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SEWAGE TREATMENT BY AERATION AND ACTIVATION*

THE AUTHOR TRACES THE DEVELOPMENT OF THE PROCESS—GIVES DETAILS OF CONSTRUCTION AND LAYOUT OF THE BROOKLYN SEWAGE EXPERIMENT STATION.

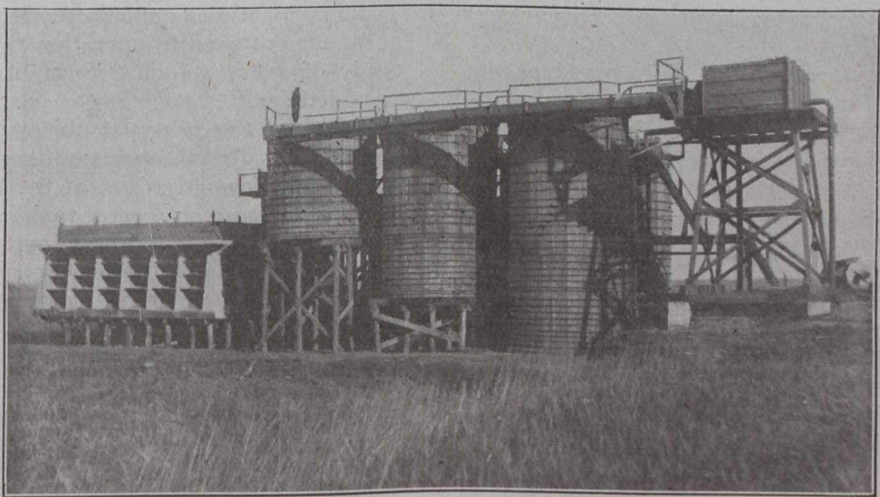
By GEORGE T. HAMMOND,

Engineer in Charge of the Sewage Experiment Station, Bureau of Sewers, Borough of Brooklyn, N.Y.

(Abstract prepared by the author for *The Canadian Engineer.*)

BY far the most interesting development in methods of treating sewage brought forward in recent years is that known as activated sludge, a name invented by Dr. Gilbert Fowler, of Manchester, England, to describe a process which, although as yet within the range of study and experimentation, has already taken its' place among approved methods of sewage treatment, and promises possibly, to occupy the entire field, if the problems connected with it can be solved by a more extensive general experience in its application. It is admitted that there are still many things to be learned about it, and difficulties to be overcome; but it may be said justly, that it gives at present great promise.

It is the purpose of this paper to present, from an engineer's standpoint, a general review of the subject, and point out the progress made up to this time, in a broad manner, so as to invite discussion by our sanitary engineers, and especially those who have been studying its special details.



View from North, Showing Imhoff Tank, Aerating Tank, Etc., at Brooklyn Sewage Experiment Station.

The essential feature of the so-called "activated sludge" process of sewage purification is the artificial application of well-known natural biological agencies, which, in the presence of an abundant supply of atmospheric oxygen, produce biochemical changes in the organic matter in the sewage, and render the sewage "stable," or incapable of putrefactive changes. This result is obtained by the biological oxidation of the organic impurities which are decomposable. The oxidizing bacteria obtain their food supply and the energy employed in their life processes from the organic material in the sewage which, in the presence of atmospheric oxygen, they rapidly attack and oxidize.

For many years the principal object of sanitary engineers in the design of sewage treatment and disposal plants has been to bring together in the most suitable and efficient manner, the decomposable materials, the oxidizing bacteria, and an abundant air supply for the bacteria.

In America, the Massachusetts State Board of Health was the pioneer, and its work is known throughout the world. In 1890, this board published a special report in which experiments are described which were begun in 1888. This report is generally acknowledged as the starting point from which biological methods of sewage treatment originate.

It can be demonstrated that the biological process of sewage treatment is essentially the same, whether filter beds, sand filters, contact filters, percolating filters, etc., are used, or a tank in which sewage is subjected to compressed air in the presence of activated sludge. This point has been discussed by Mr. O. J. Wilkinson, of Manchester, England, who shows that, aside from the mere added effect of the agitation caused by the air in a filled tank, aeration of sewage in the presence of activated sludge is a reversal of the well-known methods of filtration on bacteria beds.

The real problem is to ascertain the most economical method of applying air to sewage, with maintenance of complete circulation of the activated sludge without any formation of dead banks of material, to reproduce in the tank the changes that occur in a percolating filter bed.

The application of air to sewage has been accomplished by various designs of apparatus, among which should be mentioned the method of employing the flowing stream of sewage entering the tank to compress the air used in the treatment, and apply it while flowing and under pressure. A patent covering this method was granted to Cecil C. E. Beddoes by the U.S. Patent Office, August

*Presented at the annual Convention of the American Society of Municipal Improvements, at Newark, N.J., October 11, 1916.

