½	....	18.6		37.7	

RADIATION TESTS—Table 4

Watts. Unit No. 1

Watts.

Watts.

Unit

RADIATION TESTS—Table 4

Test No.	Date	Watts. Unit No. 1			Watts. Unit No. 2			Watts. Unit No. 3			Unit No. 4		Steam Temperature					Steam Pressure					Pounds of Steam per Hour	Losses in Watts					Watts Input. Total	Per cent Loss
		Wi	Wo	Wt	Wi	Wo	Wt	Wi	Wo	Wt	Wi	Wt	T0	T1	T2	T3	T4	P0	P1	P2	P3	P4		Unit 1	Unit 2	Unit 3	Unit 4	Total		
	May																													
4a	8	10693	4637	15330	10400	4323	14723	10753	4163	14917	....	....	285	550	762	932	...	...	13¼	11	8½	...	332.5	2960	4460	6615	......	14035	34970	40.2
4b	8	10733	....	10733	10719	....	10719	11080	....	11080	....	....	276	563	760	924	...	...	6.8	5.7	4.4	...	227	1655	4270	5550	......	11475	32532	35.3
4c	9	13003	4654	17657	11144	4580	15724	7778	4179	11957	....	....	284	589	793	887	...	...	15	13.1	9.6	...	367	1883	4955	6650	......	13488	45338	29.8
4d	9	15476	4674	20150	3401	4342	7744	5410	4172	9582	....	....	288½	701	789	875	...	...	10.8	9.2	6.8	...	296.2	3020	3755	5800	......	12575	37475	33.6
4e	10	10770	4665	15435	10652	4496	15148	11081	4130	15212	....	....	303	537½	740½	925	...	...	15.4	13.8	11	...	374.5	3038	4315	5140	......	12535	45795	27.4
	June																													
8a	4	10254	3990	14244	6545	4164	10709	2679	3800	6479	2353	2353	305	548	689	709	705	...	18.4	12.3	8.6	5.6	384	694	2619	5036	2252	10601	33785	31.4
8b	5	10066	4378	14444	9362	4004	13368	3868	4240	8108	3983	3983	297	544	742	792	813	...	19¾	13¼	9¼	6¼	381.6	727	2276	5365	2557	10925	39901	27.4
10	18	1090	3919	5009	700	4161	4861	850	4115	4965	1862	1862	408¼	494¼	532	574	591	...	13¼	8½	8	7½	262.8	1819	3101	3400	1171	9491	16697	56.8
	Dec.																													
18a	5	7275	6430	13705	5974	....	5974	1918	....	1918	....	....	300	515	572	578	...	21	20	19.8	18½	...	357	3025	3144	1680	......	8849	21597	41
18b	5	7275	6430	13705	6838	....	6838	6552	....	6552	....	....	300	519	593	695	...	21	20	19.8	18½	...	357	3025	3668	1833	......	8526	27095	31.5
18c	6	7832	6430	14362	9505	....	9505	9745	....	9745	....	....	299	524½	647	795	...	21	20	19¾	18¼	...	360	2842	3243	4710	......	10795	33512	32.3
18d	7	10808	6430	17237	8078	4830	12908	10201	....	10201	....	....	301	577	741	899	...	21	20	19¾	18	...	368.8	2857	4095	1641	......	8593	39913	21.5
18e	7	11542	6430	17972	11487	....	11487	10670	....	10670	....	....	300	580	740	905	...	21	20	19¾	18¼	...	363	3652	3307	1920	......	8879	40129	22.1
18f	8	13759	6430	20181	9881	....	9881	6493	....	6493	....	....	367	670	780	865	...	21	20	19½	17½	...	376	4291	4581	1313	......	10185	36565	27.9
18g	9	13479	6430	19909	11004	....	11004	8787	....	8787	....	....	371½	681	815	945	...	21	20	19¾	18	...	360	4270	4114	2007	......	10391	39681	26.2
18h	11	12920	6980	19904	9737	....	9737	9588	....	9588	....	....	354	688½	837	958	...	21	20	19¾	18	...	329.6	4424	2707	3758	......	10889	39229	27.8
18i	13	13337	6430	19767	7096	....	7096	9350	....	9350	....	....	373.1	695¾	799½	931½	...	21	20	19¾	18¼	...	359.4	3747	1797	2290	......	7834	36214	21.6
18j	14	13657	6430	20087	8211	....	8211	8928	....	8928	....	....	371¼	681	772½	890½	...	21	20	19¾	18	...	376.6	3667	3375	2348	......	9390	37226	25.2

TEST No. 4.—Catalysers 1, 2, and 3 were set up in adjacent spaces 4′-0″ centres and connected by a bus pipe, and interconnecting pipes and valves so that any catalyser could be cut out of the battery. In tests a, b, c, and d the valves and flanges were not lagged, corresponding to tests 1, 2, and 3, but in test e the valves and flanges were covered.

TESTS 8 and 10.—Catalyser set up on pedestal to accommodate six units, the spaces filled being 1, 3, 5, and 6. The broken spaces between 1 and 3 and 3 and 5 were connected by the bus line. In test 8 the lagging on the flanges of the pipe between 1 and 3 and 3 and 5 was partially knocked off. During the test the pan and channel iron base for Unit No. 1 was about 100° F., while for Units 3, 4 and 5 they steadily rose in temperature. In Test 10 leaks of steam were observed in Units 2 and 3, which may account for discrepancy in results from Test 8.

TEST 18 was conducted on Battery 4 of the 3rd Stage except Test 18h, which was for Battery 3. A leak of steam was observed from Unit 2 in Tests 18a to 18g inclusive, but in tests 18i and 18j the leak was repaired. These catalysers were insulated in the same manner as when tests on the 3rd stage were made.

SECTION NO. 7.

HEAT QUANTITIES REQUIRED FOR THE CATALYSERS.

General Method—Average readings of the total quantity of heat expressed in watt hours required for stages one and three are given in Tables 2 and 3. In Table 4 the radiation losses of the catalysers are given. Therefore it would appear to be a simple matter to subdivide the net heat supplied to the catalysers into two parts.

(a) That going to heat the gases.

(b) That required to bring about the desired reaction.

Causes Introducing Errors—Such a simple procedure was contemplated, and work has been done in that direction as will be shortly described. But since all data was obtained from the catalysers set up for a working and not as a testing set, the results so obtained can only be considered as very approximate for the following reasons:

(1) It has been previously stated that the thermometer readings are apparently influenced by the conduction of heat through the metal, and hence the readings of the temperature of the gases cannot be considered as absolutely accurate.

(2) The radiation losses do not follow any regular law as seen from Table 4, and are a very high percentage of the total heat supplied.

(3) The assumption must be made that the specific heat of the products of the reaction is the same as that of the substance undergoing the change, or in other words to suppose that the vapor supplied to the catalysers is first heated to the maximum temperature and that the reaction is brought about while at that temperature.

(4) According to the chemists, in the first stage there may be produced two different substances namely, alpha butylene and beta butylene. It must be assumed that the heat of formation of the two varieties are the same as no data is available as to the quantities of each present.

(5) It was seen during the running of test No. 7 first stage, that the butyl alcohol vapor was not coming over dry or superheated but very wet. Since in all other tests save 2, 6 and 7 conversion was going on as well as heating, the problem in these latter tests can only be attacked by treating the results as two simultane-

ous equations and in thus solving by differences, any errors are largely magnified. These errors are also made more noticeable because the quantities involved in the equations are nearly equal one to the other.

Proposed Experimental Installation—It is to be regretted that time was not permitted to set up an experimental installation for the purpose of separating the heat required for the reaction itself as distinct from that required for heating the gas. Such an installation was planned and parts already assembled with the idea that these quantities should be accurately determined. However the results we have obtained will be some guide for future considerations and therefore should be included in this report.

Definition of Specific Heat and Endothermic Heat—In the following calculations the heat required to raise the temperature of the gases 1° F. will be called the Specific Heat and will be expressed in watt hours per gallon first and the final results in those terms and in B.T.U.'s per lb. The endothermic heat will be considered to be the quantity of heat required to convert a certain quantity of primary butyl alcohol in butylene or secondary butyl alcohol into M.E.K. This quantity of heat will in the calculations be expressed in watt hours per gal. and then later converted into B.T.U.'s per lb.

DETERMINATION OF SPECIFIC AND ENDOTHERMIC HEAT FOR STAGE NO. 1.

In the following calculations it is to be noted that in the conversion of primary butyl alcohol into butylene there is also water formed. Theoretically, 1 gal. of Normal Butyl Alcohol gives 1.011 gals. of butylene and 0.2 gals. of water or 8.11 lbs. of Normal Butyl Alcohol give 6.12 lbs. of butylene and 1.98 lbs. of water. Besides these quantities in the actual process there are side products such as butyl ether which unite with the water, and unconverted butyl alcohol in the separator and this mixture dissolves about 10% of its combined volume of liquid butylene. Therefore in all calculations of the conversion in the catalysers this dissolved butylene must be added to the quantities collected in the tanks.

SPECIFIC HEAT—In finding the specific heat the data from the preheater in tests 1 and 6, Table No. 2 and the radiation losses obtained from Table No. 4 were utilised, where the radiation loss for test No. 2 was 302 and for test No. 6,-727 watt hours. Values were obtained for lines 1, 2, 3 and 4 respectively Table No. 2 of 1.365, 1,382, 1.315, 1.342 watts hours per gal. per 1° F. rise in temperature and another result from the same tests not listed was 1.325. Test No. 7 could not be dealt with in this way owing to the vapor coming into the preheater decidedly wet, but since the conversion in lines 5 and 6, Table No. 2 are the same, by assuming the radiation 9910 for line 5-10052 in line 6, a value of 1.4045 was obtained for the specific heat. Therefore a value of 1.35 watts hours per gal. per 1° F. will be considered as the specific heat.

ENDOTHERMIC HEAT.

In test No. 7 the results were taken very carefully and radiation tests as listed in Test No. 8, Table No. 4 were performed without the catalysers having been in the slightest disturbed. This test is therefore the most authoritative one from which to obtain values for endothermic heat of formation of butyl alcohol into butylene. A sample calculation is given below:

Units Nos. 3, 5 and 6.
Input=33034 watt hours.
Radiation=9910 watt hours.
. ·. Net Input=23124 watt hours.
Temperature Rise=161° F.
Feed=36 gals. per hour.
Conversion=30 gals. per hour.
. ·. Unconverted=6 gals. per hour.
Water formed=5 gals. per hour.
. ·. Condensate=11 gals. per hour.
Butylene dissolved in condensate=1.1 gals. per hr.
. ·. Corrected Conversion=31.1 gals. per hour.
Let y=endothermic heat.
Let specific heat=1.35 watt hours per gal. per 1° F.
. ·. $36 \times 161 \times 1.35+31.1y=23124$.
$31.1y=23124-7835=15289$.
$y=492$ watt hrs. per gal.

Other calculations of endothermic heat approach this valu closely and therefore it will be considered to be 500 watts per gallon converted.

CHECKS—If these values of 1.35 watt hours per gal. per 1° F. for the specific heat of primary butyl alcohol and 500 watt hours for the quantity of heat required to convert 1 gal. of butyl alcohol into butylene be taken and applied to rise of temperature, feed and conversion in Table No. 2, it will be seen that the theoretical heat required does not exactly check up with the net heat supplied, the latter being obtained by subtracting the radiation losses as listed in Table 4 from the gross input of Table No. 2. An example of this calculation will be given, but before passing to that, it would be well to note that no radiation tests were conducted with batteries 1 and 2 as at present set up, and it is extremely doubtful if the results from batteries 3 and 4 will exactly apply. This may account for some of the discrepancy.

But assuming that the specific heat of primary butyl alcohol is 1.35 watt hours per gal. per 1° F. rise, and that the endothermic heat is 500 watt hours per gal., a set of calculations will be worked to show just how great the discrepancy may be.

Taking lines 28 and 29:

Total heat to two batteries=65550 watt hours.

Average temperature rise=725.5—366.5 or 359° F.

Feed=60 gals. per hour.

Conversion—liquid butylene collected=	49.6 gals.
" " dissolved=	2.03 gals.
Total	51.63 gals.

Therefore heat required=

359 x 60 x 1.35+51.63 x 500=54370 watt hours.

.˙. Radiation losses theoretically=

65550-54370=11,180 watt hours for 2 batteries or 5,590 watt hours for 1 battery.

If the same figures as above for specific heat and endothermic heat be substituted in one of the earlier tests, say line 5 test 7, and in this test the preheater be eliminated, the theoretical radiation will be found to be 9604 watt hours. This checks remarkably well with the value of the radiation loss of 9907 watt hours for the three catalysers as found experimentally in test 8a Table No. 4.

FINAL RESULT—Therefore while the figures given may not be absolutely correct a close approximation to the values for the specific and endothermic heat of primary butyl alcohol may be considered as follows:

Specific heat of primary butyl alcohol=1.35 watt hours per gallon per 1° F.=0.570 B.T.U.'s per lb. per 1° F.

Endothermic heat of formation of butylene from primary butyl alcohol=500 watt hours per gallon of primary butyl alcohol=210.5 B.T.U.'s per lb. primary butyl alcohol.

DETERMINATION OF SPECIFIC AND ENDOTHERMIC HEAT FOR STAGE 3.

METHOD—In separating the specific heat from the endothermic heat for Stage 3 there were no reliable tests such as No. 2 and 6 for the first stage where preheating was separate from catalysing. We are therefore forced to consider the problem by assuming radiation losses will be the same for different parts of the same test under the same conditions and from table No. 4 to approach their value very closely. Hence the two results may be put in the form of two equations involving two unknown quantities. It is to be remembered however that the same difficulties which have been enumerated at the beginning of this section apply to the third stage as well as to the first, with this exception, that in the third there are widely differing conditions which permits a more accurate determination.

SPECIMEN OF CALCULATION—A sample of the calculations involved will be given for lines 3 and 4, Table 3 test 13a on battery No. 4.

Let x=specific heat of secondary butyl alcohol in watt hours per gallon per 1° F. rise.

Let y=endothermic heat of secondary butyl alcohol in watt hours per gallon.

Let r=radiation loss for battery No. 4=8000 watt hours (Table No. 4).

For line No. 3 Table 3, we have:

Input per hr.=28882 watts.

Temperature rise=570-301=269° F.

Feed=25 gals. per hr.

Conversion=44.6%=11.15 gals. per hr.

$\therefore\ 25 \times 269 \times X + 11.15y = 28882 - 8000$, or 20882 watt hours.

For Line No. 4:

Input per hour=28329 watts.

Temperature rise=585-247=338° F.

Feed=25 gals. per hr.

Conversion=36.4%=9.1 gals. per hr.

$\therefore\ 25 \times 338 \times X + 9.1y = 28329 - 8000$, or 20329 watt hrs.

From above two equations can be obtained:

$x = 1.125$ watt hrs. per gal. per 1° F.

$y = 1195$ watt hrs. per gal.

Other determinations of these quantities, however, point to a lower value for the endothermic heat and therefore it seems best to take it to be approximately 1000 watt hours per gallon.

CHECKS—As a check these values of 1.125 and 1000 watt hours were then inserted in every line of Table No. 3, and the results obtained were then subtracted from the total watts actually supplied. The resulting difference so closely approximated, in all cases, the radiation losses as established by Table No. 4, that the results may well be considered remarkably close. As for example: Line No. 8, Table No. 3:

25 gals. per hr. raised 278° F. require 25 x 278 x 1.125 or 7830 watts.

11.3 gals. per hour converted require 11.3 x 1000 or 11300 watts.

Total heat required (theoretically)=19130 watts.

Actual input=28882.

Unaccounted for=28882-19130, or 9752 watt hrs.

Radiation loss (Table No. 4, test 18a)=8849 watt hours.

Also in the tests where the feed of secondary butyl alcohol was divided into the two batteries, these figures apparently determine very closely the quantity flowing through each, as for example: Lines 10 and 11, Table No. 3:

Let R=the radiation for battery 3 or 4 (assumed equal).

Let X=the gallons per hr. passing to battery No. 3.

$\therefore$ 50-X=the gals. per hour passing to battery No. 4.

	Battery No. 3.	Battery No.4.
Feed gals. per hr.	X	50-X
Temperature rise °F	260°F	260°F
Conversion %	86.6%	75.8
Input Watt hours	34611	36485

$\therefore X \times 265 \times 1.125 + .8661 \times X \times 1000 + R = 34611$

$(50-X) \times 260 \times 1.125 + .758\ (50 \times X) \times 100 + R = 36485.$

From above $X = 22.9$ gals. $50-X = 27.1$ gals.

$R = 10960$ watt hours.

These values appear very reasonable and the radiation losses in this instance should agree approximately with the radiation losses listed in Table No. 4, test 18, which they do.

Final Values—Hence a fairly accurate result will be the specific heat of secondary butyl alcohol=1.125 watt hours per gal. per 1° F.=0.48 B.T.U.'s per lb. per 1° F.

The endothermic heat of conversion of secondary butyl alcohol into M.E.K.=1000 watt hours per gallon of secondary butyl alcohol, or 428 B.T.U.'s per lb. of secondary butyl alcohol.

SECTION NO. 8.

THE ELECTRIC POWER AND THE NUMBER OF CATALYSERS REQUIRED FOR A FULL SIZED PLANT OF CAPACITY 150 GALS. PER HOUR.

Electrical Power Required—In forming an estimate of the quantity of power that would finally be required for the heating of the catalysers to convert 150 gals. per hour of primary butyl alcohol into M.E.K., this estimate will be based on the known data of conversion, heat required, etc., obtained from actual operating conditions.

Theoretical Quantities—Theoretically, 150 gals. per hour or 1,215 lbs. of primary butyl alcohol should yield 151.5 gals. or 919.5 lbs. of liquid butylene. This liquid butylene on being sulphated, hydrolysed and distilled should yield 150 gallons or 1,215 lbs. of secondary butyl alcohol. After passing through the third stage we should, were there is no loss, obtain 147 gals. or 1,182 lbs. of M.E.K. Therefore, theoretically there is an efficiency of conversion of 98% by weight.

Losses of Material—But after the whole plant had been in operation, according to Mr. Legg, the efficiency of conversion by weight was about 75%, which agrees very closely with Professor Moureu's figure of 77%. Therefore in dealing with the quantities undergoing change we will assume that the M.E.K. formed will be 75% by the weight of the primary butyl alcohol used, and that the losses are equally divided between stages 1, 2 and 3. Under this supposition, we can therefore state the following will be the amounts of each substance used or formed per hour.

Primary Butyl Alcohol used=150 gals. or 1,215 lbs. per hour.
Butylene formed=139.70 gals. or 848 lbs. per hour.
Secondary Butyl Alcohol formed=127 gals. or 1,028 lbs. per hr.
M.E.K. formed=115 gals. or 911 lbs. per hour.

Heat Losses—Besides this loss during the process there are several other considerations that must be taken into account. The M.E.K. process here was in its infancy, and there were great losses of heat both in the interchanging system and piping and in radiation losses from the catalysers. A large amount of this heat could be saved in the future, which thereby would lessen the demand for power. Moreover, in the first stage there is a high percentage of butylene dissolved in the condensate and this butylene can be recovered with a far less expenditure of heat than would be required to form it from primary butyl alcohol. But since these factors are unknown, the estimate of power required will be based on actual tests and will therefore be slightly in excess of that actually required.

The tests that will be considered as samples will be tests No. 14a and 14b for the first stage and test No. 16a for the third stage.

Power Required for the First Stage—Data from first stage tests No. 14a and 14b from October 19th to November 8th, on batteries 1 and 2 (for curve of tests see drawings index).

Average feed gals. per hour primary butyl alcohol=60.
Average conversion=76.1%.
Therefore average butylene formed in gals. per hour=45.6.
Average watts input=60,612 watts.
Net hours in use (test No. 14b)=502½.

Therefore heat required to fully convert 1 gal. of primary butyl alcohol into butylene=60612÷45.6=1330 watts.

(Assuming the same amount of preheating and radiation as in the tests above.)

Therefore heat required, on the same assumption to convert 150 gals. of primary butyl alcohol into butylene=150 x 1,330=200 Kw.

THIRD STAGE—Data from third stage test No. 16a from November 2nd, to November 16th on battery No. 3 (for curve of test see drawing index).

Average feed of sec. butyl=25 gals. per hour.

Average conversion=73.3%.

Average M.E.K. formed=18.8 gals. per hour.

Average input=32,882 watts.

Net hours in use=146.

Heat required to convert 1 gal. of sec. butyl alcohol into M.E.K. =32882÷18.8=1750 watts.

Assuming the same amount of preheating and conversion as in test above.

Therefore heat required to convert 127 gals. of secondary butyl alcohol into M.E.K.=127 x 1,750=222 Kw.

TOTAL NET QUANTITY—Therefore the total quantity of power required for actually heating the catalysers for stages 1 and 3 based on above tests for a duty of 150 gals. of primary butyl alcohol per hour will be 200+220 or 420 Kw. net.

DEMAND FACTOR—But as at short intervals it will be necessary to repack certain of these catalysers with catalyst, a demand factor will have to be brought in. Owing to the trouble we have had with the old type catalysers on which all runs up to the present have been made, it would be manifestly unfair to use the demand factor established here, in designing a new plant. But it will be noticed that for stage 1 a battery will last for 502 hours against a run of 146 hours for the third stage. If we assume that 48 hours will be required to repack a battery this will lead to demand factors as follows:—

First Stage=502÷550=91%.

Third Stage=146÷194=75%.

This will therefore increase the power required to 200÷.91+220÷.91+220÷.75=220+294 or 514 Kw.

While these values of demand factors are very high, yet it would be the duty of the engineer in charge to maintain them so, and as economies in the direction of higher preheating and elimination of losses will lower the heat required per gallon below the figures employed, we will allow these high demand factors to stand.

LOSS IN CONTROLS—If the type of control adopted be the barrel rheostats, they will cause a further loss, which amounted in experiments here to about 25% of the input. This loss can be greatly reduced and heaters were being built with a much lower rating, but in any event with this type of control it would be necessary to face a loss of at least 10% on the total. If automatic controls were installed of the type described in a previous section, while the loss in the controls would be zero, yet it would be necessary in planning the size of the main power house to provide for an added demand factor over and above that which provides for the shutting down of certain batteries. This demand factor would be provided for if the plant were designed large enough to care for a 10% loss in rheostats.

TOTAL POWER REQUIRED—Therefore the total quantity of electrical power that would possibly be required for the catalytic reaction would be $514 \div 0.90 = 565$ Kw. or 756 h.p.

NUMBER OF CATALYSERS REQUIRED FOR 150 GAL. PER HOUR PLANT.

FIRST STAGE BASED ON TESTS 14 ONLY—Reference has been previously made in this section to the tests which will be considered the basis of our calculations for future needs for power. These same tests will be used in estimating the number of catalysers that would be required for a plant dealing with 150 gallons of butyl alcohol per hour. And since these calculations will be based on tests, where the inlet temperature of the gases to the catalysers was very low, the number of the catalysers required as here stated, will be really in excess of the number required. But it appears safer to base an estimate on results actually obtained and which can at least be duplicated, rather than prophesy as to what will happen when certain defects in the present system have been rectified.

From tests 14a and 14b already described, a conversion of 45.6

gals. per hour has been obtained from 2 batteries. Therefore if the catalyst had an infinite life, the number of batteries required would be 139.7÷45.6 x 2=6.1.

But since these batteries require recharging it will be necessary to add an extra one and hence 7 batteries will be required.

THIRD STAGE BASED ON TEST NO. 16 ONLY—From test No. 16a the conversion per battery equals 18.8 gals. of M.E.K. per hour. But it is required to form 127 gallons of secondary butyl into 115 gallons of M.E.K.

Therefore the number of batteries required were no recharging of the catalyst necessary=115÷18.8=6.1.

But since it has previously been estimated that after a run of 146 hours, 48 hours would be necessary for recharging and getting a battery in operation again, the number of batteries required for this stage would have to be increased in the ratio of 146 to 194 or 8 batteries would be needed.

TOTAL BASED ON TESTS 14 AND 16 ONLY—Therefore basing our estimate on tests actually performed with interchangers in position the number of batteries of 3 catalysers each that will be required will be 15. This is based however on the assumption that the new metal catalysers will not give such trouble in the flanges as previously has been encountered, (see index under section No. 6), that a battery of catalysers can be cooled, opened, repacked, made tight and put into operation in 48 hours, and that the amount of preheating required is the same as in tests 14a and 14b for the first stage and test 16b for the third stage.

FIRST STAGE CONSIDERING HIGHER PREHEATING—But in test 7, where the preheating was carried to a higher degree by means of an electric preheater than was obtained by the heat interchangers used in tests 14a and 14b, a much greater quantity of butylene was converted per three catalysers than in these later tests. Thus instead of obtaining a conversion of only 45.6 gals. per hour for 2 batteries of 3 catalysers each, a conversion of 29.6 gals. per hour was obtained for 1 battery.

Owing to this it has been decided to insert an electric gas preheater between the interchangers and the first catalyser for each battery, and while it is dangerous to estimate to what degree preheating could be carried, owing to danger of dissociation of the butyl at high temperatures, yet it is quite safe to assume that gas temperature entering the first catalyser could be brought to the value used in test No. 7 or to 550° F.

On this basis, while the total quantity of heat would be practically unaffected, the number of catalysers would be reduced for the first stage. Under these conditions therefore the number of net batteries required, assuming repacking is not necessary, will be 6.1 x .77=4.7. Therefore assuming this number must be increased in the ratio of 550/502 to take care of the loss of time through repacking, the number of batteries required will be 4.7 x 550/502=5.15 or 5 batteries will be required.