4, 1908. It is No. 895229. The deep tank of Black and Phelps, developed at Brooklyn, N.Y., provided with trellis baffles set at right angle to the flow, and the tank-aerator with slate colloiders of Clark, at the Lawrence Experimental Station, should be referred to, as well as the activating tank of Dr. Gilbert Fowler, which was, as he has himself freely stated, developed from the experimental work of Clark, seen by him at Lawrence in 1912.

In January, 1910, the Board of Estimate and Apportionment of the city of New York secured the professional services of Colonel (now General) William M. Black, Corps of Engineers, U.S.A., and Professor Earle B. Phelps, Professor of Chemistry, Hygienic Laboratory, U.S. Public Health Service, Washington, D.C., to conduct for the guidance of the municipal authorities, some investigations relative to the problem of sewage treatment and discharge into the local waterways.

In connection with this assignment, Messrs. Black and Phelps began experiments in February, 1910, on sewage treatment by means of forced aeration in tanks, at the Twenty-sixth Ward Sewage Works in Brooklyn.

The apparatus used by Black and Phelps consisted of tanks in which were placed laths made up in frames or trellises, in such manner that the interior space of the tank was practically filled with strips of wood, the surfaces of which were about one inch apart in every direction. These surfaces were made as extensive as possible for the residence of bacterial growths. Compressed air was supplied at the bottom of the tank, which was filled with the sewage to be treated. This plan of treatment gave remarkable results, which were later presented in a report to the Board of Estimate and Apportionment and published in 1911.

These experimenters found it possible to reduce the demand of the sewage for oxygen 33 to 50%, in a retention period of about three hours, by using about two volumes of air per volume of sewage, and to obtain a higher degree of purification by applying more air.

The Black and Phelps experiments were about the earliest that indicated the discovery of a practicable and successful method of treating sewage by compressed air.

Aeration experimental work received a new impetus at the Lawrence Experiment Station in 1911, and it was while visiting this station in 1912, that Dr. Fowler saw the work, which led him to take up the same line of study on his return to England, with Messrs. Ardern and Lockett, the result of which was the activated sludge process. In these studies "it was established that a well-nitrified effluent could be obtained by six hours' aeration of Manchester sewage, in intimate contact with one-fourth of its volume of activated sludge."

Progress with the new method in England has been checked by the war, but studies are being made for several institutions. At Worcester, half of the sewage of the city is under contract to be treated by this method, and at present about 1,000,000 gallons of sewage a day are being treated under this contract, which provides that not more than four parts of suspended matter per 100,000 of sewage shall be present in the effluent, and that it shall be non-putrefactive. These conditions are being successfully complied with.

Following the work at Manchester of Messrs. Ardern and Lockett, the process was successfully tried at Salford on a larger scale, making use of the existing roughing filter beds.

The reports of the English experimenters were received with great interest in America. The writer's attention was called to the paper of Ardern and Lockett by Mr. W. L. Stevenson, of Philadelphia, and by Prof. Earle B. Phelps, late in the fall of 1914. Meanwhile, Mr. H. C. McRae, of Baltimore, had become informed of these reports and had communicated them to Mr. Leslie C. Frank, of the U.S. Public Health Service. At about the same time, Mr. T. Chalkley Hatton, chief engineer, Milwaukee, Wis, Sewerage Commission, had got into touch with Dr. Fowler and secured his co-operation in conducting experiments at Milwaukee.

The first work of which the writer has knowledge was, however, conducted by Prof. Edward Bartow, at Urbana, Ill., who started his aerating tank November 21, 1914, at Lawrence, Mass. H. W. Clark started an activated sludge tank in February, 1915. Early in March, 1915, experiments were commenced at Baltimore, Milwaukee and Brooklyn; at Chicago, by the sanitary district, in May; at Regina, Saskatchewan, Canada, May 18th; Houston, Texas, began experiments in September.

For the purpose of presenting the progress of the method in this paper, the latest available information has been obtained from nearly all American plants, where it is being studied. Most of these plants have been visited by the writer since the beginning of the present year. Before presenting this data, it may, perhaps, be proper to give an account of the author's aeration and activated sludge work at the Brooklyn, N.Y., Sewage Experiment Station.

By resolution of the Board of Estimate and Apportionment, this station was authorized April 18, 1912. To meet expenses, $50,000 was made available. Before designing the plant, all of the principal sewage disposal plants in America and Europe were visited.

The plant was put into service in the autumn of 1913, and has continued in operation to the present time. The study of every standard form of sewage treatment was provided for.

One of the principal objects in the design was to carry forward to a conclusion the work of Messrs. Phelps and Black, formerly done at the location of this plant. For this purpose an aerator tank and settling tank, following the design used by these investigators, were installed, and a compressor of ample capacity provided. The tank was 12 ft. in diameter and 25 ft. 8 ins. deep. Compressed air was supplied by means of a pipe-grid consisting of ¾-in. iron pipes arranged in five circles, connected by a cross of 1¼-in. pipe, through which air entered. The perforations were on top of the pipe as it lay, and were 1/16-in. holes, 6 ins. on centres. This grid, or grill, was placed on 7½ ins. of broken stone in the bottom of the tank and covered by a like amount of the same broken stone, passing a 2-in. ring, but retained by a 1-in. ring. It has given satisfaction through three years of service, but is beginning to need cleaning at the present time.