THIRD STAGE CONSIDERING HIGHER PREHEATING—Considering the third stage we have no authorative test from which to judge the effect of the higher initial preheating of the gases. It is altogether probable that a reduction in the number required as based on test No. 16a would be made though to what extent, cannot be said. The probability is that matters would be perhaps even more improved in the third stage because the heater of the first catalyser in test 16a is loaded to its full capacity and the feed to the two batteries is only 50 gallons per hour instead of 60 as for tests 14, first stage. Moreover, the third stage catalytic action appears to take a longer time of contact of gas with catalyst than does the first stage.

This is evidenced by the fact that in general there is not so great a reduction in the heat required by catalysers 2 and 3 in the third stage as there is in the first. Therefore it would appear that the addition of an extra catalyser to the third stage would cause an improvement in the conversion and this is, in effect, what would be done, were most of the preheating duty removed from catalyser No. 1 allowing more of its catalytic surface to act on the gases when they were at the reaction temperature.

Therefore if preheating the gases before they are admitted to the catalysers of the third stage be considered as beneficial as results have proved it for the first stage, the number of catalysers required for it assuming no time lost for repacking would be 6.1 x .77=4.7. Taking into account the time lost by repacking the number of catalysers required for a 150 gal. per hour plant would have to be increased to 4.7 x 194/146=6.23 batteries, or shall we say, 6 batteries.

Conclusions—From the above figures we can then make the following conclusions as to the total number of batteries of 3 catalysers each required to convert 150 gals. per hour into M.E.K.

(1) Making no allowance for the effects of higher preheating as in test No. 7, but basing all our conclusions on tests 14a and 14b for the first stage and test 16a for the third stage we would have.

No. of batteries, First Stage = 7
No. of batteries, Third Stage = 8

Total number of batteries = 15
= 45 catalysers.

(2) Allowing a reduction in the number of batteries required for the first stage based on the known improvement in conversion per battery by higher initial preheating as shown in test No. 7 but considering this same reduction is not applicable to the third stage we have:

Number of batteries required, First Stage = 5
Number of batteries required, Third Stage = 8

Total number of batteries required = 13
=39 catalysers.

(3) Allowing a reduction in the number of batteries in the first stage as above and considering that this same reduction is applicable to the third stage we have,

Number of batteries required, First Stage = 5
Number of batteries required, Third Stage = 6

Total number of batteries required = 11
=33 catalysers.

SECTION NO. 9.

COST OF ELECTRIC HEATING EQUIPMENT FOR THE CATALYSERS.

Installation- Proposed by General Electric Company—In the report dated September 15th, 1917, on the proposed methyl ethyl ketone plant, the specification of the electrical heating equipment for the catalysers recommended by the General Electric Company were given (Electrical Section). It will be noted in that report that automatic temperature controls were to be used, but these controls were not actuated alone by the gas temperatures but also by the temperature of the resistors. What operating difficulties would have been entailed by such a method of control is very difficult to forecast.

The heat quantities assumed in this design by the General Electric Company were the most reliable figures that were then known, but they have since been found to be widely in error. However, at the time of the above-mentioned report the estimated cost of this electric heating equipment for a plant capable of handling 150 gals. of primary butyl alcohol per hour was $103,920.00, exclusive of the cost of installation, and had the British Acetones committed themselves to the purchase of such equipment, that would have been its first cost, and necessary changes in it, as well as the cost of installation, would have added considerably thereto.

INSTALLATION ADOPTED—Fortunately, it was decided to construct our own heaters in the plant, and by means of barrel rheostats to regulate the quantity of power supplied to them, and thus, through a very wide range, to control the temperature of the gases to any desired value.

Accordingly, an experimental skeleton switch board was laid out for six catalysers, the current supplied to both the inner and outer heaters of each being controlled by the rheostats. From this battery very good results were obtained on the first stage as previously described, but as no satisfactory runs for the third stage had been made, it was decided to extend this switchboard to its fullest capacity and to operate by the barrel rheostats until such time as every detail demanded by the process should be fully understood. Therefore, the switchboard was extended to accommodate 36 catalysers, and this work on November 16th was almost completed. A statement of the exact amount of work done is as follows:

WORK COMPLETED—There was completed and already in use:

(1) Transmission line of wood pole construction (but crossing under Cherry Street in lead covered cable) bringing 3 phase 25 cycle, 12,500 volt power from the Toronto Electric Light substation to the plant transformer house, a distance of approximately 000 ft.

(2) Full transformer capacity capable of dealing with a 250 gal. per hour plant under the same conditions as were described for tests No. 14 and No. 16 in Section No. 7. Three 300 Kva. Westinghouse O.I.W.C. transformers were used, the details of construction being listed in Section No. 3 (see Index).

(3) Low tension feed lines from the transformer station to the switch house described in Section No. 3.

(4) One switch board complete with rheostats for 36 catalysers described in Section No. 3.

(5) Conduit lines and wiring complete in switch house and catalysing rooms to handle 36 catalysers.

(6) 27 Inner heaters (12 being completely installed and in operation) described in Section No. 4.

(7) 17 Outer heaters (12 fully installed and in use) described in Section No. 4.

COST OF WORK COMPLETED INCLUSIVE OF ALL STORES—In the cost of this completed work is included the full purchase price of all material bought, whether used or in stores, and all time and material used in changes, radiation tests, etc., and actual installation. As previously stated, the number of men engaged in this department was kept purposely low, so that it was possible to utilise the switch board operators for construction work, when they were not engaged in their regular duties. Therefore, this cost includes the full wages paid these men from the time they began in this department to the time of the shutting down of the plant, less the wages paid when they were actually operating the board.

These costs are made up as follows:

	Labor.	Material.	Total.
Purchased direct by Electrical Dept.	$........	$20,569.98	$20,569.98
Works Orders charges	3,081.04	744.67	3,825.71
Transmission line	....	....	1,185.42
Operators' time on constructions	3,740.15	....	3,740.15
	$6,821.19	$21,314.65	$29,321.26

COST IF USABLE STORES ARE DEDUCTED—From this total, material on hand of value $3,642.62 should, however, be subtracted, as the material included in this figure has not been used, cut upon or unpacked. This amount does not include jigs, tools or fixtures, but represents alundum tubes and cement, transite, wire, etc. The net cost therefore becomes:

Labor	$6,821.19
Material	17,672.03
Transmission line	1,185.42
Total net cost	$25,678.64

Cost to Complete for 36 Catalysers—By examination of the work completed, it is seen that all that was necessary to complete the electric heating equipment for 36 catalysers, which would be capable of dealing with from 125 to 150 gals. per hour of butyl alcohol, was the construction of 9 inner and 19 outer heaters, and the installation of 24 sets complete. The cost of these completely installed and including the heat insulation of the catalysers, but not making any deductions for stores on hand, would be $3,494.00 made up as follows:

Cost of 9 inner heaters @ $95.00	$855.00
Cost of 19 outer heaters @ $85.00	1,615.00
Cost of installing 24 sets of inners and outers @ $38.50	924.00
	$3,494.00

Total Cost for 36 Catalysers—Therefore, the total net cost for this plant of the electrical heating equipment for 36 catalysers capable of dealing with 100 to 150 gals. per hour of primary butyl alcohol, where the construction was as outlined in section No. 3 of this report, would be:

Net cost for work completed	$25,678.64
Cost to complete for 36 Catalysers	3,494.00
Total cost	$29,172.64

and this cost includes all tools, fixtures, jigs, ovens, etc., necessary for the work, but not foundations, buildings, etc.

PLANT EQUIPPED WITH AUTOMATIC CONTROLS.

Advantages—It will be remembered (see section on "Temperature Controls") that the barrel rheostats were adopted as an experimental expedient to obtain necessary data on which to base the design for a permanent plant. These controls were never "approved" by the Inspection Department of the Hydro Electric Power Commission of Ontario, but because they were carefully installed to reduce every danger either from fire or shock to a minimum, the British Acetones, Toronto, Limited were permitted to use them as a temporary installation. How long such an understanding would remain in force is doubtful to say, but indications are not lacking that the Inspection Department would continue in their very reasonable view of the situation. However, for a commercial venture the loss of power in the barrels was very great, and therefore for a permanent plant the automatic controls should be installed. Indications point out that the life of the catalyst is greatly influenced by the temperature to which it is heated and by making the control automatic, the human factor is reduced.

MANUFACTURERS CONSULTED—Accordingly, while the work of setting up a temporary switch board to deal with 36 catalysers was proceeding, the manufacturers of various types of automatic controls were being consulted. The general outlines of these controls have been considered in Section No. 5, but quotations from the manufacturers with a short description of the equipment proposed will be submitted. It must not be assumed that these specifications had been fully passed upon, and adopted, but the general outlines are correct and although minor changes might be advantageous, the difference between a war-time price and one on a peace-time basis would more than offset any slight changes that might be made.

The switch board and automatic switching gear required for 42 catalysers have been fully quoted on by the Canadian Westinghouse Company, and a section of their specification reads as follows:

SWITCHBOARD—"The control equipment we are proposing to supply you now consists of:

"42 Sections mounted so as to form 14 panels each 3 sections high.

"Each section will mount a 2 pole, 125 ampere, type F contractor with blowout, 3 enclosed fuses, 1 relay, together with a resistance tube and interlock for use with thermostat. Each contractor will also be supplied with its individual push button station for opening the control from the thermostat when it is desired to cut out the automatic control feature. This push button is to be mounted by customer at any convenient point. Upon the rear of the switchboard will be mounted a 3 phase bar system for feeding the 2 pole contractors.

"Our equipment therefore, consists of the following:

"1-220 volt, 3 phase, 25 cycle special type "F" thermostatic control equipment consisting of 42 slate panels, 14" x 20" x 1", mounted complete on ¾" pipe frame supports 15 upright being used, and on these panels will be mounted the following items:

42-125 amp., 2 pole type F Magnetic Switches.
42-Relays.
42-Interlocks.
252-Fuse Holders.
126-Fuses.
Necessary bus bar copper.
42-10" Resistance Fuses.

"Separate from panel will be supplied:

42-Push Button Stations S No. 217987-A.

"The approximate net weight of the above complete will be 1675 pounds.

"Price f.o.b Pittsburgh in bond, $4,880.00.

"Shipment could be made in from 100 to 120 days after receipt of order with complete information at the Works. For approximate outline dimensions we have mailed you copies of outline Dwg. No. 329296 on which we have marked the approximate overall dimensions. This equipment is arranged so that each 100 ampere single phase circuit is to be operated from its individual thermostat. You will note that the above equipment is lined up on the basis of being used on a 3 phase, 220 volt, 25 cycle circuit as requested."

THERMOSTATS—The thermostats for operating the above switching gear have been quoted on by the Taylor Instrument Companies of Rochester, N.Y., as follows:

1 Tycos Mercury Actuated Temperature Control complete with feet of flexible connecting tubing plain bulb stem, J5 3-inch clamp flange.

Temperature range up to 550° F.	$75.00
Temperature range up to 800° F	84.00
Temperature range up to 1,000° F.	96.00

Preheaters—Besides this automatic control it had been decided to instal electric gas preheaters to raise the inlet temperature of the gases entering the first catalyser of each battery higher than was accomplished by the interchangers alone. (See Section No. 7). Work on these preheaters had been begun, and had the plant not been shut down, a very short time would have seen them in operation. Since the heat quantities required for preheating the gases would be constant, no control would be necessary for these elements, save a simple D.P.S.T. fused switch operated by hand.

The costs of the different units of the electrical equipment for this installation determined either from work done or from quotations of the manufacturers are as follows:

Unit Costs—Heaters—

Cost of 1 inner catalyser heater	$95.00
Cost of 1 outer catalyser heater (six units)	85.00
Cost of installing 1 set of heaters(inners and outers) including lagging of the catalysers	38.50
Total per 1 catalyser	$218.50

Automatic Controls—

1 switchboard section controlling 1 catalyser	$116.90
1 Thermostat to operate same	95.00
Total per 1 catalyser	$211.90

Preheaters—

1 Heater for electric preheater	$72.05
cost of installing same including lagging	15.25
Total per battery=	$97.30

Total Costs—Therefore, should it have been decided after the present installation had been completed for 36 catalysers as previously noted, to substitute automatic controls for the barrel rheostats and to provide one preheater unit for each battery and then to have extended the installation to have taken care of an additional 18 catalysers (the full capacity of the catalysing room), the cost would have been as follows:

18 heaters completely installed $218.50 x 18=	$3,933.00
54 automatic controls $211.90 x 54=	11,442.60
18 preheater units installed $97.30 x 18=	1,751.40
Conduit wire, etc., required	1,848.47
Installation costs for conduit switchboard, etc.	4,500.00
Removing old switchboard and adjusting existing conduit lines	500.00
	$23,975.47

This figure is quoted on the understanding that there is no alteration of the conduit lines already installed save to join them in the switch house to the new switchboard and that the 18 new catalysers are spaced in a similar manner to that shown by Dwg. B414. This cost also assumes that the heat insulation and installation of the heaters is the same as has previously been described (see Section No. 4) and that no considerable delays will be occasioned in installing temporary work to keep the plant operating while these changes are being made.

RESUME—As a brief resume of the work in this chapter we may note the following:

Gross cost of electrical catalysing equipment installed to date	$29,321.26

Had the plant been extended to 36 catalysers operating on barrel rheostats and then changes and extensions been made to bring it to a capacity of between 200 and 250 gals. per hour of primary butyl alcohol, the cost of the electrical heating equipment of the catalysers would have been:

Net cost of work completed to date	$25,678.64
Cost to complete for 36 catalysers	3,494.00
Cost of automatic controls, preheaters, etc., for an installation of 54 catalysers	23,975.47
Total	$53,148.11

This total of $53,148.11 for a plant capable of dealing with 200 to 250 gals. of butyl alcohol per hour contrasts very favourably with the General Electric quotation of $103,920.00 for one of much less capacity, particularly when it is understood that in the net cost of the work completed to date is included all experimental work and the changes necessary as the process became better understood.

D. J. THOMSON.

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J. H.

January 31,

REPORT

on

THE MECHANICAL CONSTRUCTION AND EQUIPMENT

of the

ACETONE METHYL ETHYL KETONE AND ACID PLANTS

of the

BRITISH ACETONES, TORONTO, LIMITED.

at

TORONTO, CANADA.

PART III.—APPENDIX I. STILLS.
APPENDIX II. EQUIPMENT

E. METCALFE SHAW, WH.SC., ASSOC. M. INST. C.E.,
Engineer-in-Chief

by

J. H. PARKIN, B.A.SC., M.E., ASSOC. MEM. AM. SOC. M.E.
Mechanical Engineer.

January **31, 1919.**

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APPENDIX I.

STILLS.

PRESENT BEER STILLS.

East Beer Still—Still—The still is 6 ft. dia. x 28' high, of copper throughout. It is made up of three 4' 6" sections containing three plates each, a top 7' 3" section containing one plate and a 4" copper beer heating coil; and a bottom 7' 3" section containing a calandria, float valve and steam supplies, etc. (these sections were all part of the old still).

Each plate carries 69-1½" boiling caps with 8" downpipe and 14" cup, and the trays are intersupported by 5" copper pipe posts in centre.

The beer heating coil in the top section is made of 4" copper pipe bent to form two spiral coils of four turns (inner 2 ft. dia., out 4' dia.) placed 13 inches apart.

The calandria contains 404-2" dia. x 42" tubes mounted between tube plates, the steam surrounding the tubes and supplied through four 1½ inch pipes—not now used.

The still is fitted also with a live steam heating coil of 5" copper pipe 4' 0" dia. perforated with five rows ⅜" holes (3" apart) around the upper half of circumference, lying on top of upper tube plate of calandria and supplied from 2" pipe. There is also a 2" live steam line blowing into side below calandria.

Exhaust steam is blown in through two 3-inch check valved pipes, just below bottom plate.

The still is provided with two 4" vacuum valves—one 1½" x 18" gauge glass, and draining taps for each plate 12 x 20 manholes between plates and at top and bottom.

The float valve in slop outlet has been removed, as it interfered with proper operation, preventing escape of steam when starting up.

The slop escapes through a 6" copper slop seal from the side of the still close to bottom, and has a 3 inch drain in centre of bottom running to sewer, into which slop seal also drains.

The pressure in the still is indicated at a point just below the fourth plate by means of a water column and float device, which has proved quite satisfactory.

BEER HEATER—The heater is of copper construction 36 in. dia. by 15 ft. long on cylindrical part fitted with sixty-six 2½ in. tubes 14 ft. long, the upper tube being about 9 ins. from the top and lower one 3" from bottom flange.

The top is slightly domed, and fitted with two 2" swing check valves on a tee acting as vacuum valves. The bottom of the heater is conical, 30 ins. deep.

The beer enters through a 3" W.I. pipe at bottom of cone passes out 6" from top through 5" pipe to still and passes through the heating coil in head of still before being discharged on third plate. The vapor pipe from the top of the still to heater is 9 inch copper and enters latter 9 ins. below hot beer outlet and leaves on opposite side 24" above bottom flange through 9" copper pipe passing directly into top of condenser. A 3" copper reflux pipe extends from beer heater back to top plate of still.

CONDENSER—The beer condenser is of copper 60 ins. dia. x 24 ft. long, fitted with 148-1½ x 20 ft. tubes on 3" centres. The vapor pipe leads to the upper tube header 42" dia. containing spray plate and provided with 4" vacuum valve.

The condenser is cooled with bay water supplied through 3 inch pipe at bottom and overflowing out of 4 in. pipe at top.

The distillate leaves condenser through 3" copper pipe leading to the twin tail box.

WEST BEER STILL—STILL—The still is of copper construction 6 ft. dia. x 22' 6" high, built up of two 4' 6" sections (from old still) containing three plates each, a 7' 9" top section containing one plate (all new) and a 5' 8" bottom section containing three plates. The latter is made of a 4' 6" section of the old still, to which an extension and bottom have been added.

Each plate carries 69-1½" boiling caps 8" downpipe and 14" cup.

Exhaust steam is blown into the still through two 4" check valved connections just below bottom plate, and live steam through a 5' 6" dia. ring of 3" copper pipe perforated with a row of ¼" holes in 1½" centres pointing diagonally inward and upward.

The still is provided with vacuum valves, a 1½" x 21" gauge glass, 12 x 20 manholes between each two plates, and draining taps for each plate. Pressure below fourth plate is indicated by a similar water column float device to that in the East Still.

The slop escapes through a 6" copper pipe slop seal from centre of still bottom, and the seal is provided with a 3" W.I. pipe drain, which also acts as drain for still. The slop seal is provided with float valve operated by float in bottom of still, but this valve is never used, the seal being sufficient to maintain proper slop level.

Beer Heater—This was formerly a molasses cooler in distillery days, and is made up of a ¼" boiler plate shell 42" dia. x 20' 3" long, with cast iron heads and contains 63-2" O.D. x 18 ft. long 18 gauge copper tubes glanded into cast iron headers.

The beer is pumped through a 3" line into bottom of beer heater and passes from top through a 5" pipe to the still, where it is delivered on the third plate. The vapor pipe from top of still to top of heater is 10" copper, and from bottom of heater to condenser is 9", dividing into two 8" O.D. copper leading to tops of the two condensers. The latter line is provided with a 3" vent to relieve air in starting up.

Condenser—The beer still condenser is made of two Beemis type condensers formerly used as condensers in the Gooderham and Worts' beer still for whiskey distillation. The condensers are of copper 32" dia. x 19' 10" long.

From the condensers copper lines unite and pass to the twin tail box.

ORIGINAL BEER STILL OF GENERAL DISTILLERY CO.

This still was cut in two and with some additions constitutes the present two beer stills of the British Acetones, Toronto, Limited.

Still—The still was of copper 6 ft. dia. by 41 ft. long composed of six 4' 6" flange jointed sections, each containing three plates and a top and bottom section 7' 3" each long. The top section contained two plates and the beer heating coil as now existing in East Beer Still, and was fitted with two 4" vacuum valves. The bottom section contained the calandria and the float of the slop outlet float valve.

Each plate contained 69-1½" boiling caps with 8" down pipe and 14" cup. There was a 12 x 20 manhole between plates, and a draining tap to each plate.

The steam surrounded the tubes in the calandria entering through a 3" pipe controlled by globe valve from operating floor, which divided into four 1½" branches leading into top of calandria at four points on circumference; the exhaust or drips escaping through two 2" W.I. pipes to two traps.

There were also two auxiliary steam inlets, one through the perforations in a 5 ft. dia. coil of 1½" copper pipe below calandria tubes, and the other a straight piece of 1½" pipe above the calandria. Both the latter were much used latterly in the still operation.

The slop outlet was practically the same as in the present East Beer Still, except that there was a float valve in the seal. The valve, however, interfered with the proper running of the still and the latter was operated with the valve held open.

The still handled 6,000 per hour of beer on acetone work.

The beer heater and condenser were those of the present East Beer Still.

RECTIFYING STILLS.

ACETONE FIRST RECTIFICATION.

(two.)

KETTLE—The kettles are of copper 14 ft. dia. x 14 ft. high taking a 13,000 gal. charge and equipped with a "scroll," or heating coil of 2" pipe consisting of four coils around side of tank near bottom, and a seventeen coil spiral on bottom of kettle. The kettles have a slightly dished bottom and a domed top with a four foot vapor head above. The charge is pumped into the kettle through a 4" pipe entering reflux line from column to kettle just above latter, and there is a drain (copper) from centre of bottom. The kettle is provided with a 12 x 16 manhole in side near bottom.

The coil is supplied with steam through 2½" pipe at its outer circumference, and drains from centre through 2" pipe to trap or drain. The steam valve is controlled by extension handle from operating floor, and the steam pressure in the main is indicated by a 5½" dial 200 lb. pressure gauge at the same floor.

The vapors pass from the 4 ft. dome on top of kettle through a 10" copper pipe to spirit column entering latter 27" from base and turning down inside to within a few inches of bottom. From this pipe a connection leads to operating floor, where are located a 6" dia. 15 lb. indicating pressure gauge and a 10 lb. recording pressure gauge (Foxboro).

The kettle is provided with a 4 inch safety valve; a 4 inch vacuum valve drawing on very slight vacuum, and a ½" gauge glass extending full depth of kettle. The 6" reflux line from column enters kettle through top near side and passes down to within 6 inches of bottom.

RECTIFYING COLUMN OR SPIRIT COLUMN—This is of copper 60" diameter by 37 ft. high. It contains 24 plates 15 inches apart, each carrying seven 7" bonnets and three 6" downpipes. The column is built up of ten 31½" sections flanged together with a 5' bottom and 4' 6" top section. The first plate is about 3' from bottom and last 2' from top, and under the bottom plate is a 12" x 16" manhole. There is a 1" copper draining bypass around each plate and a ½" sampling tap for each.

A 14 inch copper vapor pipe leads from the slightly domed top of the column to the goose dephlegmator and a 6" reflux pipe from goose to top of column. The latter is fitted with 4" vacuum valves.

GOOSE DEPHLEGMATOR—The 14 inch pipe from column is bolted to the back of a 14" x 5' 3" copper header, from which seven 6 in. outlets lead into seven parallel sets of loops of 4¾" pipe. Each set consists of six complete loops 6 ft. deep. The loops end at one end of a 14 inch x 9' 9" copper header and from the other six similar sets of parallel loops lead back to a third 12" x 4' 6" header in line with first, from which a 12" copper pipe leads to the condenser. The loops drain into pipes running into a header connecting with reflux line to column into which a 2" water connection is made for flushing down the column.

These loops are contained in a 12' 6" x 11' 0" x 8' 6" open steel tank of 7,285 gal. capacity. The tanks are supplied with bay water from roof reservoir through 4" pipe, from which five perforated 2" pipes pass between loops distributing water properly. The water flow is controlled by inverted 4" gate valve and long spindle from operating floor. A ¾" W.I. line leads from side of tank to a pail fitted with overflow on operating floor, in which temperature of water in goose tank is taken.

COOLER OR SPIRIT COOLER—The cooler is of copper construction 42" dia. x 24 ft. long, made up of 60" flange jointed sections. The 12" pipe from goose is connected with a 27" diameter chamber over tube header from which 151-$1\frac{1}{8}$" tubes 20' 0" long, lead to a lower tube header. The upper chamber is fitted with 4" vacuum valve and spray plate. The distillate leaves the condenser through a 3" copper pipe seal and passes to the tail box.

Bay water is supplied for cooling through a 2" W.I. pipe six inches from the base from which a 2" drain also leads and overflows through a 4" W.I. pipe 6" from top. There is a 12 x 16 manhole in side near bottom.

ACETONE SECOND RECTIFICATION.

A modified Barbet continuous still designed to handle 14,000 lbs. of rectified acetone per day and to fit in the existing distillation building (formerly General Distillery Co.). (See Dwgs. 7979 and 7980).

EXHAUSTING COLUMN—The column is of cast iron construction, 54" dia. 13' 6" high, containing sixteen boiling plates carrying boiling caps made up of cast iron chimney and perforated copper hood, and provided with necessary downpipe. The bottom section 20" deep is provided with perforated steam sparger manhole vacuum valve, gauge glass, etc.

RECTIFYING COLUMN—The column is 33" dia. x 19' 6" high of copper construction and contains 36 boiling plates. The column is built in seven flanged sections, six plates to each of six sections. Each plate carries 20 boiling caps, $3\frac{1}{2}$" downpipe and cup, and is supported on angles. The bottom section is 12" high and into it the 5" copper vapor pipe from exhausting column enters. The vapor pipe between rectifying column and heater is also 5" dia. copper. The copper in the shell is 3 lbs. sq. ft. and that in plates $3\frac{1}{4}$.

HEATER—The heater is of the tube type 16" dia. x approximately9 ft. overall, with copper shell of 2 lbs. copper. It contains 30 1 3/16" I.D. No. 19 Stubbs gauge copper tubes 6' $6\frac{3}{4}$" long expanded into $\frac{1}{2}$" composition tube plates. The heater has closed top and bottom is provided with interior vapour baffle plates.

DEPHLEGMATOR—The dephlegmator is of similar type construction to heater but is 24" dia. with open top and contains 85 1 3/16" tubes.

AUXILIARY PURIFYING COLUMN—The column is similar to the rectifying column, 36" dia. x 5' 0" high, containing six boiling plates and built in two sections. The lower section is provided with heating coil, gauge glass, etc. The column has proved useless in acetone work and has been permanently disconnected.

COOLER—The cooler is of similar design to the heater 16" dia. and containing 39 1 3/16" tubes.

STEAM REGULATOR—The regulator consists of cast iron pressure and copper float chambers, with necessary regulating connections, accessories and fittings, including Mason balanced piston type regulating valve, gauge glasses, etc.

SLOP TESTER—The tester is of copper 16" dia. x 2' 0" high with copper coil and hydrometer cup.

GAUGING TANKS—These tanks, three in number, are of 16 gauge galvanised iron 4' 0" dia. x 14" deep on the straight with 6" deep coned bottom 100 gals. capacity. The tanks have a riveted cover, in the centre of which is a 9" sampling hole with hinged cover, and at one side a 1½" filling flange. The outlet from bottom of cone is 1½"

ACCESSORIES—These include a slop outlet trap on bottom of exhaust column, regulating bottle on condenser outlet, indicating and regulating tester for acetone outlet from condenser, pressure bottle, etc.

There is also a 3' dia. x 3' deep iron constant level supply tank fitted with float tank.

OPERATION—The acetone to be purified or rectified is elevated through a 3" supply pipe to a 3' x 3" constant level reservoir just below the roof. The level in this tank is controlled by a float acting through a chain on a Mason Regulating Valve on the feed pump. From the reservoir a 1½" line drops vertically to the operating floor, where a control valve is located, and then rises and enters the bottom of a 13" heater on the top floor. From the top of the heater a 2" line drops to the top of a 54" Exhausting column, which is supplied with steam at the bottom through a 2" pipe from a 2" Mason Regulating Valve controlled by a 16" Steam Regulator on the operating floor. The steam regulator is actuated by the pressure at the base of the rectifying column through a 2" pipe. The slop from the bottom of the exhausting column escapes through a 4" slop seal and 4" pipe to the sewer. A ¾" line from the bottom of the columns runs through a Vapour Separator to a Slop Cooler and Tester on the Operating floor. A ¾" line runs from between the 12th and 13th plates on the exhausting column through a Pressure Bottle at the third floor into the top of the rectifying column, while a second line 1¼" dia. starting from the same level runs to the steam regulator. These latter lines are for regulating purposes.

The vapour from the the exhausting column passes up through a 5" pipe and into the base of a 36" Rectifying Column standing on the third floor. There is a 2½" returns line from the latter column to the top of the exhausting column. The vapours from the rectifying column pass through a 5" pipe to the top of the 13" heater, from the bottom of the heater to the top of a 21-⅝" dephlegmator and from the bottom of the latter through a 4" pipe to the top of a 16" Condenser. The latter three units are side by side on the top floor. Three return lines, 2½", 2" and 1½", run from the heater, dephlegmator and condenser respectively into the 2½" line and into the top of the rectifying column.

From the top of the rectifying column a 1½" line loops down to the third floor where a control valve is located, and thence into the top of a 36" Auxiliary Rectifying Column standing on the fourth floor, from the bottom of which a 1½" line drops to the top of a 13" cooler on the operating floor and passes from the bottom of the latter vertically and through a flow meter and valve to the south one of two Testers or Tail Boxes. The vapours from the top of the auxiliary column pass through a branching 4" pipe to either the top or below the first plate of the rectifying column.

The liquor from the bottom of the condenser passes through a regulating bottle and thence either through a return line to the rectifying column or through a 1¼" pipe and flow meter and valve to the north Tester on the operating floor.

RECTIFYING STILLS.

NORMAL BUTYL ALCOHOL RECTIFICATION.

(Two.)

Gooderham and Worts' Stills Nos. 2 and 3, formerly employed in manufacture of whiskey, recently operating, No. 3 on various rectifications and No. 2 exclusively on normal butyl alcohol. The stills are duplicates and are rated 7,000 gal. capacity.

Kettle—The kettle is of horizontal cylindrical form, 9 ft. dia. x 21 ft. long, actual capacity 8,300 gals. The kettle has dished heads, is built of copper, with 4' 6" diameter vapour head on top from which the 16" dia. vapour pipe leads to the column. The kettle is provided with a heating coil of copper pipe, supplied by a 3½" steam pipe, with manhole, gauge glass, filling and drain connections (4" dia.).

Column—The rectifying column is of copper construction 60" dia. x 42 ft. high, 26 plates, made up of nine 4 ft. sections, with top and bottom sections, each section except one containing 3 plates, making a total of 26. Each plate carries 3-10" boiling caps, downpipe and cup, and is fitted with draining bypass cocks. The head is hemispherical in form, from which a 14" dia. vapour pipe leads to the goose.

Goose Dephlegmator—The dephlegmator consists of thirteen loops of 11" dia. pipe and fourteen and fifteen of 10" pipe, arranged in three rows. Each loop is of U form 5' 10" deep. The vapour pipe leaving the goose is 10" diameter and there is a 5" copper reflux line from goose to column. The coils are contained in a steel tank 19' 6" x 12' 2" x 9' 2" deep, fitted with cooling water sprays and drains.

Condensers—There are two Beemis type condensers, contained in 31" x 19' 10" vertical cylindrical jackets. The cooling chamber is approximately 17' 6" long tapering from an 8¼" wide annulus with a mean diameter of 18". A 3" distillate line runs from the condensers to a tail box of the open-glass box type.

RECTIFYING STILLS.

SECONDARY BUTYL RECTIFICATION.

One of the stills which it was proposed to use permanently for secondary butyl alcohol purifying was the Gooderham & Worts' No. 1 still, formerly used on alcohol rectification. The still has recently been employed on all the various primary and secondary rectifications of normal and secondary butyl. It has a rated capacity of 4,000 gals.

KETTLE—The kettle is of copper throughout, 10 ft. dia. x 9 ft. high on straight, with dished bottom (6") and domed head. Actual capacity is 4,400 gals. It is provided with 10" circular manhole, full length gauge glass, 4" filling nipple and 6" drain.

The heating surface is divided, in the form of two coils, one spiral of eleven turns of 2½" tubing, on 4" centres, and the other helical consisting of five coils of 3" tubing, 6" centres and 6 ft. diameter. The spiral coil lies on dished bottom of kettle the helical coil being carried above it. The coils are supplied with two separate 2" steam connections and drain at centre of bottom. The effective heating surface is approximately 210 ft. of 2½" and 100 ft. of 3", or a total of 210 sq. ft.

Vapours pass from kettle to column through a 16" vapour pipe.

COLUMN—The column is 60" dia. x 38' 6" high, with 26 plates and of copper construction, made up of eight 4' 0" sections with top and bottom sections. Each of the eight sections carries three plates and the bottom section two, a total of 26 plates.

Each plate carries three 10" boiling caps, downpipe and cup, and is provided with outside draining bypass. The vapors pass from column to dephlegmator through a 14" pipe.

GOOSE DEPHLEGMATOR—The goose dephlegmator consists of fourteen loops of 9 inch copper pipe, arranged in three rows. Each loop is of U form 5' 0" deep, and each is connected to one of three reflux headers which lead back to column through a 3" reflux pipe. The vapor pipe leaving condensers is 8 inch. The coils are contained in a steel goose tank 19' 6" x 12' 3" x 9' 0" deep, fitted with cooling water sprays and drain, etc.

CONDENSER—There are three vertical Beemis type condensers contained in 32" dia. x 11' 11" cylindrical jackets. The annular vapour chamber is 10 ft. long and tapers from a 7½" annulus with a mean diameter of 17½". The distillate passes from the condensers to an open glass type tail box.

RECTIFYING STILLS.

SECONDARY BUTYL RECTIFICATION.

See Drawings 8906, 8901, 8899.

The second still for the purifying of the crude secondary butyl at the end of the second stage in the production of methyl ethyl ketone is a new still, designed to produce 150 gals. per hour of refined secondary butyl alcohol from a mixture containing approximately 90% of secondary butyl together with small amounts of heads, water, sodium chloride and other impurities. The still is installed but has never been operated.

KETTLE—The kettle is of steel 10 ft. dia. x 20 ft. long on the straight with ⅜" shell and 7/16" dished heads, provided with special manhole with hinged cover for the purpose of flushing out the salt deposited on the coils at the end of each run. The kettle is provided with a heating coil of 3" extra heavy welded steel pipe containing approximately 250 square feet of heating surface; and passing through stuffing boxes in head of kettle. It is provided with gauge glass pressure and vacuum gauge and other necessary fittings.

COLUMN—The column is 60" dia. x 16 ft. high, 24 plates and is made up of sections constructed of 8" Bethlehem rolled and welded steel channels. Each plate of ¼" thick steel carries 72 copper boiling caps over 1½" diameter chimneys and a 6½" downpipe. The plates are provided with special draining valves through the plates themselves operated by handle and spindle passing through gland in wall of section with eccentric pin engaging eye in end of valve spindle (provided with spring). The handles may be all linked up by long operating rod extending full length of column.

DEPHLEGMATOR—The dephlegmator is of copper construction 9½" dia. x 7' 8" long, containing 70-1 3/16" I.D. No. 19 gauge copper tubes 6' 6" long providing approximately 150 sq. ft. of cooling surface. The dephlegmator is provided with water and vapour baffles.

CONDENSER—The condenser is of similar box construction to the dephlegmator but 33" dia. x 7' 9" long and contains 450 ft. of cooling surface.

ACCESSORIES—There are provided the various necessary accessories such as regulating bottle, tester indicating valves in cooling water lines, vacuum relief valves, etc.

RECTIFYING STILLS.
METHYL ETHYL KETONE RECTIFICATION.

See Drawings 8892, 8911, 8887, 8888.

The still that has been used for the purifying of the crude methyl ethyl ketone from the M.E.K. plant, was specially designed for the purpose. It is rated at 150 gals. per hour of purified methyl ethyl ketone per hour from a mixture containing approximately 75% M.E.K., 25% secondary butyl alcohol, with small amounts of other impurities such as butyl aldehyde.

KETTLE—The kettle is 10 ft. dia. x 16 ft. long on the straight with 3/8" steel shell and 7/16" bumped steel heads. It is provided with manhole gauge glass, vacuum valve, inlet and outlet nipples, etc.

The heating coil is in two separate halves, of 3" extra heavy welded steel pipe, the outlets passing through glands in kettle head and each half of coil being separately connected to steam and trap. The vapor outlet to column is 6".

COLUMN—The column is 60" dia. x 25 ft. high, 36 pla built of sections constructed of channels similarly to that of secondary butyl still. The plates are constructed and drained in a similar way also with 72 boiling caps, 6½" I.D. downpipe, etc.

DEPHLEGMATOR—The dephlegmator is of copper constructi 21⅝" dia. x 7' 8" high, containing 81-1 3/16" I.D. No. 19 gauge 6' 6" long copper tubes, providing approximately 200 sq. ft. cooling surface and fitted with water and vapor baffles.

CONDENSER—The condenser is of similar design and construction to dephlegmator, but is 19½" dia. x 8' 2" high and contai

71-1 3/16" I.D. No. 19 gauge copper tubes, giving approximately 150 sq. ft. of cooking surface.

CAUSTIC WASHER—(See Dwg. 8911)—This is of copper, 18" dia. x 6' 0" high, and is provided with four plates carrying seven boiling caps each with 2½" downpipe, and the washer is fitted with a vapor separator.

GAUGING TANKS—There are four 100 gals. gauging tanks similar to those in use on acetone rectifying stills (refer back).

ACCESSORIES—These include regulating bottle and tester, vacuum relief valve, pressure gauge and indicating gate valves on cooling water controls.

SCRUBBING COLUMN AND RECOVERY STILL.

See Dwgs. 8921, 8924, 8925, 8926, 8927, 8928, 8930, 8933, 8937, 8938, and 8939.

For the recovery of methyl ethyl ketone and valuable volatile materials from hydrogen gas from the third stage catalysers. Originally a solvent naphtha scrubbing vacuum system was proposed, which on further investigation was later abandoned in favour of the present system using water as the washing agent which possesses many advantages from a chemical point of view, and resulted in considerable reduction in cost.

The system was designed on a basis of the production of 250 gals. per hour of methyl ethyl ketone.

SCRUBBING SECTION.

SCRUBBER COLUMN—The scrubbing column is of cast iron construction, 40" diameter 33' high, comprising 40 plates spaced 10" apart by cylindrical cast iron flanged sections. Each plate is provided with 33 perforated cast iron boiling caps. The gas inlet flange at bottom and outlet at top is 6" and the water inlet 2" and outlet 3". The column is provided with 18 x 18" copper vapor separator on the exit gases.

Receiving Tank for Scrubbed Liquor—This tank is of cypress, 2½" staves, 10' dia. x 4' high, approximately 2,000 gals. capacity, and is provided with gauge glasses, manhole in cover, and necessary connections.

Pump for Scrubbed Liquor—A Blake & Knowles 4½ x 4⅛" x 6" duplex steam pump.

RECOVERY STILL SECTION.

Feed Tank for Scrubbed Liquor—A steel tank 4' dia. x 6' deep of ¼" steel with riveted heads, provided with gauge glass, float valve, controlling pump, manhole, etc.

Preheater for Still—The preheater is of cast iron, closed type, 22" dia. x 7' 6" long and liquor baffles around the tubes.

Exhausting Column—The column is of cast iron construction 60" diameter, 12 ft. high, 12 plates, each fitted with 72 cast iron boiling caps and 6¾" downpipe. The sections are bolted between 8 inch flanged cast iron cylindrical sections. The bottom section is provided with steam sparger pipe for introducing live steam (2" pipe) and outlet flange leading to 3" slop outlet seal.

Rectifying Column—The column is of similar cast iron construction to exhausting and scrubbing column. It is 30" dia. x 10 ft. high with 12 plates spaced between 7½ inch flanged cylindrical sections. The plates are provided with 25 similar boiling caps to the exhausting column and 5⅛" downpipes. The rectifying column stands directly on top of the exhausting column and from the top of the former a 4" vapor pipe leads.

Dephlegmator—This is also of cast iron construction, open type, comprising 22" dia. x 8' 6" overall cast iron shell fitted with 86-1 3/16" I.D. No. 19 gauge copper tubes between steel tube plates.

Condenser—The condenser is of same type and construction as the dephlegmator, but is 24" dia. and contains 101 tubes.

Decanter—The decanter comprises decanter proper, 18" dia. x 4 ft. high, two testers, gauge glasses and necessary valves, etc.

Salting Out Mixing Kettle—The kettle is 2 ft. dia. x 3 ft. high, of 4 lbs. copper shell with 5 lb. heads. It is provided with belt driven (fast and loose pulleys) horizontal shaft driving through bevel gears (2:1) the mixing shaft at 600 r.pm., carrying 8" dia. 6" pitch propellor, which rotates in 10" dia. inner cylinder. The kettle is provided with gauge glass, handhole, etc.

Decanter for Salted Mixture—Similar to that described above.

SALT SOLUTION EVAPORATOR SECTION.

Kettle—The kettle is 4' dia. x 4' high with 5 lbs. copper shell and 6 lbs. heads. It is provided with approximately 75 sq. ft. of heating surface in form of three helical coils of 2" dia. No. 14 gauge copper pipe and also with internal 16" dia. cylindrical baffles, gauge glass, relief valve, manhole and other necessary fittings.

Preheater—The preheater is of tubular copper construction 10" I.D. x approx. 4' overall, No. 17 S.G.A. copper, provided with 19-1 3/16" I.D. No. 19 gauge x 39½" copper tubes giving approximately 28 sq. ft. of heating surface, expanded into composition tube plates.

Vapor Separator—Separator is of the copper centrifugal type 9" x 12".

Salt Solution Storage Kettle—This kettle is of copper construction 3 ft. dia. x 4 ft. deep, of No. 12 gauge copper, and supplied with helical (30" dia.) copper cooling coil of 1½" I.D. No. 16 gauge copper tube 23' 6" long. The kettle is provided with a stirring arrangement consisting of 8" dia. x 6" pitch propellor, rotating in 10" cylinder at 100 r.p.m. through bevel gears from belt driven shaft. The kettle is also provided with charging handhole, gauge glass, etc.

Circulating Pump for Salt Solution—A small 2,200 r.p.m. belt driven centrifugal type pump capable of handling 100 g.p.h., with ⅜" pipe connections.

Accessories—These include regulating bottle and tester for distilling column and necessary gauges, valves, etc.

LEAD LINED STILL.

See Dwgs. 8683, 8684, 8684-2, 8685, 8686, 8688, 8688-1.

For the hydrolysing distillation of butyl hydrogen sulphate, produced by the sulphating of butylene by dilute sulphuric acid, resulting in production of crude secondary butyl alcohol.

This still was designed to comply with the requirements laid down by the chemist, but the information which he was able to give was very limited and indefinite with regard to commercial size operations. The problem from the standpoint of design of chemical equipment was a decidedly unusual one.

SUPPLY TANK—*B.H.S. Tank No.* 1—This tank is of steel 6 ft. dia. x 8 ft. high on the straight with dished heads, bottom one riveted to shell, top one flanged. The tank is of 3/8" steel with 1/2" thick heads to stand 25 lbs. per sq. inch working pressure. The tank is lined throughout with 1/4" lead, which is fitted to bottom head, reinforced to side with steel bands, lead covered and spotted to top head. Tank is provided with 7/8" gauge glasses, inlet and outlet flanges, and valves.

KETTLE—The kettle is of steel 10 ft. dia. x 6 ft. high, with flat bottom and domed head. The shell is of 3/8" steel and heads of 1/2", bottom riveted and top flange jointed.

The tank is provided with three concentric helical heating coils containing 500 ft. of 2" I.D. x 3" O.D. antimonial lead pipe. Each coil is in two parts, each of the three steam supplies dividing into two in the kettle, and there being six exhausts. The tank is lined with 1/4" sheet lead, fitted to bottom reinforced to side with steel band and spotted to top head. The kettle has a 6" vapor outlet 2" reflux nipple, manhole and two sight glasses (no use).

The kettle is provided with a 2½" slop outlet (acid) and vapor trap.

COLUMN—The column is 72" dia. x approximately 12 ft. high, comprising 12 boiling plates with top and bottom sections. The cylindrical flanged sections are of cast iron lined with 1/4" lead.

The plates are of cast 5% antimonial lead, 3/4" thick, reinforced with four 2½ x 3" 6.1 lbs. tee bars cast in the plate. The tee bars have one flange cut off where they pass through the flange between sections which is 1-1/8" thick.

Each plate carries 71 slotted lead boiling caps (2¼" chimney) with two 6" dia. downpipes. The plates are bolted between the adjacent sections on ⅜" lead wire gaskets.

DEPHLEGMATOR—The dephlegmator is of copper construction open type, of 3½ lb. copper, 24" dia. x 8' 6" long, and contains 105 – 1 3/16" I.D. No. 16 gauge copper tubes expanded into composition tube plates, with necessary water and vapour baffles and connection nipples.

CONDENSER—The condenser is of similar construction to the dephlegmator but contains 280 – 1 3/16" I.D. No. 16 gauge tubes in a 36" dia. shell.

ACCESSORIES—These include regulating bottle and tester, thermometers, and regulating valves.

BEER STILL.

Gooderham & Worts' in Stone Building.

This still is not used by the British Acetones, Toronto, Limited. The two condensers belonging to it are in use, however, for the second beer still (west) in the Distillation Department. The still has been used on alcohol distillation for whiskey.

BEER RECEIVER—A closed copper tank 6' 6" dia. x 8' 0" (2,080 gals. capacity) on the straight, with domed head and bottom. It is provided with a 5" inlet in centre of top and 5" outlet from bottom. There is a 12 x 15" manhole in side, and the tank is equipped with a ball float.

COLUMN—The column is of copper construction 84" dia. x approximately 40' high, built in eight 4' x 4' sections with top and bottom sections, and contains eighteen plates. Each plate carries 99 – 1½" boiling caps, and a 7½" downpipe with 14" cup. The bottom section contains a 6" perforated copper pipe sparger, ⅜" holes on 2" centres. Steam supply pipe is 5". The slop outlet is through a 5" pipe, through a float valve to slot trap.

The upper two sections of the still contain four spiral beer preheating coils of 4" copper pipe, spaced 24" apart vertically, the upper two of five coils each, lower two of three coils each.

BEER HEATER—The beer heater is of copper construction 36" dia. x 16' 0" long.

GOOSE DEPHLEGMATOR—The goose dephlegmator consists of seven parallel coils of six loops each of 5" copper pipe extending from the 14" inlet header to the 12" outlet. The loops are 5' 3" deep and the goose is placed in an 18' 3" x 8' 0" x 8' 5" deep steel tank.

CONDENSERS—The condensers have already been described under the new West Beer Still.

APPENDIX II.

TABLE OF ENGINES AND COMPRESSORS.

ENGINES—

Engine.	Location.	Power.	Size.	Speed.	Type.
Mill Engine	Mill	500	20x60	60	Hor. Brown valve gear
Mash Pump (gear driven)	stone Floor	......	8x12	....	Hor. Brown valve gear
Mash Pump (centrifugal)	Stone Floor	......	8x22	220	Horiz. high speed
Unused Pump Engine	Stone Floor	......	12x10	....	Horiz. slow speed
Beer Pump (centrifugal)	Ferm. Dept.	......	6x6	250	Horiz. high speed
Beer Pump (centrifugal)	Ferm. Dept. (annex)	......	11x11	340	Horiz. high speed
Fan Engine	W. B. House	60	10x10	200	Horiz. high speed
Fan Engine	W. B. House	60	10x10	200	Horiz. high speed
Fan Engine	East House	......	6x6	250	Horiz. high speed
Butylene Comp. Engine	M.E.K.	......	9x10	....	Vert. single cyl.
Butylene Comp. Engine	M.E.K.	......	9x8	....	Vert. single cyl.

COMPRESSORS—

Air Compressor, Stone Floor	10x10x12 steam air Compressor.
Air Compressor, Stone Floor	10x12x12 steam air Compressor. (unused)
Air Compressor, Stone Floor	6x8x64 c.f.m. vertical 200 r.p.m.-belt driven double acting.
Butylene Compressor, M.E.K.	2-9x9 200 c.f.m vertical 2 cyl, single acting ammonia comps.
Butylene Compressor, M.E.K.	11x11x12 locomotive compressor.

TABLE OF PUMPS.