One important feature of this tank was the deflector discs, of which there were nine, shaped not unlike wheels, with a trellis work between the spokes. A supporting 4-in. vertical pipe passed through all of the hubs of these discs. The surface of each was horizontal and occupied the entire cross-section of the tank, which was thus formed into story-like compartments communicating through the trellis-work above referred to. They were designed to give a residence to bacterial growths, and to deflect the downward flow of sewage entering at the top of the tank, and to prevent downward streaming, and equalize and give a sinuous motion to the upward flow of air.

The sewage entered this tank from a measuring and quieting tank, and could be studied either on the continuous flow plan, for which it was originally designed, or on the full and draw plan.

The effluent passed to a secondary settling tank, from which it passed to the sewer.

Operation of this unit in 1914, after some preliminary experiments, gave the following result:—

Table 1.—Tank Aerator Operation on Continuous Flow Plan.

Average results for June, July, August and September, 1914.
Part per million, except as otherwise designated)
Period of retention in tank aerator, 24 hours; amount of crude sewage treated in 24 hours, 16,000 gallons; air applied, 2.3 cu. ft. per gallon. Settlement period in tank No. 1, 3 hours 12 minutes.

	Crude Sewage	Tank Aerator	Settling Tank No. 1
Settling matter (c.c. per liter)	2.3	5.4	0.2
Total suspended solids	164.	103.	40.
Volatile suspended solids	130.	79.	30.
Total oxygen consumed	58.	39.	26.
Dissolved oxygen consumed	37.	27.	22.
Total dissolved oxygen	1.4	3.1	1.1
Dissolved oxygen demand	191.	55.	31.
Relative stability (percentage)			
Undiluted	2.	43.	84.
Diluted 1-10 with distilled water	35.	94.	100.

On October 1st, the quantity of air was reduced one-half, and under this condition, the relative stability of the undiluted effluent fell to 59 per cent.

The stability percentage is based on the ratio of available oxygen to oxygen required to produce complete stability at 20° C. in 20 days. The method is that advocated by Prof. Earle B. Phelps.

In March, 1915, some slight changes having been made in the tank, operation was started on the activated sludge method, on the fill and draw plan of operation. The accumulation of sludge was sufficient by the middle of May, but regular operation, under test conditions, was not started until June 1st.

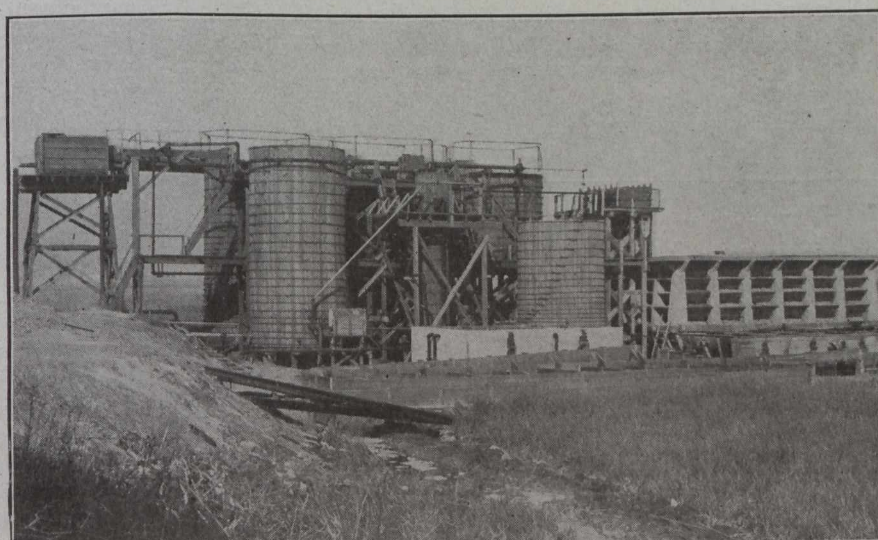
The cycle began with a period of sedimentation of about one hour, during which air was shut off, followed by a period of discharge of 1½ hours. Refilling the tank then began and air was turned on. This continued 1½ hours; aeration was then continued until the cycle began again, a period of aeration of 20 hours. Air was measured by a Venturi meter. Both influent and effluent sewages were measured.

As will be seen by the accompanying Table 2, a good effluent was obtained on the fill and draw method, after 5 hours' aeration, with 7 volumes of air per volume of sewage. This may be compared with the work of the tank aerator in 1914, under the continuous flow method of aeration, in which the activated sludge was not retained in the tank, with about 9 volumes of air and 24 hours' aeration, and also with about 18 volumes of air in the same period of aeration.

Experiments were also successfully made with the continuous flow plan of operation, but the character of the results was about the same as shown by the foregoing table, on an eight-hour retention period. These experiments have not yet been completed and are in progress.