No.		
1	West Boiler House size 15 x 9 x 12 Suction 6" Steam 3"	Boiler Feed Pump Type, Duplex, Packed Plunger Discharge 6" Exhaust 4"
2a 2b	West Boiler House Size 9 x 5 x 10 Suction 4" Steam 1½"	Boiler Feed Pump, Twins Type, Duplex, Outside Packed Plunger Discharge 4" Exhaust 2½"
3a	General Distillery Size 12 x 14 x18	Bay water Pumps, Twins Type, Single Action, Inside Packed

	Suction 14" Steam 2½"	Plunger Discharge 8" Exhaust 3"
4	General Distillery Size 6 x 8 x 12. Suction 2½" Steam ¾"	Bay Water Pump Type, Single Action, Inside Packed Plunger Discharge 3" Exhaust 1"
5a	General Distillery Size 10 x 13 x 17 Suction Steam 4"	New Cooler Pump, Sept. 15, 1918 Type, Duplex, Inside Packed Plunger Discharge Exhaust 4"
5b	General Distillery Size 8 x 6 x 12 Suction 4" Steam 2"	Cooler Pumps, Twins Duplex, Inside Packed Plunger Discharge 4" Exhaust 2"
6	General Distillery Size 8 x 6 x 12 Suction 4" Steam 2"	Cooler Hot Water Pumps Duplex, Inside Packed Plunger Discharge 4" Exhaust 2"
7	General Distillery Size 7 x 8 x 12 Suction 4" Steam 1"	Cooler Hot Water Pumps Single, Inside Packed Plunger Discharge 4" Exhaust 2"
8	General Distillery Size 12 x 10 x 20 Suction 4" Steam 1½"	Cooler Hot Water Pump Inside, Packed Plunger, Single Discharge 4" Exhaust 2"
9	General Distillery Size 10 x 12 x 6 Suction 6" Steam 1½"	Beer Pump Duplex, Inside Packed Plunger Discharge 6" Exhaust 2"
10	General Distillery Size Suction 6" Steam Belt Driven	Beer Pumps Centrifugal Pumps Discharge 4"
11	General Distillery	Spare
12	General Distillery	Water Pump

	Size 3 x 2 x 4	Duplex, Inside Packed Plunger
	Suction 1¼"	Discharge 1"
	Steam ½"	Exhaust ½"
14	Stone Floor	Spare Pump
	Size 3½ x 2½ x 5	Duplex Inside Packed Plunger
	Suction 1¼"	Discharge 1"
	Steam ⅜"	Exhaust ¾"
13a	General Distillery	Crude Acetone Pump
13b	Size 8 x 8 x 12	Single Action Inside Packed Plunger
	Suction 3"	Discharge 2"
	Steam ¾"	Exhaust 1"
15	General Distillery	Butyl Pump
	Size 7 x 10 x 5	Duplex Inside Packed Plunger
	Suction 3"	Discharge 3"
	Steam 1"	Exhaust 1½"
16	General Distillery	Beer Pump for Stills
	Size 12 x 6 Engine Driven	Duplex Inside Packed Plunger
	Suction 4"	Discharge 3"
	Steam 1½"	Exhaust 2"
17a	Shipping Room	Butyl Salting Pump
	Size 7 x 5 x 7	Duplex, Inside Packing Plunger
	Suction 1¼"	Discharge 1"
	Steam 1"	Exhaust 1"
17b	Shipping Room	Butyl Salting Pump
	Size 6 x 4 x 6	Inside Packing Plunger Duplex
	Suction 2½"	Discharge 2"
	Steam 1"	Exhaust 1¼"
18a	Shipping Room	Acetone Pump
	Size 3 x 2 x 5	Duplex, Inside Packed Plunger
	Suction 1"	Discharge 1"
	Steam ⅜"	Exhaust ¾"
19	Shipping Room	Spare Pump
	Size 8 x 12 x 10	Single, Inside Packed Plunger
	Suction 4"	Discharge 3"
	Steam 1"	Exhaust 1¼"
20	Stone Floor	Spare Pump
	Size 6 x 12 x 4	Duplex Inside Packed Plunger
	Suction 4"	Discharge 3"
	Steam 1½"	Exhaust 2"

21	New Fermenting Cellar Size 7 x 12 x 5 Suction 5" Steam 1½"	Beer Pump Duplex, Inside Packed Plunger Discharge 4" Exhaust 2½"
22	Stone Floor Size 5" Suction 6" Steam Engine Driven	Mash Pump Type, Centrifugal Discharge 5"
23	Stone Floor Size 12 x 12 x 9 Suction 6" Steam 1½"	Spare Single, Inside Packed Plunger Discharge 6" Exhaust 2"
24	Stone Floor Size 5 x 15 Suction 6" Steam, Belt Driven	Beer Pump Triplex, Vertical Discharge 5"
25	Stone Floor Size 9 x 12 Steam 5" Steam Engine Driven	Mash Pump Duplex, Inside Packed Plunger Discharge 4"
26	Stone Floor Size 10 x 8 x 8 Suction 5" Steam 2"	Mash Pump Duplex, Inside Packed Plunger Discharge 5" Exhaust 3"
27	Mill Boiler House Size 9 x 5¼ x 10 Suction 2½" Steam 1¼"	Boiler Feed Pump Duplex Inside Packed Plunger Discharge 2½" Exhaust 2"
28	Still House No. 1 Size 6 x 4 x 6 Suction 2" Steam 1"	Butyl Pump Duplex Inside Packed Plunger Discharge 2" Exhaust 1½"
29	Still House No. 1 Size 3 x 2 x 4 Suction 1¼" Steam ½"	Duplex, Inside Packed Plunger Discharge 1" Exhaust ½"
30a 30b	Packing Room Trinity St. Size 6 x 6 x 9 Section 4½" Steam 1"	Butyl Pump Single, Inside Packed Plunger Discharge 3½" Exhaust 1½"

APPENDIX ON EQUIPMENT

31a	East Boiler House	Boiler Feed Pump
31b	Size 9 x 5¼ x 10	Duplex Inside Packed Plunger
	Suction 2½"	Discharge 2½"
	Steam 1¼"	Exhaust 2"
32	Pumping Station	Boiler Feed Pump
	Size 6 x 3 x 7	Single Outside Packed Plunger
	Suction 2"	Discharge 2"
	Steam ¾"	Exhaust 1"
33	Pumping Station	Condenser Pump
	Size 6 x 10 x 12	
	Suction	Discharge
	Steam	Exhaust
34	Pump Station	High Pressure Tandem Com. Water
	Size 22 x 20 x 11 x 15	Duplex Inside Packed Plunger
	Suction 12"	Discharge 10"
	Steam 3½"	Exhaust 5"
35	Pumping Station	High Pressure Pump
	Size 18 x 11 x 15	Duplex Inside Packed Plunger
	Suction 12"	Discharge 15"
	Steam 3½"	Exhaust 5"
36a	New Fermenting	
	Size 10 x 8 x 12	Duplex Solid Plunger
	Suction 6"	Discharge 5"
	Steam 2"	Exhaust 2½"
36b	New Fermenting Cellar	Twin Pump
	Size 5 x 4	Centrifugal
	Suction 4"	Discharge 4"
	Rod 2½"	

TABLE OF TANKS

The following list comprises all tanks in buildings used in whole or part by the British Acetones Toronto, Limited :—

Name or Use.	Location.	No.	Size.	Material and Type.	Cover.
MILL AND MASHING BUILDING.					
Unused formerly slop tank stirring rake.	Ground Floor "Stone Floor"	1	6′ dia. x 8 1410 gals.	Copper vert. cyl.	Copper.
Compressed air pressure tanks.		1	36″ dia. x 10 440 gals.	Steel vert. cyl.	Domed heads.
Unused formerly Spirit Receivers Nos. 1 and 2	Second Floor	2	12′ dia. x6 4584 gals.	Copper vert. cyl.	Wooden backed copper

TABLE OF TANKS—Continued

Name or Use.	Location.	No.	Size.	Material and Type.	Cover.
Unused formerly Beer Receiver.		1	6′ 6 dia. x 8′ 2080 gals.	Copper vert. cyl.	Domed heads manhole.
Hot water tanks	Third Floor.	2	8′ 6 x 24′ 4′x′8′6″ 10950 gals.	¼″ steel rectangular.	Loose wooden.
Unused formerly slop tank		1	12′4 dia. x 8′10 6600 gals.	12 copper vert. cyl.	Loose copper.
Hot water tanks	Fourth Floor.	2	13′0 x 8′6 x 8′6 5850 gals.	Quarter inch steel rect.	None.
Formerly Hot Water tank		1	5′9 dia. x 5′0 721 gals.	Copper vert. cyl.	Wooden backed cop'r
Beer Still Goose Tank unused.	Fifth Floor	1	18′3 x 8′0 x 8′5 7650 gals.	Steel rect.	None.
Hot Water Tank		1	17′4 x 10′0 x 7′0 7550 gals.	Steel rect.	None.
Hot Water Tank		1	11′4 x 10′ x 6′10 4830 gals.	Steel rect.	None.
FERMENTATION DEPT.					
Fermenters 2–6 13–15	First Floor	8	18′ dia. x 20′0 31800 gals.	Steel vert. cyl.	Conical steel.
Fermenter –1		1	18′ dia. x 20′4″ 32000 gals.	Steel vert. cyl.	Conical steel.
Fermenters 7–12		6	18′ dia. x 20′6 x 19′6. 31800 gals.	Steel vert. cyl.	Conical steel.
Fermenters 16–19		4	18′ dia. x 20′6 x 19′6. 31800 gals.	Steel vert. cyl.	Conical steel.
Fermenters 20–22		3	17′ dia. x 22′6″ 31800 gals.	Steel vert. cyl.	Conical steel.
Cookers 1–4		4	12′ dia. x 12′ 0″ 7500 gals.	Steel vert. cyl.	Conical steel.
Sterile Water Tank.		1	6′ dia. x 8′ 1409 gals.	Steel vert. cyl.	Flat head manhole.
FERMENTATION DEPT. ANNEX.					
Unused formerly fermenter tubs.	First Floor.	6	13′ dia.x15′ 6 12393 gals.	Wooden vert. cyl.	None.
Finishing Tubs		5	25′ dia. x 15′6 49395 gals.	Wooden vert. cyl.	Conical galv. iron.
Unused formerly Slop Receivers Nos. 1 and 2	Third Floor.	2	10′ dia. x 10′ 6 7175 gals.	Copper vert. cyl.	Wooden.
DISTILLATION DEPT.					
Formerly Wines and not now used	A2 Ground Floor	1	14′ dia. x 14 13431 gals.	Copper vert. cyl.	Copper angle reinf.
Drips Sump set in concrete floor.		1	6′ dia.x 0′0″	Steel vert. cyl.	Domed flanged
Tails Tank	Second Floor.	1	6′ dia. x 5′ 881 gals.	5-16″ steel vert. cyl.	Loose wooden
Beer Still Supply (Weigh Tank)	Third Floor	1	12′ dia. x 10 7107 gals.	18 copper vert. cyl.	Light copper reinf.
Gauging Vessels		7	4′0 dia. x 12″ 100 gals.	Galv. iron cyl.	Closed metal.
Caustic Tank	Fourth Floor.	1	6′3″ x 6′0″	5-16 steel vert. cyl.	None.
Goose Tanks	Fifth Floor.	2	12′6 x 11′0 x 8′6 7283 gals.	Steel rect.	None.
Bay Water	Roof.	1	11′2″ dia. x 5′6″ 3360 gals.	Steel vert. cyl.	None.

TABLE OF TANKS—Continued

Name or Use.	Location.	No.	Size.	Material and Type.	Cover.
Continuous Still. Cons. level.		1	3′ dia. x 3′ 130 gal.	5-16″ steel vert. cyl.	Loose steel.
INOCULATION DEPT.					
Mash Kettle............. Steam Jacketed......	Fourth Floor.	1	3′4 dia. x 2′10 100 gals.	Copper.	None.
Culture Vessels Steam Jacketed.		6	13″ dia. x 12″ 5 gals.	Copper.	Domed flanged.
Inoculators Steam Jacketed.		6	3′0 dia. x 2′7½″ 100 gals.	Copper.	Domed flanged.
Seed Tanks..............	Third Floor.	16	4′6 dia. x 6′6 625 gals.	Copper.	Domed flanged.
ACETONE STORAGE.					
AB A1 and A2 Storage.	New Storage Room.	8	13′ dia. x 14′ 1	12 copper vert. cyl.	Copper. angl. reinf.
Pure Acetone A3 glass enamelled.	Shipping Room	2	8′9 dia. x 10′ 0 3740 gals.	Steel hori. cyl.	Domed heads.
Pure Acetone A3	Outside Storage House.	2	9′0 dia. x 7′ 6 2970 gals.	Galv. iron vert. cyl.	Flat head manhole.
BUTYL STORAGE.					
Butyl B1 and B2.........	North of Pipe Shop.	2	14′ dia. x 14′ 13431 gals.	Copper vert. cyl.	Copper angle reinf.
Butyl B2 formerly A3....	Shipping Room	1	7′6 dia. x 6′ 2 1700 gals.	Galv. iron vert. cyl.	Flat head manhole.
Butyl B1................	" "	1	8′ dia. x 8′ 0 2500 gals.	Steel vert. cyl.	Open.
Salted Butyl............	" "	2	16′ dia. x 15′ 0 18000 gals.	Steel vert. cyl.	Wooden.
Butyl B2................	Yard.	1	95′ dia. x 30′ high 1,250 000 gals.	Steel vert. cyl.	Steel.
BUTYL DISTILLATION.					
Still Supply Tanks........	No. 1 Tank House.	2	9′6″ dia. x 15′ 6″ 11025 gals.	Copper vert. cyl.	Copper.
Butyl Weigh Tank.......		1	10′ dia. x 10′ 7″ 5000 gals.	Copper vert. cyl.	Copper.
B1 formerly Alcohol Tanks 7 and 8.	Trinity Stills	2	6 x 10 x 10 3665 gals.	Copper rec.	Copper.
Residue formerly Oil Tank 9.	"	1	14 x 6 x 3′6 1502 gals.	Quarter steel rect.	Wooden.
Residue formerly Oil Tank 10.	"	1	10 x 9 x 12′2 1680 gals.	3-16 steel.	Wooden.
Bay Water Tank Cooling Water.	"	1	11′ 9 x 10′ 2 x 6′9 5000 gals.	Steel rect.	Wooden.
Butyl Distillates B3 and others.	No. 2 Tank House.	16	14′ 6 dia. x 9′ 0 9154 gals.	Copper vert. cyl.	Copper.
Butyl By-products.......	No. 11 Tank House.	10	16′ dia. x 10′6 13157 gals.	Copper vert. cyl.	Copper.
Crude unsalted Butyl....	No. 14 Tank House.	36	9000 gals.	Wooden vert. cyl.	Wooden.
METHYL ETHYL KETONE PLANT.					
Butylene Separator.......	Ground Floor	1	3′0 dia. x 4′ 10 128 gals.	No. 16 copper vert. cyl.	Flanged domed.
Outside Tank............ Butylene Gasometer.	" "	1	6′9 dia. x 7′ 0 1560 gals.	No. 12 galv. iron vert. cyl.	None.
Bell Butylene Gasometer	" "	1	6′0 dia. x 7′0 1235 gals.	No. 16 copper vert. cyl.	Copper domed.

TABLE OF TANKS—Continued

Name or Use.	Location.	No.	Size.	Material and Type.	Cover
Scrubbed Liquor Tank....	" "	1	10′ dia. x 4′0 1960 gals.	Wooden vert. cyl.	Wood.
Crude M.E.K. Pump Reservoir.	" "	1	3′0 dia. x 4′10 128 gals.	Copper vert. cyl.	Flanged domed
Dilute Acid Storage (lead lined)	" "	1	6′0 dia. x 7′ 0 1235 gals.	Steel vert. cyl.	Flanged domed
Acid Diluting Tank (lead lined)	Second Floor	1	6′ 0 dia. x 7′0	Steel vert. cyl.	Flanged domed.
Acid measuring tank (lead lined).		1	3′0 dia. x 4′0 174 gals.	Steel vert. cyl.	Flanged domed.
Butylene tanks (tinned)		3	3′0 dia. x 4′0 174 gals.	Copper vert. cyl.	Domed heads.
Distillates Storage (glass enamelled)..		4	7′6 dia. x 10′ 0 2760 gals.	Steel vert. cyl.	Domed heads
Sec Butyl Tank (glass enamelled).		1	8′0 dia. x 6′0 1880 gals.	Steel vert. cyl.	Domed heads.
Salted Sec Butyl		2	6′8 dia. x 8′0. 1740 gals.	Steel vert. cyl.	Domed heads.
Intermediate Tank		1	4′0 dia. x 6′0 470 gals.	Steel horiz. cyl.	Domed heads.
Unused formerly Compressed Air Tank.		1	5′0 dia. x 4′5 655 gals.	Steel horiz. cyl.	Domed heads.
B.H.S. No. 1 (lead lined)	Top Floor	1	6′0 dia. x 8′0 1410 gals.	Steel vert. cyl.	Domed heads.
B.H.S. No. 2 (glass enamelled)		1	7′6″ dia. x 7′ 6″ 2070 gals.	Steel vert. cyl.	Domed heads
Scrubbed Liquor Feed		1	4′0 dia. x 6′0 470 gals.	Steel vert. cyl.	Domed heads.
Calcium Chloride		1	3′0 dia. x 4′0 174 gals.	Copper vert. cyl.	Domed heads
Constant Level City Water.	Roof.	1	4′6″ dia. x 4′10 478 gals.	Steel vert. cyl.	None.
INTERCHANGING ROOM					
M.E.K. Separator		1	3′0 dia. x 4′10 128 gals.	Copper vert. cyl.	Domed flanged.
MILL ST. TANK HOUSE.					
M.E.K. and Sec Butyl Distillates.	Lower Floor. Upper Floor.	14	16′ dia. x 10′6 13,157 gals.	Copper vert. cyl.	Copper wood backed.
ACID PLANT.					
Strong aud Dilute Acid (lead lined)	Tank Room.	4	5′ x 17′ x 4′ 2100 gals.	Wooden rect.	None.
Conc. Acid Tank		1	10′ dia. x 20′ 10,000 gals.	Steel hori. cyl.	Domed heads
Acid Eggs (lead lined)		2	465 gals.	Cast iron.	Flanged.
Distributing Tanks (lead lined)	Top of Towers	2	8′ x 8′ x 3′6 1400 gals.	Wooden rect.	None.
Fuel Oil Tank (underground)	Yard.	1	108″ dia. x 30′3½ 12000 gals.	Steel hori. cyl.	Domed heads
BOILER ROOMS.					
Feed Water (press tank)	West.	1	6′0 dia. x 6′0 1060 gals.	Steel hori. cyl.	Domed heads
Blow off Tank.		1	4′0 dia x 7′6 588 gals.	Steel hori. cyl.	Domed heads
Feed Water	East	1	8 x 10 x 8	Steel rect.	None.

APPENDIX ON EQUIPMENT

Name or Use.	Location.	No:	Size.	Material and Type.	Cover.
			4000 gal.		
Water Softener		1	12′ dia. x 27′ 19000 gals.	Steel vert. cyl.	None.
Feed Water	Mill.	1	12′ dia. x 10′ 7050 gals.	Steel vert. cyl.	Wooden.
YARD.					
Spare (glass enamelled)		1	7′ 6 dia. x 10′0 2760 gals.	Steel cyl.	Domed heads.
Spare Section (glass enamelled)		1	7′6 dia. x 2′6 690 gals.	Steel cyl.	No heads.
Spare (glass enamelled)		1	8′5 dia. x 2′6 885 gals.	Steel cyl.	Domed heads.

APPROVED
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J. H. PARKIN.

BRITISH ACETONES TORONTO, LIMITED

LIST OF DRAWINGS.

Drawing No.	Title.
7979	Continuous Acetone Still—Elevation.
7980	Continuous Acetone Still—Plan.
8683	10' 0" I.D. x 6' 0" Lead Lined Boiling Kettle (Stage "E").
8684	72" I.D.—12 Plate Column Lined with ¼" thick C. P Lead (Stage "E").
8684-2	Detail of Boiling Cap Plate for 6' 0" Lead Lined Column.
8685	37½" I.D. Condenser, Stage "E".
8686	24" I.D. Dephlegmator (Copper) Stage "E".
8686	Stage "E" Elevation of General Arrangement of Lead Lined Still.
8688-1	Plan of General Arrangement of Lead Lined Still, Stage "E".
8887	10' 0" x 16' 0" Kettle with 250' 0" Steam Coil.
8888	60" I.D.—36 Plate Steel Exhausting Column.
8899	Steel Kettle 10' 0" I.D. x 24' 0".
8901	60" I.D.—24 Plate Exhausting Column.
8906	General Arrangement of Secondary Butyl Alcohol Still.
8911	Caustic Washer (proposed).
8921	40" I.D.—40 Plate Column (Stage "F").
8924	21-⅝" I.D. Preheater to Recovery Still.
8925	60"—12 Plate C. I. Column (Stage "F").
8926	3' I.D.—12 Plate Column (Stage "F").
8927	22" I.D. Condenser (Stage "F").
8928	18¼" I.D. Oil Decanter.
8930	4' 0" I.D. Evaporator (Kettle).
8933	36" I.D. Salt Solution Storage Tank.
8937	Stage "F" Elevation of General Arrangement of Scrubbing and Recovery Systems.
8938	Stage "F" Plan of General Arrangement, Scrubbing and Recovery System.
8939	Stage "F" Diagrammatic Arrangement of Scrubbing and Recovery System.

REPORT ON ALTERATION AND ERECTION OF BUILDINGS OF THE ACETONE, METHYL ETHYL KETONE AND ACID PLANTS OF THE BRITISH ACETONES TORONTO, LIMITED, AT TORONTO, CANADA.

E. METCALFE SHAW, WH.SC., ASSOC. M. INST. C.E.,
Engineer in Chief.

By

W. CHARLES COLLETT, B.A.SC.
Architect.

JANUARY 31, 1919

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GENERAL DESCRIPTION.

The Plant—In the manufacture of acetone, the British Acetones Toronto Limited have taken over and utilised the properties of the General Distillery Co. and Messrs. Gooderham & Worts Limited.

The buildings used in the process were taken over as they were required. At the time the operation commenced, these buildings comprised the following: The Mill, Mash Building, Bacteriological Laboratory, Pump House, Coal Shed, East Boiler House, and Grain Elevator, owned by Messrs. Gooderham & Worts; also, the Fermenting Room, West Boiler House, Shipping Room, and Storage Tank of the General Distillery Co. At a later date, the cooper shops and paint shops were converted into Workmen's Lavatories, Timekeeper's Office and Stock Room, as well as the Fermenting Cellar, the Storage Warehouse used for cleaning of acetone drums, and the Charcoal Filter Room and Tank Room used for steamfitters' and tinsmiths' shops.

When additional property was required for the erection of the M.E.K. Plant and extension of the Acetone Plant, the Gooderham and Worts' Barrel Wash House, adjacent vacant lots, Tank Houses No. 2, No. 11 and No. 14, as well as the warehouses of the General Distillery Co. on the north side of Mill Street west of Trinity Street, were taken over.

Drawing No. 416 shows the extent of the property which occupies the waterlots between Parliament and Cherry Streets.

The Property—This property is located about a mile and a half east of the Railway Terminus of the City of Toronto, at the Junction of the Main Line of the Grand Trunk and Canadian Pacific Railways. The Grand Trunk siding to the south of the property is used exclusively in the handling of coal and grain, as well as the shipment of the finished product.

The C.P.R. siding north of the property is located at Parliament Street, and has been of great convenience in handling the materials f construction which were received from the Canadian Pacific Railway.

Adjacent to the plant occupied by the British Acetones Toronto Limited, are located to the west The Polson Iron Works, Toronto Railway Shops, and the Consumers Gas Co., etc.; to the east and south are the Canadian Northern Freight Yards, the National Iron Works, the British Forgings Limited, etc.

WATER SERVICE—The water service used in the operation of the plant is obtained from Lake Ontario through the Main of the City of Toronto Waterworks Department.

The temperature of water varies from 40 to 56 degrees according to the season of the year, and at an approximate pressure of 80 lbs. per square inch. The city water supply is connected to the system of hydrants located on the streets, which form a part of the Civic Fire Protection System.

In addition to the City water supply, a private system is operated on the plant which delivers Bay water from the Toronto Harbour; the pressure of 100 lbs. is obtainable from the pumping station of the property and connected to the system of hydrants on the property as well as stand pipes in the various buildings, beside which are located hose racks enabling immediate water service in case of fire.

This water system has not been used in the general operation of the plant, owing to the fact that the Bay water is not sufficiently clean to enable its use in a system whose fundamental principle is sterilisation.

FIRE PROTECTION—The protection of the property against fire is afforded by the Toronto Fire Department as well as by the fire service of the plant.

The signal box of the Toronto Fire Department is located at the entrance to the property on Trinity Street, and the hydrants of the City of Toronto Waterworks Department are within easy access of the various buildings which deliver water pressure of 80 lbs. per square inch.

The Pumping Station of the British Acetones Toronto Limited takes water from the Toronto Harbour, and enables a pressure of 100 lbs. per square inch to be delivered to any of the buildings. This is connected to various stand pipes throughout the property having hose racks on various floors.

The coal crushing system designed and ready to instal provides for the prevention of the placing of explosives in the coal.

In addition to these systems of protection, the Holmes Electric system is installed throughout the plant, which enables the alarm to be given immediately in case of fire.

Schedule C in the appendix of this report gives a list of the equipment available with the location of same around the property, as well as the type of fire extinguishers which are placed and ready for use.

In places where the adjacent buildings have interconnecting openings, tin-clad doors bearing the Underwriters' label have been installed. The protection is afforded by a sliding door on an inclined track. This door is counterbalanced with a weight attached to a cord. In case of fire a fusable link allows the counterweight to be separated from the door and the opening is automatically closed.

Fire escapes have been located on the Still Buildings to enable the evacuation in case of explosion or accident, more particularly in the case of the acetone still building, on which escapes are as follows:

The south side of the building has an exit on every floor to a fire escape located at the western end of the distillery. The escape to the third floor is carried the full length of the building, and joins a fire escape placed on the east end of the building, which leads to the roof of the office. This escape also has a ladder to the roof for the protection of workmen.

The M.E.K. Still Building is referred to in the report on buildings of M.E.K. Plant.

NATURE OF THE SOIL—Owing to the filled-in nature of the property, the soil varies in different portions of the plant. The property south of Mill Street was many years ago reclaimed from the Toronto Bay, which at that time extended its shores many feet north to the vicinity of Mill Street. The fill varies in composition, partly clay and partly sand, which has in many locations pits and watercourses, necessitating foundations many feet in depth. The solid bearing occurs at a depth of from six to nine feet, and in many instances at a depth of three feet, a sufficiently high bearing power has been obtained.

PROTECTION OF PROPERTY—Owing to the volatile nature of the solvent manufactured, it has been necessary to protect the property as fully as possible, which has been accomplished by giving attention to the following details:

1. Exclusion of flame from buildings where volatile matter is either in process or storage.
2. Protection of openings with wire guards.
3. Watchmen.
4. Fencing of property.

1. Owing to the immediate and urgent demand for acetone, it was necessary to operate the plant using as far as possible the equipment and storage tanks as they existed. This involved a hazardous risk, which was altered as speedily as possible.

Care was taken throughout the process from the beginning to isolate those buildings in which there was a possibility of the use of a naked flame. In addition to this, it became expedient to store the acetone apart from the distillery.

2. The openings facing the exterior of the property have up to the height of two floors above the ground been protected by wire guards. These are made of diamond mesh on an iron frame, which are fastened to the frames of the openings by means of staples. These cover all doors and windows which face the exterior of the property. This has effected the opening of doors and windows when ventilation is required without leaving the openings unguarded.

In addition to the protection of doors and windows, the skylights located near the railway track have been covered with wire screen having a ½" x 2" rectangular mesh. This type of mesh is used in the skylight, as it is designed to catch the glowing cinders discharged from locomotives.

3. Unprotected entrances to the plant are as follows, viz.: on Trinity Street, Mill Street and Parliament Street, at which positions watchmen are stationed. In addition to this, at entrance to the Acetone Building a watchman is placed whose duty it is to take matches from anyone entering the building. This has eliminated the risk of accident by fire.

4. Owing to the extension of the plant it was desirable to cut off as much as possible the various portions of the plant from the outside properties or street by means of non-climable fencing. The fence used is known as the chain link non-climable fence, and was to be located at the extremity of all properties used by the British Acetones Toronto Limited. This would facilitate the observation

of openings by watchmen, etc., much better than the former system would permit.

It was considered necessary to place these fences across Mill Street at Parliament Street, across Mill Street at the west side of Trinity Street, across Mill street about one hundred yards east of Trinity Street, across Trinity Street at the north end of the property, and across Trinity Street at the southern boundary of the property north of the Grand Trunk tracks, running the fence from the mill to the pumping station.

The permission of the City Council was obtained to effect the protection during the War, with the understanding that the fence would be removed when the plant was not used for war purposes. In accordance with this the fence, which was under construction, has been removed.

BUILDINGS OF ACETONE PLANT.

Dwg. No. 101 and 416.

The buildings of the plant have been maintained, repaired or altered as occasion demanded by the work for which the buildings were intended.

The material taken from existing buildings have been salvaged as far as possible in the construction or alteration or other buildings, and to some extent these materials have affected the type of construction used, as in the Seed Tank Room and Fermenting Room.

The report does not attempt to outline the complete work done in all trades under the architect's supervision, but rather described the conditions of the buildings and notes the important changes, either in arrangement of buildings or type of construction.

The electric wiring has not been at any time in the hands of the architect. This is explained by the fact that the workmen in the mechanical trades have been employed by the Department of the Mechanical Superintendent, and the power distribution in the hands of the Electrical Engineer.

A general description of the buildings is submitted herewith, and has been drawn with respect to the groups of buildings required for

(I) Manufacturing Purposes,
(II) Storage,
(III) Power Equipment,

(IV) Miscellaneous Buildings,

of which the drawings submitted give a description of the more important parts of the work.

I. BUILDING FOR MANUFACTURING PURPOSES.

1. Mill Building—The Mill consists of a four and one half storey building of stone and brick construction. The floors throughout are doubled ⅞ lumber on wooden joists. These are carried by box girders, which run across the building and are supported by cast iron columns. This building consists of two sections known as (1) the Mill, (2) the Mashing Section.

The only alteration to this building consists in the revision of the second floor of the mashing section, as shown on Drawing No. 171.

The reconstruction of the floor referred to has been undertaken for the following reasons; The alterations in wooden construction from time to time has left the floor in such a condition that it neither prevents the water from penetrating the floor below, nor allows the mash tuns to be protected by a circulation of air below the floor. The existing wooden joists have been removed and replaced by steel work.

This supports an 1¾" splined plank floor with a ⅞" floor overlaid. This floor is calked to make it watertight and drained to a central gutter.

The mash tuns have been replaced by tuns of a larger capacity because the existing tubs were unfit for use, and it was possible in reconstruction to build the 6,000 gal. tuns from the material in stock instead of the smaller tuns formerly in use.

The steel supports have been lowered and set between the supporting box girders to permit the placing of the mash tuns as low as possible, thus facilitating the operations of the mashing department.

2. Fermenting Building—This building is of brick construction with monitor running the full length of the building. The upper floor and roof carried on wood joist supported on light steel work. The platform or second floor of the building was limited to the space occupied by the Fermenters, Cookers, and Yeast Tubs. Three Fermenters were added to the west section of the building,

filling in the molasses pits below the floor level. Later, four Fermenters were installed south of the Cookers and Fermenters removing tanks and scale tanks occupying this space. The platform around the fermenters was accordingly extended to suit the Fermenting Tanks installed.

In addition to the enlargement of the Plant, the arrangement of the building has been modified so that it is possible to obtain samples from the fermenter at a point between the operating floor and the ground. This consists of a runway about three feet wide passing the full length of the Fermenter Building.

The Fermenting Building has been enlarged, the New Section containing six Fermenters. This consists of the northerly fifty feet of the building, formerly known as the Barrel Wash House, and lies directly east of the Fermenter Rooms referred to. The platform is placed in this building to correspond with the platform in the main Fermentation Plant, and also a lower gallery midway between platform and the concrete floor.

The new Fermenters referred to are set on concrete foundations, which carry the steel I beams riveted to the bottom of the Fermenter Tanks.

The new section of building has been united to the main fermenting section by means of interconnecting arches, which are placed on each floor or gallery.

The Fermentation Building has been provided with a door at either end, the west door leading to the roof of the steamfitters' shop and the east door to the fire escape leading to the yard, as well as an interconnecting door between the two buildings.

The Cooker support which formerly consisted of wooden framework, has been replaced by a structure of steel work supported on columns which are braced to the supporting beams.

The footings consist of reinforced concrete which receive each pair of columns and are placed midway between the tanks supported. This arrangement permits of the use of the space below the cookers for location of coolers and interconnecting piping.

The installation of a system of cooking which meant the connecting together of the four cookers referred to, made it necessary to erect rigid supports under the cookers.

The foundations were set between the cookers and brought to the floor level, leaving the anchor bolts ready to receive the columns supporting 24" I beams.

The steel work was erected in place, the columns grouted and allowed to set, after which the tanks were wedged in position and wooden framework removed.

The fermentation section embraces the Seed Tank Room and Inoculating Room, which are located on the third and fourth floors of the distillery (see Appendix A).

Ventilation of Fermenter Room is described in Appendix B.

3. Fermenter Finishing Room—The alteration to this building by means of a brick wall provides for a storage room in addition to the Fermentation Section.

The upper floor, which was in bad condition, has been rebuilt, the condition being due to the dampness in the building and lack of ventilation.

4. Distillery—A five-storey building is of steel frame construction and curtain walls of brick. The columns supporting the floors and roof within the building are of cast iron having lugs supporting the framing steel, which carries the floor joists and floor.

No details of the properties of C.I. section in the wall are to hand, and no plans of the foundation showing either the size of the footing or value of the soil under each footing.

As the steel was heavily loaded, it was deemed advisable to carry all extra loads by independent supports, providing ample footing under each column to support its load.

The sections of equipment supported comprised the following: No. 2 Beer Still, Heater and Condenser for same, and the Acetone Continuous Still. These were carried on steel framework, which was connected into the steel work of the building, and steel columns have been placed wherever desired to support the load on th foundation.

5. Laboratories—When the system of fermentation was enlarged to its final proportion, the laboratory space was found to be inadequate. It became necessary to alter the space occupied by the offices and draughting room to make the premises suitable for laboratories, plans of which are shown on Drawing No. 114.

The ground floor has been converted into a Chemical Laboratory to be used in connection with distillation of acetone and manufacture of M.E.K.

The upper floor has been altered to suit the condition of the Bacteriological Process Laboratory. This section is connected to the second floor of the Distillery Building by means of a balcony, thus permitting attendants to pass from the Laboratory to the Fermenting Department without having interconnecting doorways between the departments.

The alteration of the building consists chiefly in benches, lockers and fixtures suitable for laboratory work in addition to the plumbing required.

The balcony referred to forms an additional fire escape for the Distillery Building second floor as well as the Laboratories. The said balcony is provided with a drop ladder at its easterly end.

II. BUILDINGS USED FOR STORAGE.

1. **The Grain Elevator** is constructed of heavy timber on pile foundations, with a superstructure of wooden framework, covered with corrugated iron. Beyond the maintenance of the building and construction of any additional chutes, etc., required in the handling of grain, there have been no structural alterations.

2. **The Coal Building** is a frame construction with corrugated iron covering. This building has, owing to its age and heavy use, required the replacement of many of its timbers. The settlement due to the burning of posts made it necessary to replace structural members and level up the roof.

It was decided that the lower supports of the structure should be removed and replaced by steel columns, and the members of the roof which have been strained or broken, replaced by new timbers. This work, due to the shutting down of the plant, has been stopped, as it was decided that reconstruction of any portion of the work should not be proceeded with until the purposes of various buildings were finally settled.

3. **Coal Handling Equipment**—Due to the large and increasing consumption of coal, it was decided to instal a system for handling and crushing the coal as it was received in cars. This system was intended to operate as follows: The coal was to be delivered from the car through a track conveyor, to an apron feeder, thence to a coal crusher, after which a bucket conveyor was

provided to elevate the crushed coal to a loading hopper immediately above a weigh scale. Provision was made to remove the existing scale south of the G.T.R. siding and reset same in the location provided as a part of the coal handling equipment.

The operation of the coal handling equipment and weigh scale were to be effected from a brick building constructed as a part of the coal handling equipment.

Drawing No. 346 shows a block plan of the required building for Coal Handling Equipment. The track hopper is located about thirty feet west of Trinity Street, allowing a 60 ft. car to be placed for unloading to the west of Trinity Street. The cars of coal are placed west of the point, and allowed to run to the position of the track hopper, which point is at the lowest end of the siding. The empty cars may be allowed to run over Trinity Street, and handled by a shunting engine as required.

The building consists of:

(1) Pit containing hopper, crusher, conveyor and scale.

(2) Operating room or weigh house.

(3) Support for overhead machinery.

(4) Loading Hopper.

See Drawings No. 374 and 375.

(1) The pit is constructed entirely of reinforced concrete, which is designed with retaining walls and concrete slabs. Owing to the water pressure due to the condition of soil and relative height of lake, this has made it necessary to treat the walls as retaining walls and the floors as concrete slabs resisting the water pressure due to depth. The walls contain in addition a weight of concrete equal to the water displaced.

(2) The operating room consists of a one-storey brick building having a 4-ply felt and gravel roof. The floor to be of plank supported on a framework of steel.

(3) The support for overhead machinery consists of a framework 6 x 6 pine timber covered with $\frac{7}{8}$ sheeting and corrugated iron. The loads not being excessive, the structure is of a simple nature.

(4) The loading hopper, which has not been detailed, consists of a rectangular bin constructed of steel with a mechanical dumping device. This sets on the four brick walls, which enclose the scale, as shown in Drawing No. 375.

The cessation of the manufacture of acetone has shut off the necessity for Coal Handling Equipment, and the work for this reason has not been proceeded with.

4. AUXILIARY ACETONE STORAGE TANKS are connected to the shipping system by means of pipe lines.

The building is of steel frame construction with corrugated iron covering and Kalemein clad door. The footings are of concrete and the floor under tanks is of reinforced concrete, the drainage of which is open to the atmosphere to allow the evaporation of waste.

This steel work, as well as all other steel work fabricated in the work as erected in accordance with the By-laws of the Municipality of Toronto.

5. SHIPPING AND DRUM CLEANING ROOMS have undergone no structural alterations other than the locating of Tin-clad Fire Doors between the Shipping and Drum Cleaning Rooms as well as between the Drum Cleaning Room and Storage Tank Room.

The roof supports of this building have not been repaired, and are not in good structural condition.

The roof consists of wooden joist construction carried on trussed beams, which are supported from the walls to central posts in each of the buildings.

Screen doors have been added to the south side of the building, which enables the opening of the doors in hot weather to assist ventilation, which is accomplished by means of skylights having large openings to the roof, which are protected as described in report on protection of property.

.6 ACETONE STORAGE BUILDING—Formerly Tank House No. 11 of Messrs. Gooderham and Worts, consists of a brick building having a felt and gravel roof. The tanks used in Mill Street Tank House formerly occupied this building. These tanks were supported on brick piers, which run longitudinally throughout the building, and to provide storage space for drums a 3" plank floor fastened to 4 x 4 plates has been laid throughout. A doorway has been located, and provision made for the storage of two tiers of acetone drums. The floor is about 18" below doorsill, which is at the level of a lorry, and this enables the rolling in of drums to either tier for storage without any equipment added for the purpose.

III. POWER BUILDINGS.

1. **Boiler House**—The East Boiler House consists of brick buildings similar in construction to the low buildings already referred to. The East Boiler House has not undergone any building alterations other than brickwork necessary in maintenance of boilers.

The West Boiler House has been revised and contains in the eastern section of the building an engine room which is separated from the boiler section by a metallic lath partition on wooden studs. These are supported by a brick wall about 4 feet high and simply form a protection against dust for the machinery placed therein.

This building has, similar to the other buildings, been ventilated by means of skylights as described under heading of "ventilation."

2. **Electrical Switch House** (see Dwg. No. 285) consists of a brick building fire proof throughout, which is located adjacent to the Distillery. Its construction is as follows:

Walls are of brick throughout. Ventilation is obtained by means of pipe inlets about two feet above floor and an outlet eight or ten feet high; and is protected in such a manner that water cannot enter the building through the ventilators.

Windows are of wired glass in steel frames, having fusible links on the tilting mash for fire protection.

Doors are of 1¾ Kalemein Clad doors having wired glass panel above and Kalemein panel below.

Roof is of reinforced concrete covered with a 4-ply felt and gravel roofing.

3. **Pump House**, which is located at the southerly limit of Trinity Street at the intersection of the Grand Trunk Right-of-Way, is of brick construction and has undergone no structural alteration.

IV. MISCELLANEOUS BUILDINGS.

1. **Offices**—The lack of office space in the office used by the British Acetones Toronto Limited, for the first year and a half of operation necessitated the erection of larger office accommodation, which was commenced as soon as Messrs. Gooderham & Worts could give occupation of the barrel wash house, which was the site chosen for an office building.

The building was two stories in height and had similar floor construction to the other buildings described. The posts used in construction were altered to suit the required plan, and the interior of the building trimmed with Georgia Pine sheeting on the ground floor and White Pine on the upper floor.

The lower portion contained the Executive Offices and comprised the Office of General Manager, Assistant General Manager, Matron, General Office Staff, and Mechanical Superintendent. The upper floor was occupied exclusively by the Engineering staff and the office staff of that Department.

2. THE STEAMFITTERS' SHOP occupies the room formerly used for the charcoal filter and storage tanks. The charcoal filters and piping were removed and the tanks isolated from the main room by means of a 14" brick wall, which protected the Fitters' Shop from the vapours from the storage tanks.

3. WORKMEN'S LAVATORIES—The space formerly occupied for barrel storage in the cooperage department of Messrs. Gooderham & Worts has been converted into Timekeeper's and Foremen's offices. The barrel paint shop has been altered to serve the purposes of Workmen's Lavatories and Lunch Rooms and Locker Rooms. These two sections of the plant have been united by means of an interconnecting door.

This section of the building has been isolated from the portion of the plant under construction by means of a brick wall which was placed across the east end of the building containing the workmen's lavatories. The archways connecting the present Stock Room and the Excise Room of Messrs. Gooderham & Worts have been bricked as shown.

The section for Timekeeper and Foreman provides an office, which contains the time clock and telephone switchboard, and is beside the passageway leading to the workmen's lavatories.

The Foremen's Room comprises a Lunch Room, which faces the passageway leading to the workmen's rooms. This permits the identification of workmen as they pass to and from their work.

There is also provided a wash room, containing lavatories and shower bath, and a room containing clothes lockers.

THE METHYL ETHYL KETONE PLANT.

(See Drawings No. 101 and No. 166.)

GENERAL CONDITIONS—The group of buildings referred to in the report as the M.E.K. Plant has been erected in accordance with the information received regarding the location and weight of the equipment to be supported.

In consequence of the offer of Messrs. Gooderham & Worts to place at our disposal the whole of their barrel wash house and cooperage, the location occupied by this building was chosen as a site for the plant referred to.

The choice of this site was influenced by the fact that the space required for the smaller plant which was under consideration at that time was ample.

The subsequent arrangement of apparatus from time to time made it impossible at any one time to arrange a complete layout of the plant.

The arrangement of the plant provided for the location of the acid plant on the northern section of the property set out for the M.E.K. plant.

This work was governed by the following conditions:

(1) The work had to be advanced as far as possible before the cold weather set in.

(2) The brickwork in the concentrator required a minimum of sixty to ninety days for the completion of the towers, after which the packing and the lead burning had to be completed.

(3) The confined location of the building made it necessary to dispose of the material on hand as rapidly as possible.

In consequence of these conditions it was necessary to work overtime, which included night as well as Saturday afternoon and Sunday work, and the completion of the work when the acid towers were required has justified this assumption.

SOIL TEST—The soil on which the acid plant was erected proved to be of the nature of soft wet clay. This portion of the property is of a filled-in material, which has consolidated to a great extent but which, owing to the presence of water, has maintained its wet clay nature.

In accordance with the by-laws of the City of Toronto a test was made in the presence of the Building Inspector, who approved the values placed upon the soil. The test consisted of a two-ton weight on a platform which was balanced on a post 12 inches square. The deflection noted in twenty-four hours was 5/8 inch, at which point the load permanently settled. The load has therefore been distributed over an area sufficiently large to permit a bearing power of one and a half tons per square foot.

PLANS AND SPECIFICATIONS—Plans and specifications were drawn for the Acid Building. The specification embraced a general description of the work entailed in the subsequent erection of the M.E.K. plant.

The contracts let for this work comprise the following:

(1) Contracts by special agreement, drawn by the Architect and signed by the Owner and Contractor.

(2) Sundry contracts under written order under the system used for purchases in the M.E.K. Purchasing Department.

(3) Sundry instructions to trades under the Mechanical Superintendent given by Works Order under instructions from the Architect.

The contracts for the Acid Building were drawn for the general contract, steelwork and tinsmithing trades. The terms of the contract with the general contractors applied to all subsequent work handled by this contractor, the details of which are handled under the subject of Costs.

The work was divided to such an extent that it was found advisable to carry out portions of the work under written orders on form used in the M.E.K. Purchasing Department. This was necessary owing to the fact that small contracts did not warrant special contract forms being drawn, as well as the fact that immediate deliveries were obtained and records kept by the M.E.K. Purchasing Department, which assisted materially in the checking of invoices and the apportioning of costs to the various departments.

The work was handled by workmen employed by the British Acetones Toronto Limited, or by contractors working on a time and material basis, whose men are listed on the time clock of the British Acetones Toronto Limited. The order for this work was issued in the form of a Works Order.

COST DATA—The cost of construction is therefore compiled from three sources:

(1) The purchasing orders.
(2) The general contractors' statements.
(3) The Works Orders.

The purchasing orders were recorded in duplicate, and a summary kept of the orders in card index form. These orders contained the prices quoted and the numbers listed on accounts as they were paid. The departmental classification used throughout the plant has been followed and enabled the segregation of cost to various portions of the work.

The general contractor renders monthly a statement of materials and labour, cost of plant, profit, etc., which is checked by our architect by means of a daily report based on the time sheet rendered daily by the contractor and checked by timekeeper.

The daily time sheet, which is a form of recapitulation sheet, records a list of workmen and wages which are distributed to the various portions of the work by means of numbers which are given to the various jobs. The different trades on each job are separated under letters used to designate the variety of work, thus the cost of any section of work may be obtained.

The material has been apportioned by the architect to the various jobs, and is subdivided in the following manner:

(1) Materials delivered specially to the individual jobs.

(2) Material bought and delivered into general stock and later apportioned to the job in proportion to the work done from day to day.

The total costs of work done by this contractor are computed by listing labour, material, proportionate rate of cost of plant, workmen's compensation and profit. These are apportioned to the building for which the work had been done.

The record from the cost clerk gives the total costs of material and labour supplied to the buildings under Works Orders.

The summary of costs as compiled by the architect is submitted under a section of the report listed "Cost of Buildings."

DRAINS—The continual use of the plant has prohibited the rearrangement of the drainage system. It has therefore been necessary to use the existing system, connecting new drains to the old system from time to time. The low level of the plant has to some extent hampered the drainage of water from the floors. The existing tile drains are in many cases flat, which has necessitated the altering of the location of drains and introduction of means of cleaning drains by use of sumps. The sumps have been constructed of concrete, permitting the water to flow into them, any solids are collected in the pit, and the water allowed to flow through the tile pipes leading from the sump to the main sewer.

UNFINISHED CONDITION OF BUILDING—The uncertain element which enters into a new work of the nature of the M.E.K. Plant has left a number of small details unfinished, owing to the fact that the stoppage of the work has not warranted their completion.

THE SULPHURIC ACID PLANT.

(See Drawings Nos. 103, 104, 105, 108, 112, 113, 167.)

The site of the former barrel wash house of Messrs. Gooderham & Worts was chosen for the acid and methyl ethyl ketone plants.

The brickwork of the acid towers was of such a nature that sixty to ninety days were required for completion, after which lead work and packing had to be done.

Seventeen days were allowed in which to complete the work on the buildings and concrete foundations, which was accomplished in the following manner:

(1) Brickwork on south wall to be erected, scaffolding from the existing floors and roof, the brickwork ready for steel roof on December 22nd.

Work in north wall to be toothed in during the periods allowed for changing of scaffolding.

Concrete forms to be built and piled outside of the building, ready for use.

DESCRIPTION OF THE WORK—The work comprised the alteration of an entire building, retaining the walls where possible. A new wall was built on the south boundary of the acid plant, and the north wall strengthened because of additional height to which the brickwork was to be carried.

The roof construction is of steel fabricated as shown on drawings No. 104-105, and covering is of corrugated galvanised iron.

The roofing materials are discussed in Appendix D of this report.

The acid tank house is of brick and steel construction, as shown on Drawing No. 167.

Foundations for the acid towers have been built of reinforced concrete, and have been designed to spread the load so that it will be uniformly distributed. This uniformly distributed load is taken at 2,500 lbs. to the square foot, owing to the soft clay nature of the soil.

Foundations below grade are shown on dwgs. No. 102, and the detail of foundations above grade on dwg. No. 113.

As the work had to be done in the shortest possible time, two sets of concrete forms were placed at an increased cost, which is referred to under the cost section of this report.

INCREASE IN COST—The total cost of the work includes wages paid for overtime, which exceeds the actual rate by $1,278.48, in addition to $400, which would represent the cost of the additional framework for building the two sets of foundations at one time.

M.E.K. PLANT.

CATALYSER BUILDING consists of the following sections:

(1) Badger Distillation Section.

(2) Catalyser Room and Heat Interchanger Room.

(3) Furnace Room and Electrical Workshop.

These buildings all exist under one roof, being separated by brick walls.

GENERAL ARRANGEMENT—Drawing No. 166 shows the relation between the various portions of the Catalyser Building, which are arranged in this manner for the following reasons:

(1) The apparatus in the Badger or western section is controlled by operations in the Chemical Department under the supervision of the Chemical Laboratory.

(2) The Catalyser Room is operated and erected under the supervision of the Electrical Department, which has a workshop located over the room referred to as furnace room. The gases from the Badger section are kept isolated from the Catalyser Room by means of the arrangement shown on drawing.

(3) The Heat Interchanger Room is located over the Catalyser Room.

BADGER SECTION of the Catalyser Building has been erected according to dwgs. No. 101, 115 to 120 and 290.

The work consists of steel and brick construction. The loads are carried by a steel framework supported by the enclosing walls and columns which carry the superstructure.

The steelwork consists of several contracts, and the arrangement of the steework as it was completed is shown on dwgs. No. 115, 116, 117, 118, 119, 120 and 290.

The roof of the building over storage tanks in second floor has been raised and supported on brick walls and steel shown on dwg. No. 290.

The entrance door to the M.E.K. Plant is constructed of Kalemein, see dwg. No. 344, which arrangement provides for the removal of any portion of the equipment in this section of the building.

Dwg. No. 366 shows the arrangement provided for the erection of materials used in the salting plant. These materials were raised to the third storey and conveyed to the floor below by means of a chute. This method of handling was necessitated by the congestion of plant and piping on the lower floors.

CATALYSER SECTION—Dwgs. Nos. 254, 255, 256 and 304

This portion of buildings consists of the Catalyser Room and Heat Interchangers above, also the rooms used for oil burning furnace, a part of the oil burning catalyser system, and the electrical workshop.

A corridor has been arranged as shown on plan, which permits the entrance door to the Catalyser Building to open to the atmosphere. This has been fitted with a tinclad sliding door bearing the Underwriters' label; thus the Catalyser Room has been isolated from the Badger section.

The east wall has been altered (using the existing masonry) windows have been bricked up between Switch House and Catalyser Room, and new windows placed in upper section. The walls around the building have been carried up as parapet walls for fire protection.

The steelwork consists of skeleton framework supporting the roof and upper floor of the building, together with travelling cranes used for the shifting of the catalysers. The travelling cranes are of the Herbert Morris Crane Company's manufacture, having a capacity of 1½ tons, and operate the full length of the building.

VENTILATION—The Catalyser Room is ventilated by means of a Type D No. 17½ Keith Fan, having an approximate capacity of 5,000 cubic feet per minute, driven by a 3 H.P. motor. This fan is placed at the top of a brick flue which exhausts the air from the Catalyser Room by means of ducts placed in the floor of the room. The ducts are located between the rows of catalysers, and so arranged that the gas is taken away from the lower portion of air around the catalysers.

The registers may be closed or opened to increase the draught in any portion of the room, and the flues are proportioned in such a manner that when all registers are open the air will be received from all parts of the building with a uniform velocity. Dwg. No. 304 indicates the form of the ducts, which are built of brick. These are covered with reinforced concrete slabs, which have been made in section and laid in position after the walls of the ducts have been placed. The concrete floor is laid even with the surface of the ducts. Thus the removal of any partion of the floor covering the ducts would permit of any alteration with very slight disadvantages to the operation of the plant.