During the present year the object has been to remove the sludge-forming materials from the sewage by means of tanks, or by screening before treatment, and to see if the sludge itself cannot be activated; also, how much it can be reduced by continued aeration. A series of tanks seems necessary for this, and it seems possible to reduce materially the volume of the sludge by aeration, accompanied by a constant removal of free water. This work has been much interrupted by the need of repairs to tanks and power plant, our plant now having been operated three years, and having been only a temporary structure in the beginning. Another year's work will probably be necessary, and extensive repairs, in order that we may complete our activated sludge experiments now projected. We have found that our Riensch-Wurl screens, with the coarse aperture 5/64 of an inch, are too fine to use before activation; probably ⅛ in. would be fine enough, and ¼ in. might be better.

Besides the data obtained at the Brooklyn Sewage Experiment Station, the author has been able to secure recent information from nearly all of the principal plants doing experimental work on activated sludge. The Lawrence, Mass., Experiment Station reports that it is continuing the work originally started several years ago with the Lawrence aerating tank, and is studying activated sludge. Mr. H. W. Clark, chemist and director, states



View from the South. (a) Aerating Tank Used in Activation Experiments; (b) Settling Tank Used in Activation Experiments.

The tank for re-activating sludge is hidden by the aerating tank. In the foreground, are the secondary settling tanks.

that both methods give stable effluents, generally speaking, the Lawrence tank method requiring generally more time but less air, the activated sludge effluent being the clearer of the two. He considers that the governing factors in the success of the activated sludge process are: cost of power for supplying the air, and a sewage that readily yields to the treatment; and concludes that it is not impossible that certain sewages cannot be purified in this manner.

The plant at Cleveland, Ohio, was designed to treat one million gallons of sewage per day, with two hours' aeration of the sewage and about two hours of the settled out sludge, before its return to the entering sewage. The experimental work at this plant, while of great interest, has not yet reached a proper stage for publication. Air is supplied with porous plates, which, the author understands, have been fairly satisfactory. Experiments are being made with aeration for the further reduction of the surplus sludge that seem very promising.

Table 2.—Results of Sewage Aeration in the Presence Activated Sludge on the Fill and Draw Plan.
(Parts per million.)

Month	Crude Sewage	Hours after refill. 0	2	5	20
Suspended solids—					
June	180	35	24	20	14
July	147	21	12	8	14
August	154	24	12	9	6
Dissolved oxygen—					
June	1.0	0.0	0.1	0.4	2.5
July	0.7	0.0	0.0	0.2	1.7
August	0.5	0.0	0.0	0.1	0.9
Relative stability—					
June	...	14.	31.	76.	100.
July	...	11.	34.	84.	100.
August	...	12.	28.	63.	88.
Oxygen demand—					
June	230.	53.	38.	...	7.
July	173.	63.	38.	...	4.
August	211.	53.	34.	...	11.
Nitrite—					
June	...	0.08	0.11	0.49	1.50
July	...	0.01	0.07	0.25	0.53
August	...	0.00	0.07	0.12	0.66
Nitrate—					
June	...	0.10	0.60	1.20	7.30
July	...	0.00	0.10	0.55	2.80
August	...	0.00	0.10	0.55	2.80
Volume of air per volume of sewage		1.17	3.50	7.00	24.55

At Champaign, Ill., a very interesting plant is operating. This plant is under the direction of Prof. Edward Bartow, of Illinois Water Survey.

It will be recalled that Prof. Bartow was the first American to start experiments with activated sludge after the English experiments were published, which he did in November, 1914. The results obtained by him in treating sewage by this method have been very gratifying. The present plant has not been very long in operation—about three months. The dissolved oxygen determinations show from 1 to 9 parts per million, and stability with methylene blue lasting from 5 to 15 days and longer. From 1.5 to 3 cu. ft. of air per gallon has been applied by means of porous plate distributors. The former figure is found to be sufficient. Sludge-drying on Imhoff drying beds has not been a success.

There are two activated sludge plants in Chicago. The first, which is the larger, was installed by the Sanitary District in January of this year. So far, the results have been negative, owing mainly to trouble caused by the porous plates used to diffuse the air. Mr. Langdon Pearce thinks that we should go slow in the adoption of this method. It is not a simple process to operate, but one whose entire limitations are not yet developed. The cost problem is still uncertain, particularly the cost of handling the sludge.

The other Chicago plant is that of Armour and Company, soon to be demolished, as its work is about completed, and a permanent plant of large size is to be installed for the stock yards. This is an experimental plant, having, with an 8-hour retention period, a capacity of 30,000 gallons per day. The sewage treated, derived from the stock yards, carries at different times from 58 to 3,000 parts per million of suspended matter. For air distribution, porous plates were used at first, but gave trouble and were soon abandoned, pipe grids being substituted, which could easily be removed and cleaned, and these have given full satisfaction. The pipes are one-inch galvanized pipe and are perforated with 1/25-inch holes, staggered, two inches apart. Mr. G. L. Noble writes of this plant:—

"We have been operating constantly since last February and feel more surely than ever that activated sludge will probably be the cheapest and most efficient method of sewage disposal for our particular needs. . . . We are now installing an experimental plant at Fort Worth, Texas, to use on our sewage down there. We are still experimenting with dewatering the sludge, concerning which our conclusions are not yet final."