The vertical flue is fitted with nozzles which spray water through the flue gases, and the water passes to the drain with the soluble gases in solution; the balance of the gas is discharged on the roof.

This system has maintained ventilation, which has enabled the removal of vitiated atmosphere.

The southern end of the building has been left in an unfinished state, owing to the fact that (1) the full set of catalysers had not been required or laid out. (2) The space was being used for the oil burning system of catalysers, which had been set up and was under construction but not in use. Accordingly, a small four-inch ledge has been left, 2 feet high, to prevent the gases from flowing to that portion of the building which has not been provided with ventilation.

HEAT INTERCHANGER ROOM—The operation of heat interchangers has been accomplished by means of an operating floor placed above the catalyser room. The drips from the piping are caught in trays, and thus kept from the catalysers below. In addition to this, the gases of the room below are more easily exhausted from the building.

The floor has been covered on the under side with corrugated galvanised iron, protecting exposed woodwork from direct flame.

Dwg. No. 256 shows the location of the hollow tile partition which has been built to prohibit the interchange of gases between the catalyser and heat interchanger rooms, at the same time permitting the daylight to be used in the catalyser room.

The lighting of the Heat Interchanger Room has been effected by means of skylights, which also serve for ventilation. These are placed over the heat interchangers, and operated as desired.

The Heat Interchanger Room opens to the outside atmosphere, where by means of a balcony exit may be obtained to the roof of the Switch House. In addition to this, an air door is provided to roof, where exit is obtained through pent house. Each exit is provided with a Kalemein door.

FURNACE ROOM for Oil Burning Equipment.

This has not undergone any material alteration. The underside of joists in the room has been covered with a cement plaster on metallic lath, in accordance with Fire Underwriters' requirements. The floor has been left in an unfinished state pending the final instructions regarding drains, pipes below floor, etc., and for this reason is incomplete.

ELECTRICAL WORKSHOP—This consists mainly in the provision of racks and benches, etc., for accommodation of workmen. Lighting and ventilation are obtained by means of additional skylight and window.

TRANSFORMER HOUSE has been constructed according to the plans shown on dwg. No. 174. All work is of fireproof construction as shown, with Kalemein doors and steel sash with wired glass.

STILL BUILDING—Dwgs. No. 221 to 228, 315, 379.

The Stills for Primary Butyl, Secondary Butyl and M.E.K. are provided for in a brick building shown as Still Building in block plan No. 101. This building has been completed according to dwgs. Nos. 221 to 228, 315 and 379. The building is of brick and steel construction, with plank floors, similar to the construction used in the M.E.K. Catalyser Building.

The front of the building is built in such a manner as to allow all the glass possible, thus providing for an escape of gases in case of an explosion. This is accomplished by framework set in between the piers, having a series of doors placed on the floor level, with tilting window sash over the transome bar and panelled woodwork covering the frame of the buildings, as shown on dwg. No. 379.

A fire escape has been erected as shown on dwg. No. 379. This fire escape has been built in accordance with Ontario Factory Inspectors' Specification.

Should it become necessary to place an additional building to hold the three stills now on Trinity Street, the unused space to the east of the Still Building would be sufficient to permit the installation.

TANK HOUSE—See dwgs. Nos. 280, 281, 284.

The building to the north of the Still Building is utilised for the enclosing of 18 tanks, and referred to as Mill Street Tank House.

The alteration of this building consists chiefly in structural provision for the support of roofs and tanks on steel framing.

The existing roof in the northern section of the building has been carried by a row of steel columns supporting a steel beam, which carries the ends of the existing roof joists.

The centre portion of the building has been altered to permit of the elevation of 4 copper tanks above the tanks already provided for.

The existing building has been altered to permit the use of a second storey as shown on dwg. No. 284. The steelwork carries the central and north portion of the upper section of the roof. The southern section of the roof joists as well as the floor around the upper row of tanks is carried on temporary framework of 2 x 6 studs at 16" on centres. These rest on a trussed beam of wooden construction which is carried by the existing wooden posts.

The exposed walls of the monitor are covered with corrugated galvanised iron as indicated on drawings, and south wall is provided with windows as shown with 1¾" tilting sash.

This section of the building has been left in an unfinished state, owing to the fact that there was a possibility of placing a second still building next to the one provided, in which case the existing walls would have been removed, and the new wall would provide support for the floor and wall supported by the temporary partition referred to.

Catalyst Manufacturing Rooms—Dwg. No. 339 shows section and elevation of the rooms set apart for manufacture of First and Third Stage catalyst.

The western portion of warehouse on the north side of Mill Street has been altered by dividing it into two sections, as shown on Block Plan No. 101. The portion to the east of catalyser manufacturing rooms has been used for the storage of building materials throughout the work.

The catalyst manufacturing rooms have been altered to provide that all walls shall be fireproof and wooden posts removed. The roof has therefore been supported as shown in dwg. No. 399 by a steel beam which carries the load to the brick walls.

The windows are constructed of steel with wired plate glass, having a tilting sash in each window.

The roof has been isolated from chimney by means of concrete filling, and the beams resting on the wall containing the flues have been packed into the wall with an insulation of 2" asbestos fibre, and kept at least 18" away from flues.

The furnaces have been erected according to drawings submitted by the Engineering Department, the construction being of firebrick dipped in fireclay. All joints are laid thin and all brickwork shaped or cut to forms required for installation of burners.

The openings between the catalyser and storage room have been hung with tinclad sliding doors in accordance with the Fire Underwriters' requirements.

APPENDIX "A."

The Seed Tank and Inoculating Section was originally located in the Fermentation Section.

The floor of this section was strengthened to carry the Tanks in question; later, this number was increased and additional support provided for the floor. The Inoculating Section was raised above the Fermenter and supported as shown on Drawing No. 27.

This provided for three inoculators and mashing kettle, allowing also a small testing room, as shown. It was found, however, that the number of seed tanks was inadequate, and therefore the only position available was in the distillery section over the molasses evaporator.

The third and fourth floors have therefore been supported to carry the load placed. The material used was salvaged from other portions of the plant, and the floor supported on steel girders and columns which extend to the ground floor as shown on Drawing No. 139. Where the steel girders were not sufficiently strong, small H columns were placed as struts, thus providing ample strength to carry the floor joists.

The columns of the building were of cast iron with cast brackets supporting the steel braces, which crossed the wall in this section of the building. There was no information as to the material in the wall, nor as to the size of the foundation of the building, and it was therefore inadvisable to place any additional load on the building.

The supports provide that all additional heavy loads placed in the building shall have their loads carried to the foundation independently of the steel framework.

APPENDIX "B."

VENTILATION OF BUILDINGS.

The ventilation of various buildings has been handled by either mechanical ventilators or delivery of fresh air into the building by means of a fan.

FERMENTING ROOM—The ventilation of the Fermenting Room has not been satisfactory, which is entirely due to the fact that the Fermenters which had a tremendously large radiating surface, were subject to variations in temperature. This temperature when fermenter was steaming was that of live steam, which discharged into the atmosphere at 15 lbs. pressure. In the cooling stage this temperature was reduced to 98° F. From this it will be seen that the solution of the problem for one set of conditions would not apply to the room as a whole; furthermore, the necessity of having an intermediate gallery between the upper and lower floors made the ventilation of the whole building impossible.

Fresh air was discharged on the working floor at various points which, although it did not solve the problem, aided materially in making the room habitable.

SEED TANK ROOM—This presented the same problem, and was treated in the same manner, discharging fresh air into the centre of the room at atmospheric temperature, thus causing a circulation of air.

APPENDIX "C"

FIRE APPLIANCES

LOCATION.	Key	Hose Wrench	Nozzle.	Axe.	Crowbar.	Reels.	Hose.				Fire Ext.		Firebucket
							1½	2½	2¾	3¾	Imp.	Pyrene	
							ft.	ft.	ft.	ft.			
Railroad Tracks (Elevators)	1	4	1					300	50		1		
West Gate		1	1						50				
Acetone Tanks Yard	1		3		1	1			200				
Pumping Station Trinity Street	1		2	1	1			200					
East Boiler House	1	4	2	1					200				
Cooper Shop and Barrel Room													21
Gong Room													5
Shipping Room No. 2												1	
Tank House												1	
No. 3 Still House												1	
No. 2 Still House 1st and 2nd Floor												2	
No. 1 Still House												1	
Butyl Room Trinity Street												1	
Mill, Trinity Street													36
Store 5, Floor 4th									30				3
Store 4, Floor 3rd										100			6
Store 3, Floor 2nd										100			6
Store 2, Floor 1st										100			9
Store 1, Floor Ground										100			6
Elevator Hose			1				50						
Emp. Locker Room												1	
Stock Room												1 or 2	
General Office 2nd Floor							100					1	
General Office 1st Floor												1	
M.E.K. Building 3rd Floor												1	
M.E.K. Building 2nd Floor												1	
M.E.K. Building 1st Floor												1	
Catalyser Building											1		
Catalyser Building Exit Hall												2	
Tray House												1	4
Electrical Workshop												1	
Switch House												2	
Paint Shop. St. Hose												1	
Shipping Room			2	1							2	2	

APPENDIX "D."

ROOFING MATERIALS FOR ACID BUILDING.

The materials available for roofing of Acid Building were considered fully and consisted of the following:

1. Corrugated galvanised iron.
2. Corrugated asbestos roofing. Asbestos Manufacturing Co., Lachine, Que.

3. Asbestos Protected Metal, manufactured by Johns Manville Co.

Of these materials the first was chosen because of the delay caused by obtaining the others, as well as the fact that galvanized iron could be supplied and applied by any tinsmith, and could be delivered immediately.

Asbestos corrugated roofing has fire resisting qualities and under a direct flame the composition breaks at high temperature, otherwise this material would be serviceable.

Asbestos corrugated roofing has fire resisting qualities but cemented a three-ply asbestos paper with a cement of a bituminous nature. The action of direct flame causes this cement to melt and the asbestos to separate from the corrugated metal. As an insulating material there is a distinct advantage of the Asbestos Protected Metal over other materials, especially in this climate where condensation is a difficult matter to handle. The difference of temperature between the interior of the building and the outside air in cold weather is such that the substances which do not insulate from cold have a tendency to permit condensate on the inside of all exposed walls and roof, and this is a detriment when sulphur dioxide gas is given off in the atmosphere or vapors of sulphuric acid.

The corrugated covering has been protected from acid by lead paint. The condensate, nevertheless, is an objectionable feature in extremely cold weather, but as the speed of the work was an important factor, it was impossible to wait one month to receive the material which was not available in Canada.

COSTS OF BUILDINGS.

The summary of costs of buildings erected as a part of the Methyl Ethyl Ketone Plant is submitted herewith. The method of arriving at the various valuations placed upon the work have been referred to in the report on buildings of the M.E.K. Plant under the heading of "Costs."

The comparison of the estimate of buildings required for the purpose, with the list of buildings erected, will show that the estimate submitted did not contain the following:

(1) Oil Tank.
(2) Acid Tank House.
(3) Transformer House.
(4) M.E.K. Tank House.

(5) M.E.K. Still Building.
(6) Catalyst Manufacturing Rooms.

Acid Plant—The size of the Acid Plant, which was approximated per cubic foot of building space, was based on the information available at the time the estimate was made, since then the storage capacity required for the weak and strong acid has necessitated the addition of a tank house which involved a cost of $4,009.83.

The cost of footings for equipment which amount to $8,685.34, include the foundations for Sulphuric Acid Concentrator, which extend to a height of nine feet above the grade line, and which were not included in the original estimates. In addition to this, the soft nature of the soil necessitated an expenditure, which could not be estimated in the original estimate unless the site of the plant had been selected at the time the estimate was made, and foundations designed before being estimated on.

It will also be noted that the buildings which have been converted for the use of the Acid Plant include the demolition of existing construction, which involved a cost of $709.69.

The necessity for overtime work has added to the actual cost of the work the sum of $1,278.48, which was not considered in the statement of estimated costs.

Eliminating from the cost of the Acid Building as set forth in statement of Costs, the amounts charged for work not set forth in estimate, the comparison of costs will be shown in the following statement:

Total charges in Acid Building and equipment foundations		$27,676.33
Work not included in original estimates:—		
Cost of equipment foundation	$8,685.34	
Cost of additional tank house	4,009.83	
Cost of demolition of old building	709.69	
Extra charge due to overtime	1,278.48	14,683.34
		$12,992.99
The amount estimated for a building of steel frame and corrugated covering was		$14,022.49

M.E.K. Plant—The cost of the buildings of the M.E.K. Plant as originally laid out, did not include the Transformer House, M.E.K. Tank House, Still Building, nor Catalyst Manufacturing

Rooms. Each of these buildings presented a separate problem as the plant was developed.

The necessity for a Transformer House was settled for the limits set by the fact that current was received at high voltage. This will be dealt with more fully by the Electrical Engineer. The type of building was defined by By-law as well as by the Company installing the electric service. This work was handled in mid-winter and due to weather conditions, demanded a great deal of Sunday work and overtime.

The Still Building, Tank House and Catalyst Manufacturing Rooms have their costs separated, as shown in the enclosed statement. These were not included in the original costs, as it was proposed to handle the distillation by the stills in Trinity Street, the limitation of which however will be described by the Engineer-in-Chief.

An examination of the layout of the plant submitted in September, 1917, will show that the estimate of cost for the M.F.K. building was based on the space occupied as 40 x 75 ft. in area.

The following statement shows the relation between the estimated and final costs of the Catalyser Building:

Items not included in estimate:—		
1. Demolition of old building	$2,000.00	
2. Travelling Crane	748.00	
3. Skylight over H. I. Room	579.18	
4 (a). Drains as part of Equipment	1,402.56	
(b). Drains .	99.00	
5. Plastering .	336.23	
6. Electrical Workshop	858.64	
		$6,023.61
Support for equipment estimated at $2,500 in absence of data, weight of apparatus and nature of soil. Actual cost $4,632.16	Difference	2,132.00

Increase in cost due to the following causes:—

(1) Occupation of area 4,500 sq. ft. instead of 3,700 sq. ft. as shown on drawings.

(2) The support of heavy equipment and steel storage tanks on second floor instead of ground floor as originally estimated.

(3) Increase in cost due to increase in wages and material as shown in Table of Wages and Material costs for various years.

(4) Increase in cost due to the unsettled nature of the work.	
(5) The cost of ventilating system necessary for Catalyser Room.	
(6) The cost of providing Heat Interchanger Room and flooring over same.	9,017.29
Amount of original estimate	18,401.00
Amount for Items V. and VI. in Schedule of Costs	$35,573.90

The cost of building during the period of the War has materially increased; this has been shown by the gradual advance in prices of material as well as by the change in rate of wages paid to the various classes of workmen. The scarcity of labour has decreased the efficiency of the buildings trades; this is explained by the fact that it was not possible to make a selection of the best workmen. This has increased the cost of labour about 30% in addition to the increase in cost of wages and material as set forth in the following table:

RELATIVE COST OF LABOR IN VARIOUS BUILDING TRADES DURING THE WAR.

Rate of Wages per Hour.

	Pre-War	1916	1917	1918	1919	Increase.
Carpenters	45c.	45c.	May 1 55c.	May 60c. Aug. 65c.	65c.	44½%
Bricklayers	62½c.	62½c	62½c.	May 1 67½c.	Jan. 1 72½c.	16 %
Laborers	30c.	35-40c.	40c.	Aug. 28 45c.	45c.	50 %
Loss in efficiency due to scarcity of labour						30 %

COMPARATIVE COST OF MATERIALS.

	Pre-War	1916	1197	1918	Increase.
Lumber (based on cost of pine)	$30.00	$52.00	$60.00	$65.00 per M.	116%
Brick	9.00	14.00	16.00	17.00 per M.	88%
Stone	1.10	increase	0	1.80 per ton.	72%
Sand	.80	increase	0	1.35 per ton.	69%
Cement	1.75	increase	0	2.95 per bbl.	70%
Lime	8.00			15.00 per ton.	87½%

From this it will be seen that the price of work in various trades has been increased as follows:—

	Increase.
Concrete—Based on cost of labor, stone, sand, cement.	60%
Brickwork—Bases on cost of bricklayers, laborers, sand, cement and lime	55%
Carpentry—Based on carpenters' wages and cost of lumber	75%
Steelwork—Based on contractors' estimate, figures of cost very uncertain as prices vary from day to day.	125%

The cost of handling building work during cold weather has a tendency to increase the costs, viz.: from 10 to 30%, according to the nature of the work. From the foregoing figures and assumptions it may be assumed that in normal times work similar to that undertaken by the British Acetones, Toronto, Limited, would cost 40% to 50% of the costs presented herewith.

I. COST OF ACID BUILDING.

James A. Wickett, Ltd.	Carpentry	$ 1,066.55	
	Masonry, Drains, etc.	11,137.85	
	Glazing	30.41	
	Hardware	57.47	
	Wrecking	709.69	
			$13,001.97
Dominion Bridge Co.	Steel		2,675.00
Wheeler & Bain.	Tinsmithing		1,243.00
Robinson Bros.	Painting, etc.		435.45
J. A. Larkin.	Roofing		129.01
British Acetones.	Glazing		49.00
	Heating		178.86
			$17,712.29

II. COST OF FOUNDATIONS FOR ACID CONCENTRATOR.

James A. Wickett, Ltd.	Concrete	$8,418.59
British Acetones.	Soil Tests	266.75
		$8,685.34

III. COST OF PLACING OIL TANK.

James A. Wickett, Ltd.	Concrete and Masonry	$1,210.70
Dominion Bridge Co.	Steel	78.0
		$1,288.70

IV. TRANSFORMER HOUSE.

James A. Wickett, Ltd.	Excavation	$ 204.06	
	Masonry	1,911.89	
	Carpentry	219.76	
	Wrecking	22.57	
	Drains	25.36	
	Preparation	195.73	
			$2,579.3

Dominion Bridge Co.	Steel	129.20
J. A. Larkin.	Roofing	37.00
A. B. Ormsby.	Fireproof Doors and Windows	413.50
Robinson Bros.	Painting	45.10
British Acetones.	Glazing	18.70
		$3,222.87

V. CATALYSER BUILDING.

Sulphuric Section, Salting Plant, Catalyser Room, and Heat Interchanger Room. Furnace Room, Electrical Workshop, etc.:

James A. Wickett, Ltd.	Excavation	774.46	
	Masonry	11,389.88	
	Carpentry	4,063.78	
	Wrecking	2,000.00	
	Scaffolding	1,249.73	
	Drains	1,402.56	
	Plaster	336.23	
	Hardware	137.12	
			21,353.76
Dominion Bridge Co.	Steel		6,566.09
W. E. Dillon.	Sheet Metal	525.00	
	Skylight	95.00	
			620.00
O. Torrence & Co.	Whitewashing	66.40	
		16.80	
			83.20
Reid & Brown.	Cast Bases		10.25
H. Morris Crane Co.	2-1½ ton Cranes		748.00
A. B. Ormsby.	Fireprofing Doors, etc..		485.20
J. A. Larkin.	Roofing		795.46
British Acetones.	Drains	99.00	
	Glazing	50.00	
	Welding	1.38	
			150.38
Robinson Bros.			129.40
			$30,941.74

VI. EQUIPMENT FOUNDATIONS.

James A. Wickett, Ltd.	Carpentry and Masonry	4,198.49
Dominion Bridge Co.	Steel	433.67
		$4,632.16

VII. ELECTRICAL WORKSHOP.

James A. Wickett, Ltd.	Carpentry and Masonry	$858.64

VIII. SWITCH HOUSE.

James A. Wickett, Ltd.	Masonry	66.79	
	Carpentry	581.92	
	Hardware, etc.	27.24	
	Cinders	20.20	
			696.15
J. A. Larkin.	Tinsmithing		25.05
			$721.20

IX. MILL STREET TANK HOUSE.

James A. Wickett, Ltd.	Masonry	2,653.93	
	Carpentry	2,668.56	
	Excavation	399.53	
	Hardware	73.60	
	Wrecking	811.12	
	Drains	24.38	
			6,631.12
Dominion Bridge Co.	Steel		4,200.00
Robinson Bros.	Painting		137.60
Graham & Travers.	Removing Fixtures		20.54
J. A. Larkin.	Roofing . —		149.93
			$11,139.19

X. STILL BUILDING.

James A. Wickett, Ltd.	Excavation	330.64	
	Masonry	10,044.38	
	Carpentry	6,278.15	
	Wrecking	1,292.67	
	Forms	80.00	
	Cinder Fill	61.22	
	Preparation	73.41	
	Hoisting material for other trades	25.11	
	Drains	178.93	
	Hardware	399.69	
			18,764.20
Dominion Bridge Co.	Steel		4,210.00
Gamble & Travis.	Plumbing, unfinished		31.76
British Acetones.	Steel		125.28
Robinson Bros.	Painting		541.15
J. A. Larkin.	Roofing		154.13
Robinson Bros.	Glazing		218.00
	Painting, Steel		259.33
A. B. Ormsby.	Fireproof doors		246.00
			$24,549.85

XI. CATALYST MANUFACTURING ROOMS.

James A. Wickett, Ltd.	Excavation	699.70	
	Masonry	3,180.91	
	Carpentry	476.49	
	Wrecking	517.18	
	Drains	37.78	
			4,912.16
Robinson Bros.	Painting		177.00
Dominion Bridge Co.	Steel		123.32
A. B. Ormsby.	Fire Doors		245.80
British Acetones.			42.75
			$5,501.03

SUMMARY OF COSTS OF BUILDINGS FOR ACID AND M.E.K. PLANTS.

	Equipment Foundations	Buildings	
1. ACID PLANT—			
Concentrator	$8,685.34	$17,712.29	
Tank	....	1,288.70	
		$19,000.99	
	$8,685.34	8,685.34	
			$27,686.33
2. M.E.K. PLANT—			
Transformer House		$3,222.87	
Catalyser Building	$4,632.16	30,941.74	
Electric Switch House		858.64	
Switch House		721.20	
Tank House		11,139.19	
Still Building		24,549.85	
Catalyser Mfg. Room		5,501.03	
	$4,632.16	$76,934.52	
		4,632.16	
			$81,566.68
			$109,253.01

BUILDINGS	$19,000.99		
	76,934.52		
		$95,935.51	
EQUIPMENT FOUNDATIONS	$ 8,685.34		
	$4,632.16	13,317.50	
			$109,253.01

Approved:

E. METCALFE SHAW,
Engineer-in-Chief.

W. CHARLES COLLETT,
Architect.

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GENERAL REVIEW.
OF
OPERATIONS, EXPENDITURE AND RESULTS
AT THE
BRITISH ACETONES TORONTO, LIMITED,
AT
TORONTO, CANADA.

By

E. Metcalfe Shaw, Wh.Sc., Assoc. M. Inst. C.E.
Engineer-in-Chief.

February 28th, 1919.

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BALANCE SHEET.

Based on Trial Balance November 30th, 1918, with Stocks added as determined to February 28th, 1919.

ASSETS—		
Accounts Receivable		$ 128,833.27
Cash and Bank Deposits		79,657.21
Plant and Equipment, including alterations to Buildings		1,103,178.45
Stores on hand—		
Acetone	$ 41,946.70	
Butyl	1,741,169.43	
M.E.K.	5,553.90	
Supplies	47,222.08	
Corn	299,447.79	
Coal	85,599.20	2,220,939.10
		$3,532,608.03
LIABILITIES—		
I.M.B. Advances	$3,341,315.45	
Accounts Payable	12,405.40	
Drums	22,512.88	3,376,233.73
		$ 156,374.30

PRODUCTION.

PRODUCTION COST. (*No charge for Capital and Directorships*).

Corn		$2,605,933.72	=69.5% of total cost
Coal		256,653.11	= 6.8% " " "
Factory Expenses	$360,181.52		
Less Stores	47,222.08		
		312,959.44	= 8.3% " " "
Overhead Expenses		47,517.27	= 1.3% " " "
Wages		529,515.11	=14.1% " " "
		$3,752,578.65	

PRODUCTION—		
Acetone	5,744.285 lbs.	
Butyl	11,814,271 lbs.	
		17,558,556 lbs.

Total Production	**17,558,556 lbs.**
Total Cost	**$3,752,578.65**
Cost per lb.	**21.372 cents.**
Cost per ton	**$427.44**

IS IT POSSIBLE TO RUN THE BRITISH ACETONES, TORONTO, AS A COMMERCIAL PROPOSITION?

NEGLECTING CAPITAL AND MANAGEMENT CHARGES, THE COST OF ACETONE AND BUTYL ALCOHOL DURING THE YEARS 1916, 1917 AND 1918, HAS BEEN 21.372 CENTS PER LB.

This represents the cost during the War period when the prices of materials and labour were exceptionally high. Corn has ranged from 91 cents to $2.39 per bushel (see M.E.K. report September 15th, 1917, the average price being $1.52 per bushel.

Whilst it is certain that the cost of wages and material will not return to the old rates, it is equally certain that they will not be maintained at the War rate.

Now, considering the effect of reduced costs, the most important of these will be in connection with corn, and in view of the fact that it has frequently been as low as 40c. per bushel, it is not unreasonable to assume that after the present shortage has been supplied, a figure of 65c. per bushel may be safely counted on. A reduction, therefore, of the price of corn from $1.25 to 65c. means a reduction of 57.2% of the cost of corn, or taking 100 as the total cost of production, 57.2% of the corn cost of 69.5% equal to 39.75% will be deducted from the total cost.