At Chicago, about 25,000 gallons of sludge, 99% water, is produced per million gallons of sewage. This gives about 1¼ tons of dried material containing 4½ to 5 units of ammonia, the value of which gives the sludge a value of $9 to $10 per ton in the dry state.

Perhaps the most interesting as well as the largest activated sludge plant in this country is that located at Milwaukee, Wis. After extensive experiments, in which Dr. Gilbert Fowler, of Manchester, England, co-operated, this plant was constructed and put into service in January of this year. Its nominal capacity is 1,620,000 gallons per day; but owing to the settling basin having proved insufficient in capacity, not more than 1,200,000 gallons can be properly treated. Additional settling capacity is being, or already has been, provided, which will bring the plant up to its designed capacity.

Much trouble has been experienced with the porous plate air distributors, and the soundness of the material, of which they are formed. The porosity runs from 1.85 to 4.50 cu. ft. of air per minute per square foot of surface, under 2 inches of water pressure. The air filter is not yet entirely satisfactory, and permits some oil and dust to enter the plates, which results in some plates working more freely than others, and the uneconomical use of air. There seems good reason to believe that these difficulties will soon be overcome, as they are only questions of experiment and design.

Cold weather has been found to increase the amount of air necessary and to decrease the nitrates in the effluent; but in February, March and April, 98 per cent. of suspended matter and 95 per cent. of bacteria were removed, and a stability secured of 108 hours without dilution.

The dewatering of sludge has been successfully done with either of two kinds of presses. The sludge which contains 99 per cent. water is reduced to 75 per cent. water without difficulty, and further dried by a direct or indirect heat drier to 10 per cent. moisture.

As to the value of the sludge recovered, this is stated to be about $12.50 a ton of dry material, on the basis of 5 per cent. of available ammoniacal nitrogen, which is worth about $2.50 per unit, each per cent. being taken as a unit. This does not include phosphoric acid or potash, of which the combined value may be from $1 to $2 in each ton.

Milwaukee is so situated and the cost of electric power, stated to be about 6/10 of a cent per kw.h., is so low, that the activated sludge method seems particularly well adapted to the place, and problems of design now seem to be the principal problems to be met.

At Baltimore, Md., activated sludge experimental work has been progressing with many difficulties, caused mainly by the form of air compressor at first installed. The oil used to lubricate this got into the porous diffusers, which gave considerable trouble and was not prevented by the interposition of a gravel strainer in the air line.

The outstanding fact, writes Mr. Frank, is that thus far the experiments have not been successful in demonstrating the feasibility or economy of the process under existing experimental conditions.

In October, 1915, the idea suggested itself, Mr. Frank states, that some form of preliminary treatment might possibly be of advantage. The relation between the biologic oxygen demand of the sewage and the amount of compressed air necessary, it would seem, should bear an almost arithmetical relation to each other. Imhoff tank treatment, exclusive of the cost of drying sludge, may be estimated roughly at $1 per million gallons for the average municipality. It is estimated that air alone cost in Milwaukee $4.45 per million gallons of sewage; this being on a basis of $2.50 per million cubic feet of air. Imhoff tank treatment would need to reduce the oxygen demand only 22.6 per cent. before it began to assume importance. The activated sludge might also thereby be considerably reduced. Estimates from experiments indicate that instead of producing one volume of sludge to 104 volumes of sewage, which was true of the unsettled sewage, there was produced only one volume of sludge for 525 volumes of settled sewage. It is questionable whether activated sludge can be as economically disposed of as Imhoff tank sludge.

Much trouble has been experienced, both with the compressor and with the porous discs. A new compressor has recently been installed and a very ingenious arrangement and design of the disc diffuser has been adopted.

The work at Baltimore may be said to have just started anew with much promise. At Houston, Texas, the experiments have been discontinued and the new plant is under construction. This plant will have a capacity of 18 million gallons per day. The sludge will be applied to land, for the present; no definite plan for dewatering the sludge has been adopted.

At San Marcos, Texas, an activated sludge sewage disposal plant is in regular service and is doing satisfactory work. The aerating tank is of concrete, 10 ft. deep. It is practically a channel 4 ft. wide and 160 ft. long, divided into four sections, each 40 ft. long. There is a single row of filtros plates down the centre of each section, spaced 3 ft. on centre, with each plate in the bottom of a hopper; a Connersville blower supplies the air, which is under 5 lbs. pressure. It requires only 4 kw. of current to drive this blower. Much trouble has been experienced with the porous plates; some clog, others break. The plant is operating with about 150,000 gallons per day at present, giving an effluent always clear and sparkling, with a relative stability of 99 per cent., according to the methylene blue test, and with a bacterial removal of 98 per cent. The plant is free from odor. The work of this plant is reported as satisfactory, except the trouble with the porous air diffusers. Sludge will be too small in quantity to make dewatering pay. It will probably be disposed of on land.

The activated sludge plant at Edmonton, Alberta, Canada, has recently been put into service. Mr. A. W. Haddow, acting city engineer, states that, as this plant was designed eighteen months ago, when very little was known about the activated sludge process, and as the plant was not solely for experimental study, the precaution was taken of building an Imhoff tank alongside of the aerating tanks. The plant treats the sewage of 4,500 persons. The sewage amounts to 33,000 cu. ft. per day.

The plant has many interesting features. Air is obtained from a Connersville high-pressure blower, which has capacity to spare for the one tank now in operation.

Air distribution is by means of a grid or grill of iron pipe. The tank under experiment has four 1½-inch down pipes, with a valve on each pipe. The pipes are placed 30 inches on centres, and branch into two 1-inch air distributing pipes at the bottom of the tank, one running towards each end, where they are plugged. Each down pipe, with its valves, is an independent unit, and by unscrewing the Dart union, it can be lifted out for examination without interfering with the blowing on the other pipes. The air-distributing pipes are supported from channel irons by means of ⅜-inch rods. In the bottom of the tank there are four lines of these 1-inch pipes, laid 30 inches apart, and perforated on the underside with ⅛-inch holes, separated 3 inches. This gives an excellent distribution of air.

Each of the down pipes above mentioned, which carry the air to these grills, is so connected below the valve and above the Dart union at the top, with a 3-inch high-pressure water pipe, that it and the distributing pipe can be flushed out. In addition to this, by shutting off the water from the high-pressure pipe and turning on steam, the grills can be steamed out, if they become clogged with grease or oil. A check valve is placed in the main air feed line, to prevent water getting into the blower in case of carelessness in operating the valves.

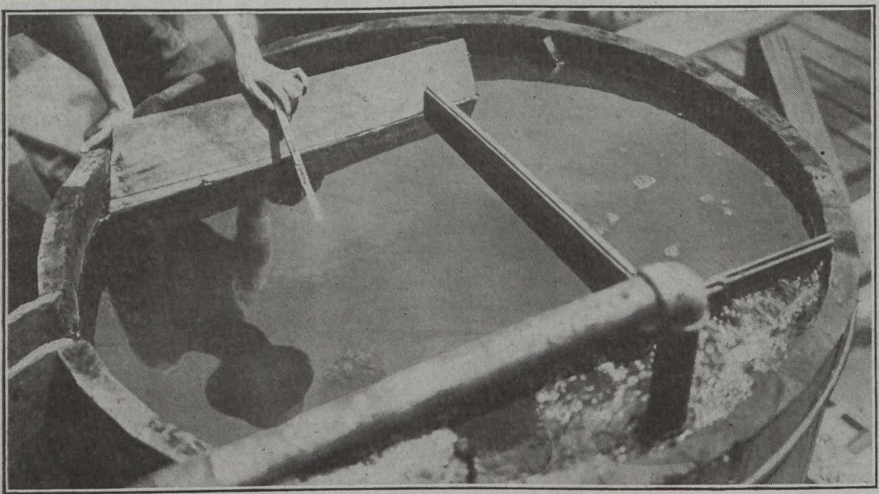
View of Top of Activated Sludge Tank in Operation, Showing the Even Character of the Air Distribution.

The motor is 15 h.p., belt-connected, a.c. 60-cycle, 3-phase. The power consumption at low speed is 4 kw. per hour.

The whole plant is housed in, on account of low temperature in winter. This plant at present operates on the fill and draw plan, but can easily be made to operate on the continuous flow plan later.

Experiments have been conducted at the city of Regina, Saskatchewan. Mr. J. Russell Ellis, acting city engineer, writes that the idea in starting was to obtain data on the adaptability of the process, after which a plant might be designed for the whole city, if the experiments were successful. The results indicate that the process is adaptable to local conditions, and consideration is being given to the design of a large scale unit. Air distribution was effected by means of perforated pipes, covered with canvas.

It is notable that in the midst of our enthusiasm for the activated sludge method of sewage treatment, a studious reserve is maintained in every paper describing experiments, as to the general outlook. There are many unsolved problems, all acknowledge, and as yet there is need of caution. It is now nearly two years since the method was announced, and studies have multiplied relative to it. What, may we ask, is the present status of the method, and what are the main problems as yet unsolved or not completely solved?



View of Top of Continuous Flow Tank of Imhoff Type, Showing Clearness of Contents in the Flowing Through Chamber from which the Tank Discharges.

At the annual convention of the American Society of Civil Engineers, an informal meeting of those interested in sewage disposal was held, which was attended by thirty-two members of the society. The purpose of the meeting was stated by Mr. T. Chalkley Hatton, of Milwaukee, as follows:—

1. To discuss the problems connected with the treatment of sewage by the activated sludge process.

2. To compare results obtained from the several experiments carried out in the United States and Canada.

3. To harmonize those results with a view of determining the causes for the variance.

4. By co-operation to determine, if possible, the following questions:—

(*a*) Most efficient depth of aerating tanks.