Coal has cost during the War an average of $6.70 per ton, and a reduction of at least one-third of 6.8% may be counted on in this respect, making say 2.3 again off the total 100 cost.

Factory expenses have been necessarily very high owing to the experimental nature of the whole process in its early stages, and the amount of 8.3 figured on the production cost can be safely reduced by 3.95. Wages are most likely to remain somewhere near their present cost, but it may be expected that increased efficiency and a slight reduction in the price of labour will take 2.1 off the 14.1 due to this item.

PRODUCTION COSTS—WAR COST=100.

	War Cost 1916-1918.	Peace Time Reduction.	Peace Time Cost.
Corn	69.5	39.75	29.75
Coal	6.8	2.3	4.5
Factory Expenses	8.3	3.95	4.35
Overhead Expenses	1.3	0.0	1.3
Wages	14.1	2.1	12.0
	100.0	48.1	51.9

51.9% of the War time production cost of 21.372 cents makes 11.09 cents per lb. as the probable peace time cost per lb. of acetone and butyl alcohol.

Up to this point it has been shown that acetone and butyl alcohol can be produced at a uniform cost of 11.09 cents per lb. and it will be shown further on that an additional cost of $17,000 for catalysers; $3,494 for electric equipment for completing the 36 catalysers; $23,975.47 for completing 54 catalysers with automatic controls, etc.; and $5,000 for completing the acid concentration equipment, making a total cost of $49,469.47 necessary to complete the whole equipment, will put the plant in order for the production of 2,500 tons of acetone and 4,000 tons of methyl ethyl ketone per year.

It seems possible that a market may be found in the United States for about 1,000 tons of butyl alcohol yearly, but unless some new use for this substance is found, no alternative seems possible but to convert 4,000, if not 5,000 tons of it into methyl ethyl ketone.

This substance seems to be as effective as acetone in the production of cordite, and it appears to have some exceptionally good properties as a solvent in connection with high grade varnish. Quite apart from its special value for aeroplane work, the fact that it can be used in the production of very high quality varnish seems to indicate that it ought not to be difficult to find a ready market at a good price.

CONVERSION OF BUTYL ALCOHOL INTO METHYL ETHYL KETONE.

Total yearly Production of Butyl Alcohol, 5,000 tons.

Data obtained during the working of the M.E.K. plant and given in the sectional reports shows that an actual conversion of 75% was made from butyl alcohol into methyl ethyl ketone.

In regular working and with the improvements suggested by experience which were being installed, it is probable that 80% of the 5,000 tons of butyl alcohol or 4,000 tons of methyl ethyl ketone would have been produced.

BRITISH ACETONES TORONTO, LIMITED

CONVERSION OF BUTYL ALCOHOL INTO METHYL ETHYL KETONE.

Labour, 40 men	$60,000.00
Catalyst	35.000.00
Electric Current	48,000.00
Fuel Oil	7,275.00
Steam	10,000.00
Renewals and Repairs	28,000.00
General Expenses	20,000.00
Cost of H2SO4	12,000.00
	$220,275.00

This is equal to a cost of 2.75c. per lb. (These figures are based on experience in working the plant).

5 lbs. of butyl alcohol will produce 4 lbs. of methyl ethyl ketone, so that the cost of raw material (butyl alcohol) for producing one lb. of M.E.K. will be 11.09 x 5/4=13.86c. Adding to this 2.75c. (the cost of conversion), the actual first cost of methyl ethyl ketone will be 16.61c. per lb.

CAPITAL, MANAGEMENT AND ROYALTY CHARGES.

Assuming the business to be capitalised at $2,500,000.00.

Interest, 7½% on $2,500,000.00	$187,500.00
Amortisation 10% on $2,500,000.00	250,000.00
Management 1% on $2,500,000.00	25,000.00
Rates and Taxes, including Business Tax	16,000.00
Insurance	13,920.00
Royalties—½ of 1 cent per lb	65,000.00
Yearly charges	$557,420.00

With an output of 13,000,000 lbs. of solvent, this will add 4.29 cents to the first cost of 11.09 cents and 16.61 cents for Acetone and M.E.K. respectively. This fixes a minimum selling price of 15.38 cents for Acetone and 20.9 cents for M.E.K. per lb.

(1) Is the sudden break from 25½* cents per lb. in the United States to 15** cents due to unloading, or will the latter be a normal price?

---

*January price New York.

**March price New York.

(2) What is the prospect of the process being worked in the States?

(3) Can a contract be made with the Imperial Government for Acetone and M.E.K.?

(4) What market is there for Acetone and M.E.K.?

(5) Will the special value of M.E.K. for aeroplane and high class varnish find a market for 4,000 tons?

SUMMARY.

Acetone asked for by the Imperial Government in 15 months		250 tons
Acetone actually delivered in 15 months		1,080 tons
Acetone actually delivered to November 30, 1918		2,830 tons
Rate of yearly output November 11, 1919, Acetone	2,500	
Estimated yearly output of M.E.K., 1919	4,000	
	——	6,500 tons

(No charge being made for Capital and Directorship.)

Actual cost of producing Acetone and Butyl Alcohol during the War	21.372c. per lb.
Cost of producing Acetone and Butyl Alcohol in future	11.09 c. per lb.
Cost of producing M.E.K. in future	16.61 c. per lb.

Cost in future including Capital and Directorship charges:

Acetone	15.09 c. per lb.
M.E.K.	20.61 c. per lb.

Canada produced 78 per cent. of the Acetone made in the British Empire, of which the British Acetones produced 75 per cent.

Actual Acetone output during the War by the British Acetones, Toronto:

58 PER CENT. OF OUTPUT OF BRITISH EMPIRE.

GENERAL REVIEW OF OPERATIONS, EXPENDITURES AND RESULTS.

The success achieved by the British Acetones Toronto, Limited, has been due to the methods adopted. These may be summarised under the following heads:

(1) MANAGEMENT.

MANAGEMENT—The excellent results obtained at Toronto are evidence on this point. It is perhaps well to emphasize three features of importance:

(1) Almost entire freedom of initiative was allowed to every man holding a responsible post, so long as he worked hard, showed results, and was amenable to suggestion.

(2) The happy combination of capable business control and highly trained specialists.

(3) Realisation that the firing line began right inside the Works.

It should be mentioned that the heads of four departments were graduates of the Toronto University, of which Colonel Gooderham is a Governor. Captain A. E. Gooderham, who was entirely in charge in the absence of the Managing Director, undertook the general management of the Works and offices. J. H. Parkin, B.A.Sc., M.E. Assoc. Mem. Am. Soc. M.E., released from most of his duties as lecturer on Engineering at the University, was in charge of the mechanical department and designed and arranged details as well as general plant layouts. D. J. Thomson, B.A.Sc., demonstrator in Engineering at the University and instructor at the Toronto Technical School, handled the electrical work, and W. Charles Collett, B.A.Sc., took charge of all building operations. The sectional reports written by them testify to their knowledge, ability and thoroughness.

The University of Toronto laid the foundations for much of the success of the British Acetones, Toronto, in training these gentlemen.

(2) METHODS.

These can be classed under four heads:

PROCESS METHODS—*Methods in relation to the processes.*

Whilst very full knowledge of the chemical questions arising in the Weizmann process was supplied by the chemists who were sent out from England, the mechanical arrangements for working the process were changed from the English system of discontinuous to an almost continuous system, and in this matter the very large experience of the writer on similar change of methods in various industries enabled a system of working to be accomplished, which was characterised by two main features, continuity and a positive action. These are fully dealt with in the accompanying report.

CONTROL METHODS—*Methods applied to systems of management and control.*

These are fully explained in the reports by the chemists in charge of the operations in their departments. The Fermentation Department, under the control of Mr. Speakman, offered a particularly good field for systematic working, and a careful investigation will show this to be a model for work of a similar kind. Another excellent example of systematic management and record was in connection with the Electrical Department under Mr. Thomson.

METHODS IN RELATION TO LABOUR—*Methods in connection with the workers.*

Employment of Women—Mrs. Bowes, a lady well qualified for the post of matron, secured the services of a staff of 40 workers, nearly all of whom were of good social position, and proved to be a body of extremely capable and conscientious workers. It was particularly noticeable that the effect of having refined women in the Fermentation and Distillation Departments tended to elevate the whole tone of the Works.

Men—Wages have been rising (see appended sheet), with the increased cost of living, but the men have earned their money well. The provision of excellent lavatories, lockers, baths and rest rooms, enabled good men to be secured and retained. Four hundred men were regularly employed.

DAY OF REST—*The Day of Rest.*

Colonel Gooderham overruled the wishes of the heads of the departments in regard to a seven-day week, and adopted the six days of continuous work, closing down everything possible at 12 o'clock Saturday night till 12 o'clock Sunday night. As time went on, the wisdom of this policy was shown, for it enabled all the workers to remain fresh and keen, and the stopping period was afterwards found to be of vital importance as giving an opportunity for thorough cleansing and sterilisation. The record of the last continuous run of 3,480 fermenters dealing with 1,300 tons of mash daily, without the loss of a single fermenter charge, is unquestionably due to the good results arising from the Sunday stoppage of work.

GENERAL REVIEW OF CONSTRUCTION.

Reference to blue print No. 416, forming part of the Architect's report on Building Operations, will show that the ground area of the premises originally offered by Messrs. Gooderham & Worts, and occupied by the British Acetones, Toronto, Limited, amounted to 31,060 square feet, whilst 178,500 square feet additional ground space was being used by the Company on November 11th, 1918. Thus it will be seen nearly seven times the ground space was being used as that originally offered (see Architect's report).

Complete information on all details of construction and operation will be found in the reports previously presented on July 14th, 1917; September 15th, 1917; February 1st, 1917, and in the four sectional reports accompanying this dated January 31st, 1919.

ACETONE PLANT.

Particulars are given in a sectional report as to the extension of the plant by the provision of further fermenters and the general arrangements made for raising the output from a rate of 1,000 tons, as mentioned in the report of July 14th, 1917, to 2,500 tons per year.

Total expenditure, $407,742.36.

METHYL ETHYL KETONE PLANT.

A large expenditure has been incurred in connection with the Methyl Ethyl Ketone plant, and it was from one point of view unfortunate that it had only just commenced operations when the Works were closed down. The plant was already proving itself a success. Ten tons of rectified M.E.K. had been produced. The reports on the M.E.K. and electrical equipment give complete information on construction and operation.

Total expenditure, $695,436.09.

Letter Handed With Report to Mr. W. Noble Pirrie—The following extracts are from a letter, dated September 26th, 1917 by the writer to Mr. Pirrie, which accompanied the original M.E.K report:

"Some attention has been given to the construction of a tub evaporator for the concentration of the sulphuric acid, but this method has been rejected for the present owing to the impossibility of getting lead lined steel tubes in reasonable time, and the uncertainty as to the life of the lead lining.

"The tower concentrator, though bulky and costly, is a safe method of dealing with this part of the problem and should be installed.

"The Catalysers are of new construction designed on the lines I have laid down, as the most efficient means of obtaining as far as possible, the flow of heat from the metal to the catalyst and then into the gas. Considerable difficulty has been met with in getting the General Electric Company to quote and undertake the construction of the Nichrome heating installation. They will take at least 5 months to fill the order, and therefore, if this method of supplying the heat is finally adopted, we may construct the heaters ourselves with a saving in time of several months.

"Meanwhile, further attention is being given to a different form of catalyser heated by oil fuel. An experimental apparatus is being constructed and if successful, the catalyser can be made at greatly reduced cost and in less than three months. If this can be done, it will be possible to reduce the installation period to three months, overtime on the lead still and a few other parts will be necessary, but I should not expect the increase of cost over the estimates to exceed $8,000."

NEW APPARATUS—In this letter a new method of Sulphuric Acid Recovery and two new systems (a) and (b) of catalysing were referred to, the system (a) being adopted, having been tested on a large experimental scale and found to work. The other systems for acid recovery and catalysing have been followed up so far as was consistent with the urgent need for actually getting to work without delay with known types of apparatus. Had work continued, both had been developed sufficiently to have been in actual use by January 1st, 1919.

NEW CATALYSER SYSTEMS.

CATALYSER SYSTEMS (a) AND (b)—The Catalyser system (a) now installed (see M.E.K. report), supplied heat partly to the gas and partly to the catalyst. This system is an improved form of the ordinary catalysing tube. All such systems, however, are defective because of the constant danger of polymerisation or decomposition in the hot film on the heat transmitting walls. For this reason the general temperature of the gas has to be kept much below the point of maximum efficiency. Even then it seems probable that the evil effect of the action taking place in the hot film has much to do with poisoning the catalyst, and it was partly for this reason that whilst this system of catalysing was used because at any rate it would give practical results, the second system of catalysing was followed up because it is free of this defect.

Under the second system (b), the fact is utilised that between the high safe limit and lowest effective conversion limit of temperature, there is a margin of probably 78° to 150° F. The gas is heated to the high limit and passed through the catalyst, leaving at the low limit. This action is repeated from four to eight times according to the properties of the gas until conversion is completed. The heating agent is superheated steam, which is never allowed to have a temperature in excess of the high safe limit of temperature of the gas. The gas is heated by the steam in a Shaw Jolt Tube, to within 50° F. or less in some cases of the steam temperature. The real gain by the apparatus cannot be determined except in actual work, but it is safe to state that this system might be expected to provide the operating staff with a far more easily controlled and efficient apparatus than is possible under the (a) system.

The heat is provided by taking steam at say 120 lbs. pressure from the main, passing it through coiled pipes in an oil-heated furnace, when it is superheated to the ascertained safe high limit of temperature, say 900° F., then through a Jolt tube where it supplies heat to the gas, subsequently through another coiled pipe in the furnace where it is further heated, and so on. The plans (which are not complete owing to stoppage), give a good idea of the layout—see Drawings A325, A318, A301, A291, B338, B337, B342, C332, C289. The scheme being to pass steam at 120 lbs. through the six sets of heaters and jolt tubes in series, using up say 10 lbs. pressure on each, thus completing the 1st stage catalyser. Then leaving at 60 lbs., the steam passes through another set of interchangers and catalysers for the third stage of say four sets of units losing 10 lbs. in each again to finally exhaust into a low pressure system and be available for other steam uses in the Works.

The heating coils are in the second set of flues heated by the gas coming from the first set of flues of the oil furnace, the lower temperature required for the third stage admitting the use of lower temperature heating gases.

The catalysers are arranged five in series and then two in parallel, so that extra time is allowed to complete the reaction in the last stage.

Features of this second catalytic system are:

(1) Reduced cost of plant.
(2) Wrought metal non-porous catalysers.
(3) Exact control of gas temperatures.
(4) Prevention of decomposition and polymerising effect.
(5) Catalysing vessels of any convenient size.
(6) Rapidity of changing catalyst.
(7) Safety-superheated steam is all that can leak into the gases.
(8) A catalyser charged for use is heated by a flow of superheated steam.
(9) General convenience and minimum cost of working.

DETAILS OF EXPENDITURE.

(1) First and Third Stage Catalysers.
(2) Electrical Equipment.
(3) Second Stage, Sulphating Process.
(4) Rectifying Stills.
(5) Acid Recovery.
(6) Miscellaneous.
(7) Buildings.

CATALYSER COST.

COST CATALYSER SYSTEM (a)—Reference to the original report on the M.E.K., dated September 15th, 1917, will show that an estimate was made providing for four 4 ft. catalysers and one 6 ft. costing altogether $6,000. This set was capable of dealing with 50 gallons per hour No. 1 stage; while for the No. 3 stage provision was made for six 6 ft. catalysers, costing $7,200—thus a total cost was allowed for of $13,200 for a 50 gallon plant, $39,600 for a 150 gallon plant, and the cost at this rate would be $66,000 for a 250 gallon plant.

Reference to the M.E.K. report (J. H. Parkin) will show that a total of fifty-four 2 ft. catalysers would have been sufficient to do the work of both first and third stages. From the known lifetime of the catalyst, it is probable that six spare catalysers would have been sufficient to keep the full number in operation. Of the catalysers paid for, about forty would have been found fit for use. Thus twenty more would have been required. If the bronze had still been used, the cost for the remaining catalysers (if purchased from the Delta Company) would have been $17,000. The total cost of the catalysers when operations were stopped was $61,636.17, so that the total would have been raised to $78,636.17 if the plant had been completed.

Cost Catalyser System (b)—When work stopped the expenditure on this system amounted to $5,506.53 for catalyser furnaces, piping, etc. The installation would have been finished in about three weeks at a total cost of less than $6,400.00. A complete installation with oil burning furnaces on this system for first and third stages for 250 gallons per hour could have been installed for $35,000.00. This shows a considerable reduction of cost as compared with the (a) system.

ELECTRICAL EQUIPMENT.

The sectional report on the Electric Installation shows that the electrical equipment of thirty-six 24" catalysers for 150 gallon plant with transformers cost $25,678.64 to November 11, 1918, whilst $3,494.00 would be required for completion, making a total of $29,172.64.

The original report (see M.E.K. report September 15, 1917) estimated the electrical equipment necessary for the 150 gallon plant for twenty-one 72" catalysers and twelve 48" catalysers at $103,920.00.

It was found advisable to make shorter catalysers, and by the improved methods of working adopted the total catalyser length has been cut down from 172 ft. to 72 ft. for the same output.

The chief reason for the reduction has, however, been that instead of placing the work in the hands of the General Electric Company, it was left to Mr. D. J. Thomson who designed and installed the whole equipment for this greatly reduced figure. In addition, his staff of men constructed the heaters and fitted out the whole installation in the most satisfactory manner.

Mr. Thomson's estimate for completing the equipment as a permanent layout with automatic controls is $23,975.47.

The total cost of the electrical equipment for a 250 gallon plant will be $53,148.11.

At the rate of estimate made by the General Electric Company, the cost would have been $173,200 without fixing or wiring.

SECOND STAGE SULPHATING EQUIPMENT.

The report on the proposed M.E.K. plant included the sum of $49,000, being Badger's estimate of the probable cost of the plant needed for carrying out the second stage of the M.E.K. process. After the authorization had been received for the construction of the plant, Badgers raised their estimate to $86,000, stating that they had not been sufficiently informed as to the exact nature of the operation which was necessary, and that they found it absolutely essential that increased provision in some cases and new provisions in others should be made in order to ensure the success of the plant. Bearing in mind the novelty of some of the operations, it is satisfactory to note that the plant as provided answered its purpose completely.

Mr. H. M. Perry closed the contract with Badgers for $72,000, to which amount was subsequently added another $9,000 for further provisions in connection with the scrubbing system. It will thus be seen that the total cost of this part of the equipment was $81,000. Further items which added to the cost of this part of the equipment amounting to $22,406, covering labour, lead, butylene storage tank, and valves, with a further sum of $4,621.43 for various smaller items, raised the total cost of this part of the equipment to $107,621.42, an increase of $58,621.43 over the original estimate.

RECTIFYING STILLS.

It was found necessary to provide two stills not allowed for in the original estimate at a cost of $49,172.00, and the erection of a new Still House with provision for three stills at a cost of $24,549.85.

SULPHURIC ACID RECOVERY PLANT COST.

Cost Acid Recovery Tower System—The original estimate provided for an expenditure of $60,000 for two 30-ton acid concentrating towers, equal to the demand caused by the 150 gallon plant. Assuming the cost to be pro rata, the 250 gallon plant would have raised the cost for acid recovery plant to $100,000. The costs which have actually been incurred for the sulphuric acid plant are $66,307.87. It must be pointed out that these towers are only capable of dealing with about 60 per cent. of the acid concentration required for the enlarged plant. It will be seen from the M.E.K. report (J. H. Parkin) that the interior passages in towers were showing signs of disintegration, and the use of the Shaw Heat Interchanger system is referred to. It is of interest to note here that in the original M.E.K. report, mention was made of research work on the lines of the writer's "film" evaporators for the concentration of the sulphuric acid, and that this had been put on one side owing to certain difficulties. Reference to this matter is also made elsewhere in the report.

The accompanying report on Heat Interchangers shows how the difficulties have been overcome, and that a practical acid concentrator on these lines has been constructed. The evidence of the tests indicates that this method would have been adopted in connection with the plant, and that the whole of the weak acid could have been concentrated to 50% strength by this means. This would have enabled the towers to deal with the whole of the acid required from the 50% stage, and at the same time would have removed the cause of trouble which was destroying the inside lining. The cost of the interchanger system would not have exceeded $5,000, making the total cost $71,307.87.

MISCELLANEOUS.

This item covers the cost of all the smaller items of the plant, pumps, compressors, tanks, interchangers and labour, including all the work and apparatus of which the need was not foreseen when the original estimates were compiled. In this section $30,817.03 was allowed for the 150 gallon plant. Pro rata this would have been $51,361.72 for the 250 gallon plant, but it actually amounted to $142,113.18.

BUILDINGS AND FOUNDATIONS.

The cost of this section was $109,253.01 instead of $32,423.49 and $54,039.09 for the 150 and 250 gallon plants. This item includes plant foundations, a new still house, transformer house, etc., not previously estimated for.

SUMMARY OF THE M.E.K. PLANT COSTS.

Provision was made in the original M.E.K. report for an expenditure of $315,156.52 on equipment and buildings.

The capacity of the plant installed was raised to 250 gallons per hour, so that not only the new production of Butyl Alcohol could be converted, but that the stock of more than 1,000 tons could be gradually dealt with.

The total expenditure up to November 11th, 1918, was $587,673.93. The completion of the plant would have increased this item by $47,478.00 to $639,099.08.

The enlargement of the plant by 60% would have entailed a total increase in expenditure of 102%.

ACETONE, BUTYL ALCOHOL AND METHYL ETHYL KETONE PLANT COSTS TO NOVEMBER 11TH, 1918.

Total Cost of Plant and Equipment, Alterations to Buildings, etc. and Starting Operations	$1,103,178.45
Equipment, Expenditure on the Fermentation and Distillation Plant for producing Acetone and Butyl Alcohol	$407,742.36
M.E.K. Costs	695,436.09
	$1,103,178.45

	Estimate for 150 gallon plant	Pro Rata Cost for 250 gallon plant	Actual Cost to complete plant 250 gal. capacity
Electric Catalysers	$39,000.00	$66,000.00	$78,636.17
Electrical Equipment excluding erection and wiring	103,920.00	173,200.00	53,148.11
Sulphating Equipment Badger contract	49,000.00	81,667.00	107,621.42
Rectifying Stills	....	....	24,549.85
Acid Recovery	60,000.00	100,000.00	71,307.87
Miscellaneous — Tanks, Compressors, etc.	30,817.03	51,361.72	142,113.18

BRITISH ACETONES TORONTO, LIMITED

Buildings and Equipment foundation	32,423.49	54,039.09	109,253.01
Total Installation Cost to date			$586,629.61
Estimated Cost of completing the plant			49,469.47
	$315,156.52	$526,267.81	$636,099.08

Butyl Alcohol used on experiments	$96,349.14
Sulphuric Acid used on starting	11,413.02
Cost of starting plant	$107,762.16

SCHEDULE AS TO RATE OF WAGES OF WORKMEN BEFORE AND DURING THE WAR.

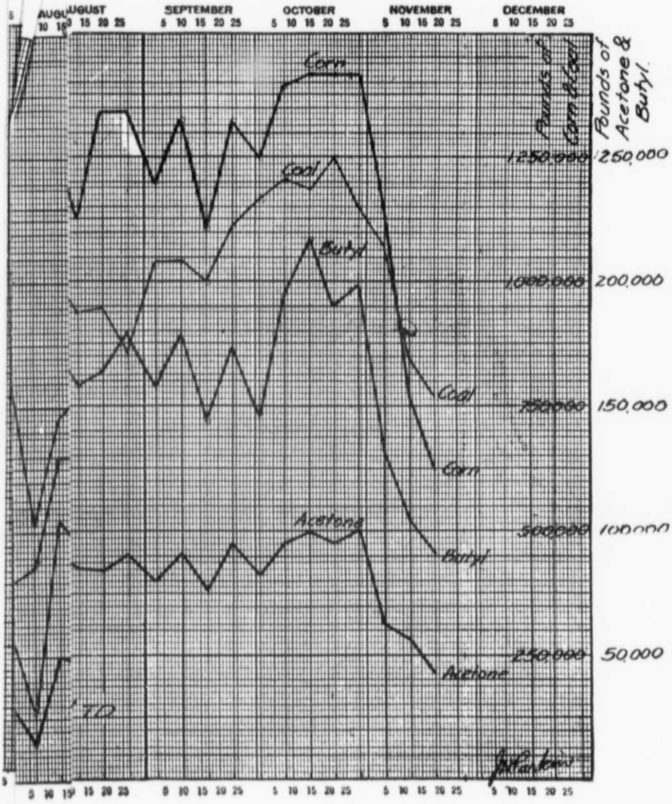
TORONTO.