(*b*) Most efficient type of aerating tank, embracing 1, baffles; 2, unbaffled; 3, bottom cross-section; 4, circular or rectangular.

(*c*) Most efficient method of diffusing air, embracing 1, open air pipe; 2, perforated or woven metal disks; 3, stone ware; 4, wood plates.

(*d*) Probability of diminishing efficiency of air diffusers, and consequent necessity for providing appliances and facilities for cleaning same at intervals.

(*e*) Most efficient type of sedimentation tanks, embracing vertical flow and horizontal flow and probable velocity in each to effect satisfactory precipitation.

(*f*) Best method for removing sludge from sedimentation tanks and regulating the volume to be returned to the aerating tanks.

(*g*) Volume of dry sludge (10% moisture) secured per million gallons of sewage treated.

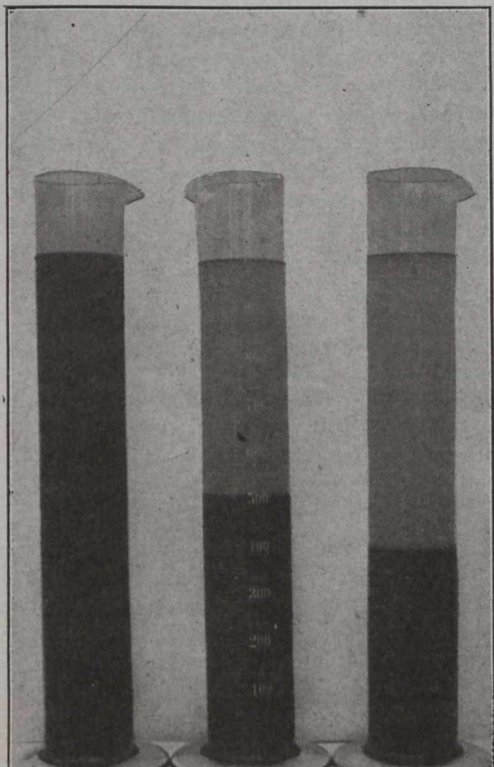
(*h*) Removing surplus sludge from sedimentation tanks and dewatering, 1, subsequent settlement under water pressure; 2, pressing; 3, centrifuging; 4, fermentation; 5, absorption; 6, natural drying; 7, artificial drying.

(*i*) Marketing sludge.

(*j*) Standardization of terms in the activated sludge process with a view of comparing results, embracing, 1, air used, and its measurement; 2, diffusion area; 3, volume of activated sludge; 4, quality of activated sludge; 5, volume of surplus sludge removed; 6, putrescibility and stability of sewage and sludge; 7, such other standardizations as may seem desirable.

The question was discussed of effecting a permanent organization for systematically co-operating in solving the several problems of the activated sludge process so as to avoid duplication of experiments throughout the United States and Canada, and also to protect the process from being controlled by patents issued without complete information having been submitted to the Commissioner of Patents by those who had knowledge of the process prior to the application for letters patent.

It was finally decided that this was not the proper time for effecting such an organization; that the objects sought could best be obtained for the present through a committee and individual service, and upon motion of Professor Earle B. Phelps, a committee composed of F. A. Dallyn, provincial sanitary engineer, Toronto, Canada; George T. Hammond (the author), engineer of design,



A B C

Samples from Continuous Flow Activating Tank to Illustrate Rate of Sedimentation.

A—Unsettled; B—Settled five minutes; C—Settled twenty minutes.

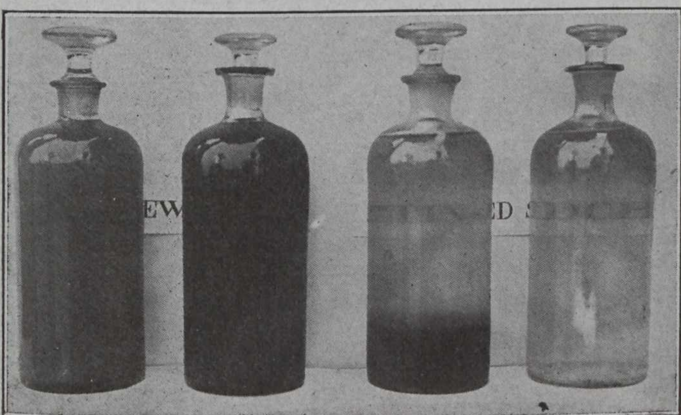
Borough of Brooklyn, and T. Chalkley Hatton, chief engineer, Sewerage Commission, Milwaukee, was appointed for the following purpose:—

First—To prepare standard definitions and other terms relating to the activated sludge process of treating sewage.

Second—To tabulate and distribute a summary of work now being done, or contemplated.

Third—To suggest such correlation of the work being done as may from time to time be desirable.

The foregoing will give some idea of the amount of work which remains to be done and experimentation carried out before we are entitled to claim that we have reached a complete solution of the problems involved in the activated sludge process.