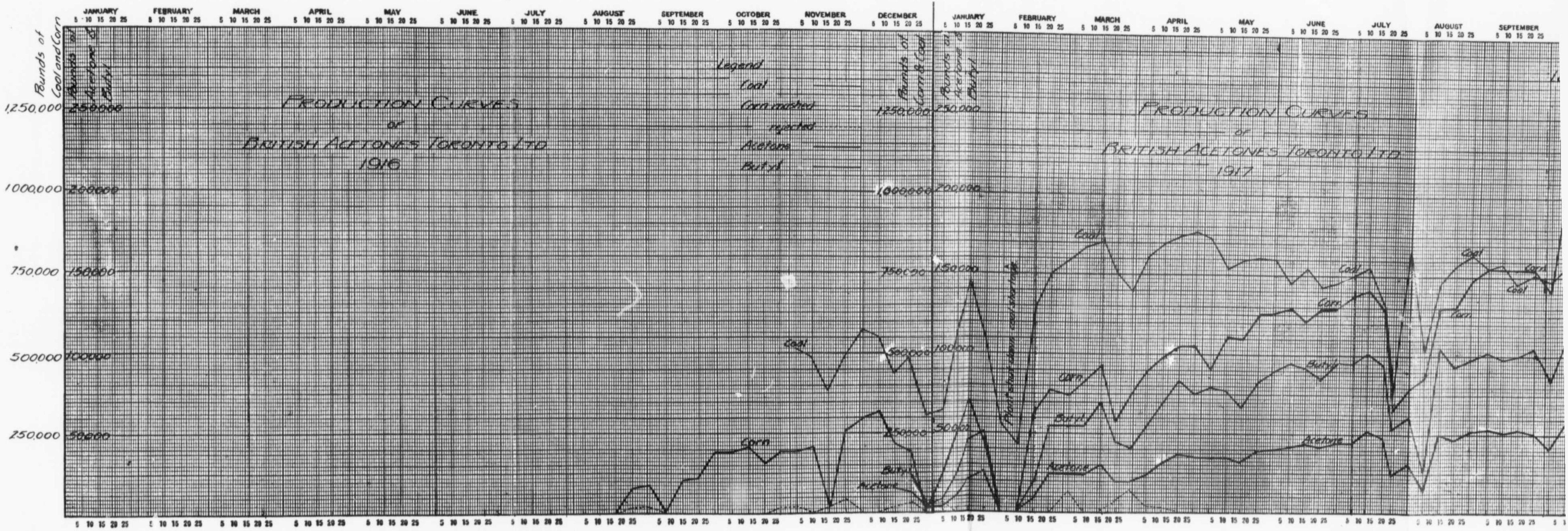
	June	June	June	June	June	Nov. 11
	1914	1915	1916	1917	1918	1918
Trades.	Hr.	Hr.	Hr.	Hr.	Hr.	Hr.
Steamfitters	45c	50c	50c	50c	65c	65c
Carpenters	45	45	47½	50	60	60
Machinists	40	45	50	55	65	65
Bricklayers	55	55	60	62½	67½	72
Electricians	45	50	50	55	55	67½
Painters	35	35	35	45	50	50
Boilermakers	45	50	50	55	55	55
Coppersmiths	45	60	70	70	80	$1.00
Tinsmiths	40	50	50	60	65	65
Blacksmiths	45	50	50	50	60	60
Labor	30-33	33 1/3-40		40	50	

Firemen $18.00 per week, gradually increased to $27.00, foremen, $28.00
Engineers $20.00 per week, gradually increased to $33.00, foremen, $40.00

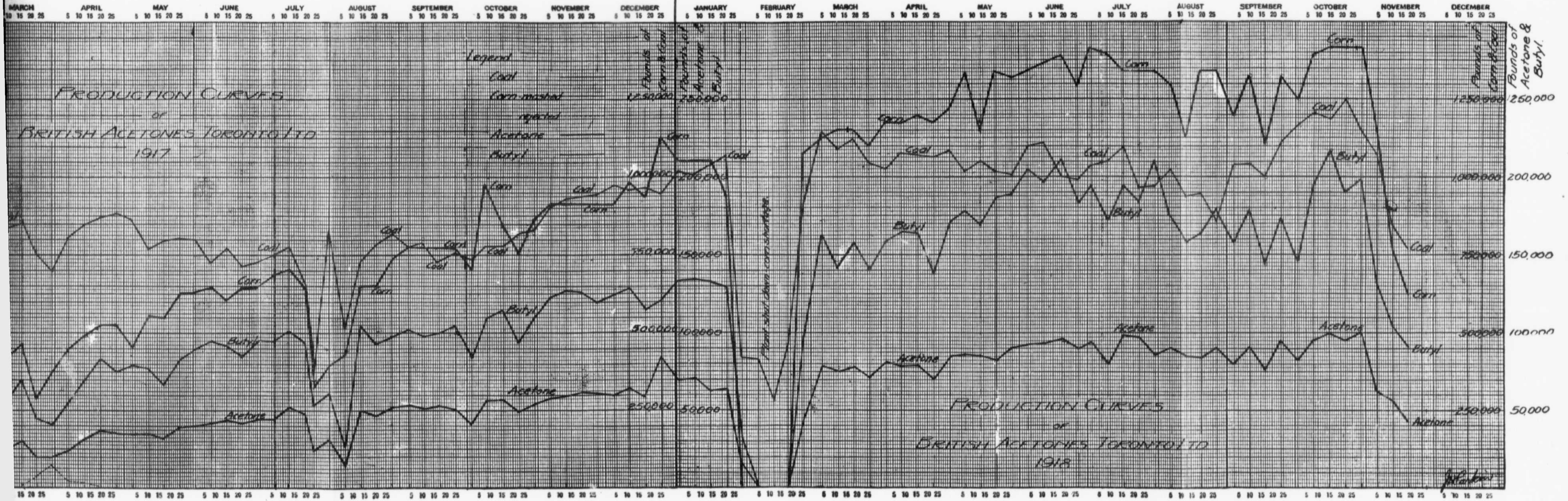
E. Metcalfe Shaw,
Engineer-in-Chief.

r. 11
18
r.
5c
7½
0
0



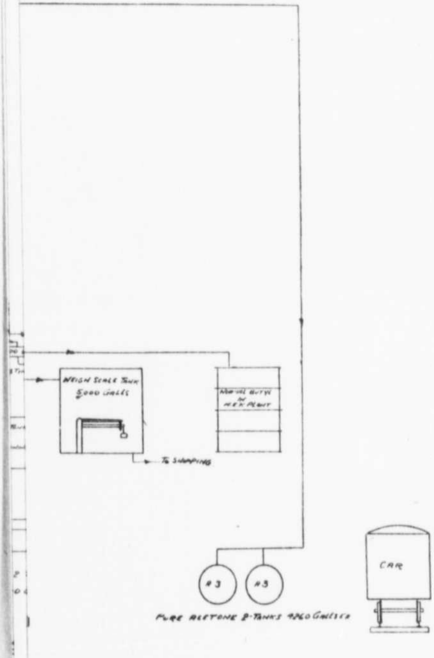


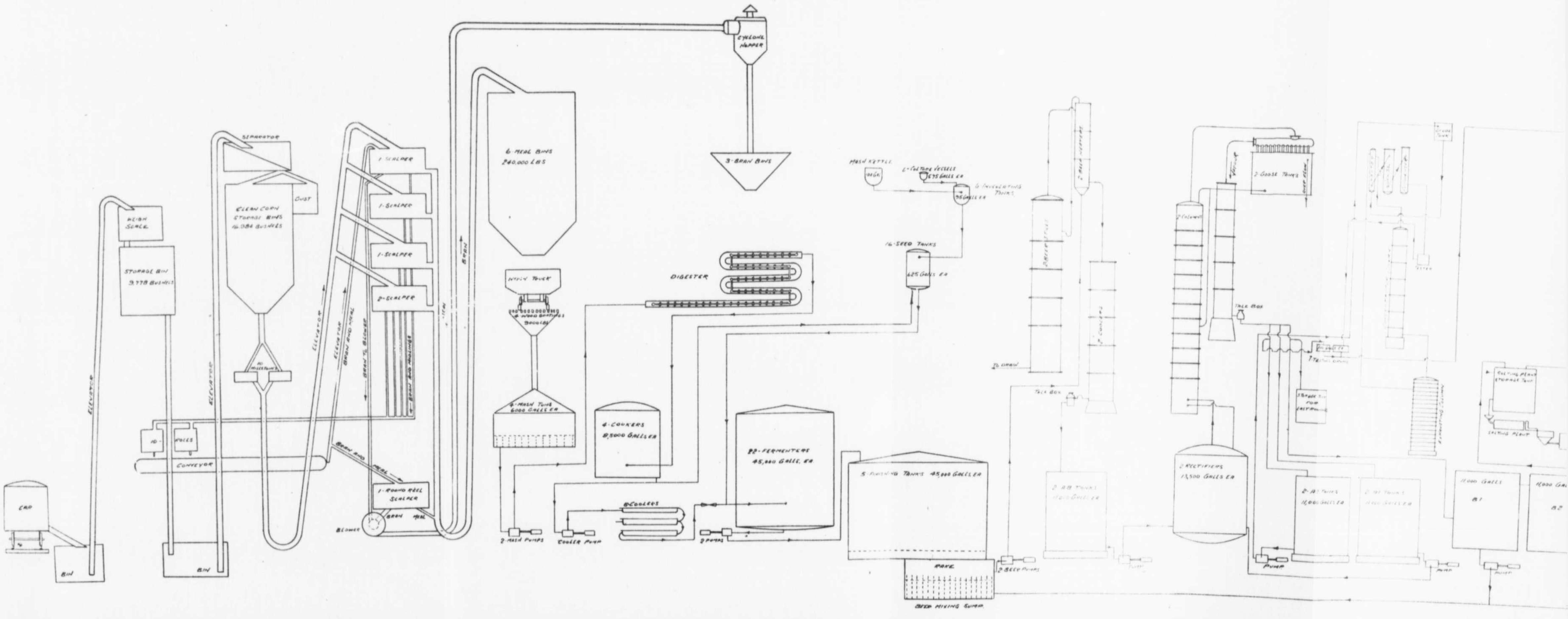
PRODUCTION CURVES
OF
BRITISH ACETONES TORONTO LTD
1916
PRODUCTION CURVES
OF
BRITISH ACETONES TORONTO LTD
1917
Legend
Coal
Corn mashed
rejected
Acetone
Butyl
Pounds of Coal and Corn
Pounds of Acetone & Butyl
Pounds of Corn & Coal
Pounds of Acetone & Butyl
1,250,000
250,000
1000,000
200,000
750,000
150,000
500000
100,000
250,000
50,000
1250,000
250,000
1000,000
200,000
750,000
150,000
500,000
100,000
250,000
50,000
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
5 10 15 20 25
Coal
Corn
Butyl
Acetone
Coal
Corn
Butyl
Acetone
Plant shut down coal shortage
Coal
Corn
Butyl
Acetone
Coal
Corn
Coal
Corn
Coal


PRODUCTION CURVES
of
BRITISH ACETONES TORONTO LTD
1917
Legend
Coal
Corn mashed
rejected
Acetone
Butyl
Pounds of Corn & Coal
Pounds of Acetone & Butyl
1,250,000
250,000
1,000,000
200,000
750,000
150,000
500,000
100,000
250,000
50,000
Plant shut down corn shortage
PRODUCTION CURVES
of
BRITISH ACETONES TORONTO LTD
1918
Pounds of Corn & Coal
Pounds of Acetone & Butyl.
1250,000
250,000
1,000,000
200,000
750,000
150,000
500,000
100,000
250,000
50,000
Corn
Coal
Butyl
Acetone
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
5 10 15 20 25

BRITISH ACETONES, TORONTO LIMITED
ENGINEERING DEPARTMENT
TITLE FLOW DIAGRAM
TORONTO ACETONE PLANT

SCALE 1/8 Ins. – 1 Ft.
Drawn by ______ Date APRIL 17th 1919
Traced by F.H.
Appr'd by ______
Appr'd by ______ ENG. IN CHGE
Dwg. No. 376

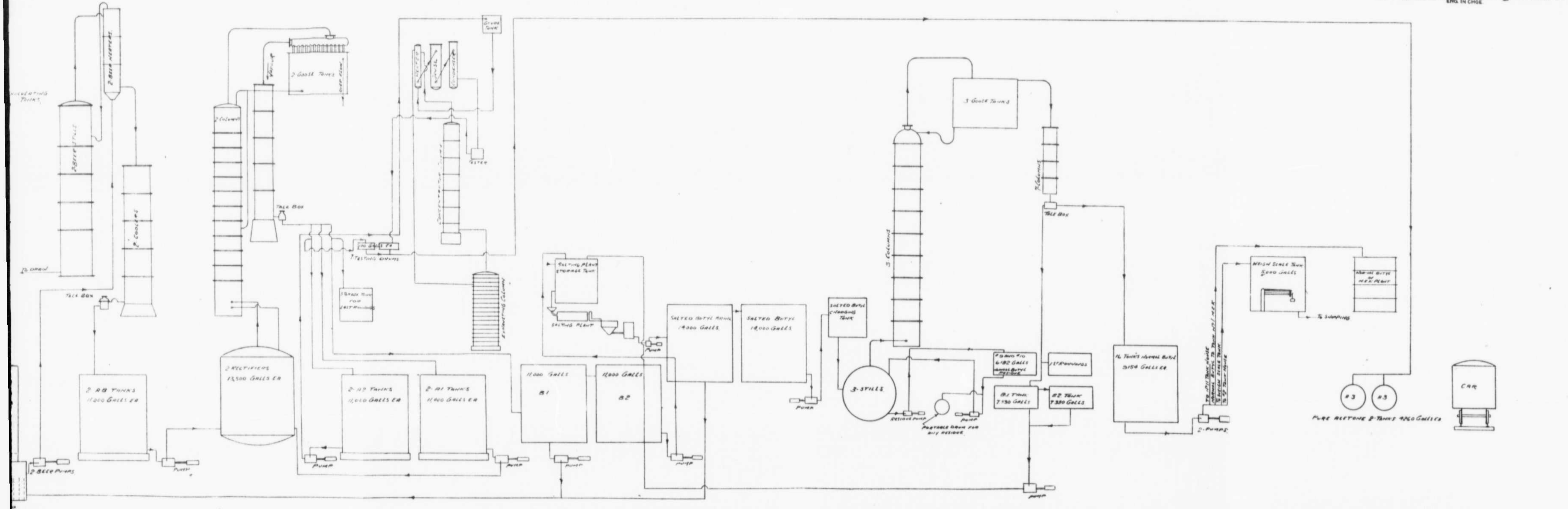


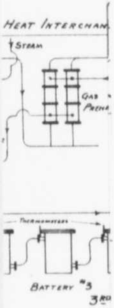

CAR
BIN
ELEVATOR
WEIGH SCALE
STORAGE BIN 3,778 BUSHELS
BIN
ELEVATOR
SEPARATOR
DUST
CLEAN CORN STORAGE BINS 16,384 BUSHELS
10 MILLSTONES
10 - ROLLS
CONVEYOR
ELEVATOR
ELEVATOR
BRAN AND MEAL
BRAN TO BLOWER
BRAN AND MIDLINGS
1-SCALPER
1-SCALPER
1-SCALPER
2-SCALPER
BRAN AND MEAL
1-ROUND REEL SCALPER
BRAN
MEAL
BLOWER
MEAL
BRAN
6-MEAL BINS 240,000 LBS
CYCLONE HOPPER
3-BRAN BINS
WEIGH TRUCK
4 WEIGH BOTTOMS 3000 LBS
4-MASH TUBS 6000 GALLS EA
2 MASH PUMPS
4-COOKERS 8,5000 GALLS EA
DIGESTER
8-COOLERS
COOLER PUMP
2 PUMPS
22-FERMENTERS 45,000 GALLS. EA
MASH KETTLE
100 GAL
6-CULTURE VESSELS 575 GALLS EA
6 INOCULATING TANKS
35 GALLS EA
16-SEED TANKS
625 GALLS EA
5-FINISHING TANKS 45,000 GALLS EA
RAKE
BEER MIXING SUMP
2 BEER PUMPS
2 BEER STILLS
2 BEER HEATERS
TO DRAIN
TALE BOX
2 COOLERS
2 AB TANKS
PUMP
2 COLUMNS
VAPOUR
2 GOOSE TANKS
OVER FLOW
TALE BOX
2 RECTIFIERS 13,500 GALLS EA
PUMP
7 TESTING DRUMS
STORAGE TANK FOR LAST RUNNINGS
2-A1 TANKS 11,000 GALLS EA
2-A1 TANKS
PUMP
FILTER
SALTING PLANT STORAGE TANK
SALTING PLANT
11,000 GALLS
B1
PUMP
11,000 GA
B2

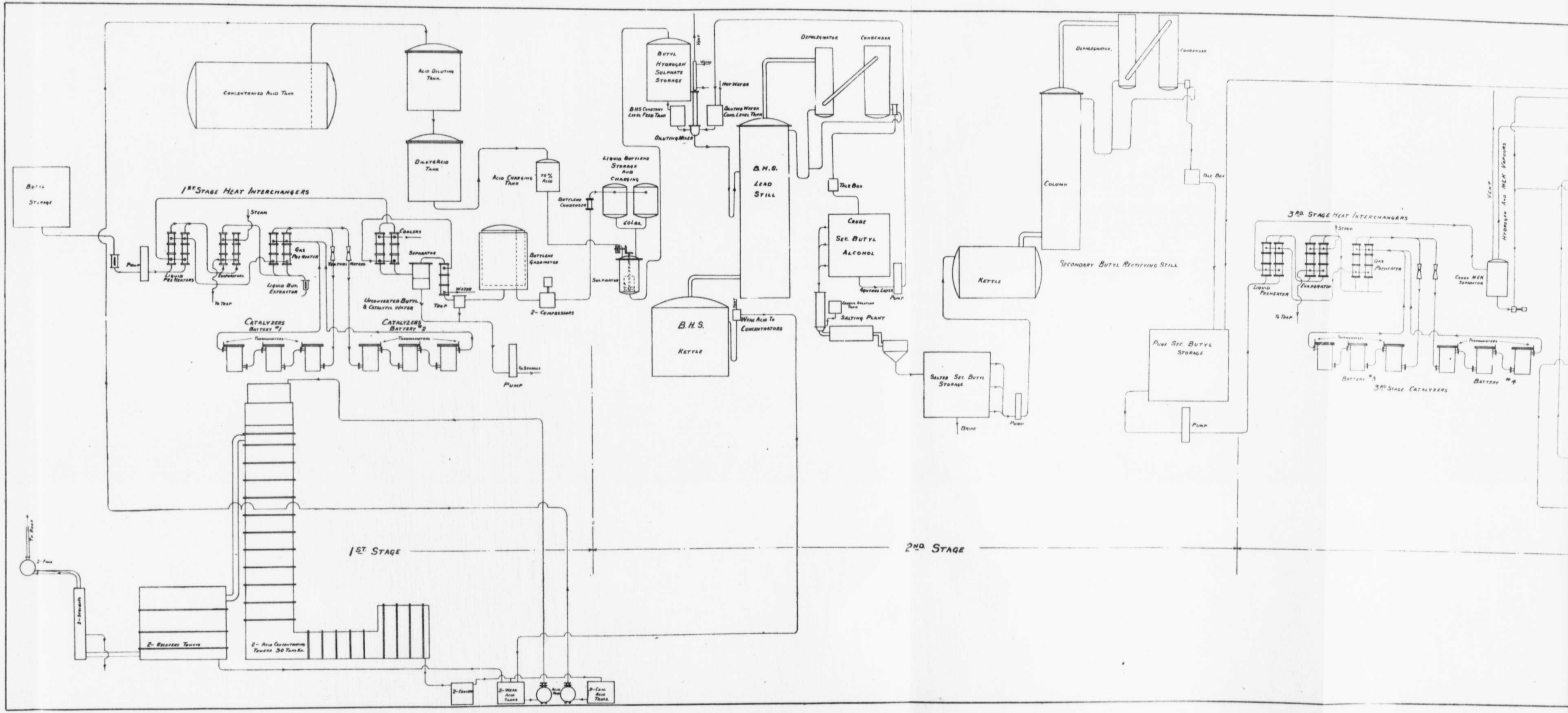
BRITISH ACETONES, TORONTO LIMITED
ENGINEERING DEPARTMENT

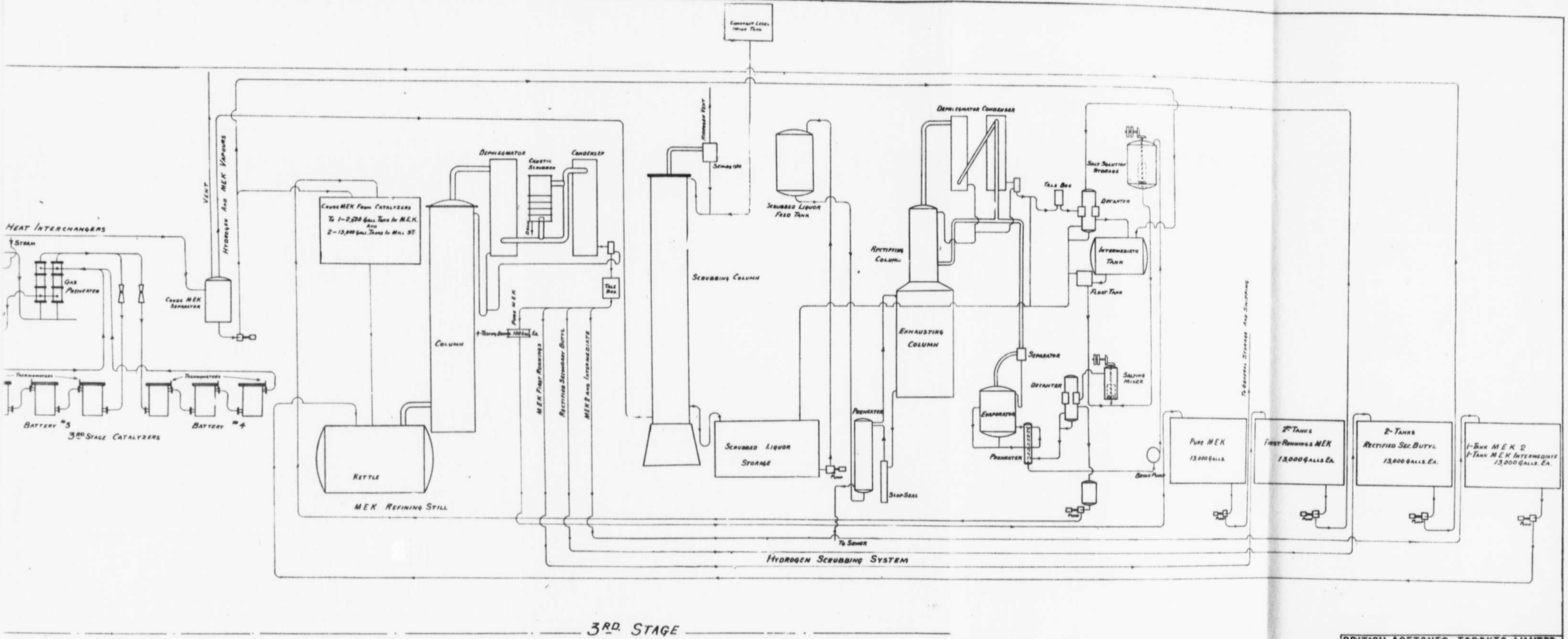
TITLE FLOW DIAGRAM
TORONTO ACETONE PLANT

SCALE 1/8 Ins. – 1 Ft.
Drawn by
Date APRIL 17th 1919
Traced by F.K.
Appr'd by
Appr'd by
ENG. IN CHGE
Dwg. No. 376




HEAT INTERCHAN
STEAM
GAS
PREHE
THERMOMETERS
BATTERY #3
3RD


Concentrated Acid Tank
Acid Diluting Tank
Dilute Acid Tank
Butyl Storage
1st Stage Heat Interchangers
Steam
Pump
Liquid Pre Heaters
Evaporators
To Trap
Gas Pre Heater
Liquid But. Extractor
Venturi Meters
Coolers
Separator
Water
Unconverted Butyl & Catalytic Water
Trap
Catalyzers Battery #1
Thermometers
Catalyzers Battery #2
Thermometers
Pump
To Storage
Acid Charging Tank
75% Acid
Butylene Gasometer
2- Compressors
Butylene Condenser
Liquid Butylene Storage and Charging
60 Lbs.
Sulphator
Butyl Hydrogen Sulphate Storage
Vent
Water
Hot Water
BHS Constant Level Feed Tank
Diluting Water Const. Level Tank
Diluting Mixer
B.H.S. Lead Still
B.H.S. Kettle
Vent
Weak Acid To Concentrators
Dephlegmator
Condenser
Tale Box
Crude Sec. Butyl Alcohol
Aqueous Layer
Pump
Caustic Solution Tank
Salting Plant
Salted Sec. Butyl Storage
Brine
Pump
Column
Dephlegmator.
Condenser
Kettle
Secondary Butyl Rectifying Still
Tale Box
Pure Sec. Butyl Storage
Pump
3rd Stage Heat Interchangers
Steam
Liquid Preheater
Evaporator
Gas Preheater
To Trap
Thermometers
Battery #3
3rd Stage Catalyzers
Battery #4
Crude MEK Separator
Vent
Hydrogen and MEK Vapours
To Roof
2- Fans
2- Scrubbers
2- Recovery Towers
2- Acid Concentrating Towers 30 Tons Ea.
1st Stage
2nd Stage
2- Coolers
2- Weak Acid Tanks
Acid Pumps
2- Con. Acid Tanks



BRITISH ACETONES, TORONTO LIMITED
ENGINEERING DEPARTMENT
TITLE Flow Diagram
Toronto M E K Plant

SCALE ⅛ Ins. – 1 Ft.
Drawn by S.S.T. Date Nov. 27th 1918
Traced by S.S.T.
Appr'd by J.H. Parkin
Appr'd by H.M. Shaw for Chf Eng. in Charge Dwg. No. 377