A B C D

Samples Illustrating the Activated Sludge Process, from Continuous Flow Method.

A—Crude sewage; B—Unsettled sample from the activating chamber; C—Sample from the activating chamber settled ten minutes; D—Sample of effluent from continuous flow method.

Taking a broad view of the field, it is of much interest to observe the work being done by the many investigators and scientists who are making a study of this method of treating sewage, and the outlook is quite encouraging, the more so as it is seen on every hand that the problems, both scientific and practical, are well recognized and are receiving careful study.

WEEKLY RAILWAY EARNINGS.

The following are the earnings of Canada's transcontinental railways during September:—

	1916.	1915.	Increase.
Canadian Pacific Railway.			
September 7	$2,679,000	$2,002,000	+ $677,000
September 14	2,728,000	2,214,000	+ 514,000
September 21	2,779,000	2,408,000	+ 371,000
September 30	3,660,000	3,371,000	+ 289,000
Grand Trunk Railway.			
September 7	$1,276,061	$1,091,711	+ $184,350
September 14	1,263,629	1,054,808	+ 208,821
September 21	1,320,277	1,061,047	+ 259,288
September 30	1,796,466	1,416,944	+ 379,522
Canadian Northern Railway.			
September 7	$ 708,900	$ 456,500	+ $252,000
September 14	668,000	590,900	+ 77,100
September 21	726,000	654,700	+ 71,300
September 30	1,085,000	1,054,900	+ 30,100

The Canadian Pacific Railway reports August earnings as follows: Gross earnings, $13,270,467; working expenses, $7,802,680; net profits, $5,467,787.

WHAT FOREST FIRES COST CANADA IN 1916.

According to a special bulletin just issued by the Canadian Forestry Association, Canada has lost through forest fires in 1916 over nine million dollars. This equals more than six times what has been spent on forest protection work from coast to coast. The enormous sum wasted through this year's forest fires, most of which were preventable, would add another $480 to the first year's pension allowances of nearly 19,000 Canadian soldiers.

It is noteworthy that while some parts of the Dominion owe to rainy weather their immunity from fire damage, the season's record proves beyond gainsay that in areas where first-rate fire protection systems were in operation losses of life and property were held down to a remarkable minimum.

Quebec had some heavy fires in the Lake St. John and Saguenay districts, also in the Gaspé peninsula and west of Escalana, on the Transcontinental Railway. It is a striking fact, however, that within the 24,000 square miles of Quebec, covered by the two well-organized associations of limit-holders, the amount of green timber burnt is practically negligible. This immunity was not a matter of luck, but of consistent, patient effort to educate settlers, lumberjacks and others in care with fire, coupled with a system of promptly reporting all outbreaks, and attacking forest fires in their incipiency with large forces of men and modern equipment.

British Columbia faced fairly favorable fire conditions through the summer months, and the cost of fire-fighting was reduced by about 75 per cent. over the record of 1915. The number of fires was about half of last year. The British Columbia forest protection service is the most complete in Canada thus far, and the saving of timber is a logical consequence.

A heavy average of rainfall kept fire troubles at arm's length in Alberta, Saskatchewan and Manitoba, and this weather condition was undoubtedly responsible for the escape of the main areas of big timber throughout Ontario. The Claybelt fires at the end of July and first week of August provided a tragic sacrifice of 262 lives and what is estimated to be six million dollars worth of property. There was practically no forest-guarding organization in the fire-swept district except along the railway track.

New Brunswick escaped the risks of 1916 with a very small timber loss, Nova Scotia having a similar experience. The records of the Dominion Railway Board show that the private-owned railway lines of Canada have not been responsible this year for any damaging forest fires. Those that were started were promptly extinguished by railway employees.

Recent estimates show that there are about 400 hydro-electric development plants in Japan.

Tungsten deposits are now being worked experimentally near the banks of the Miramichi River, in New Brunswick. Three veins of ore are reported, one being 26 in. thick. A concentrating plant of 20 tons daily capacity and a crusher have been installed.

American engineers have drawn up details of a plan to dig a canal from the Arctic Ocean through Russia and Finland to the Gulf of Bothnia. The project is reported to be strongly supported in Russia. The proposed canal would run from Kandalaska, on the White Sea, to Tornea, near the Swedish frontier, and would cost 300,000,000 roubles. The total distance would be about 250 miles.

APPLICATION OF COAGULANT INTERMITTENTLY IN EXCESS AMOUNTS.

In a paper read before the New England Waterworks Association, Mr. E. E. Lochridge, chief engineer of waterworks at Springfield, Mass., deals with a problem that has given concern to those in charge of waterworks plants. Following is an abstract of Mr. Lochridge's paper:—

Coagulation by sulphate of alumina prior to slow sand filtration has been the practice at the West Parish Filter Plant of Springfield, Mass., since its construction. Records are now available covering six full years. During the last four years of this time the method of application has been so altered that materially reduced amounts of coagulant are necessary, although at all times it has been

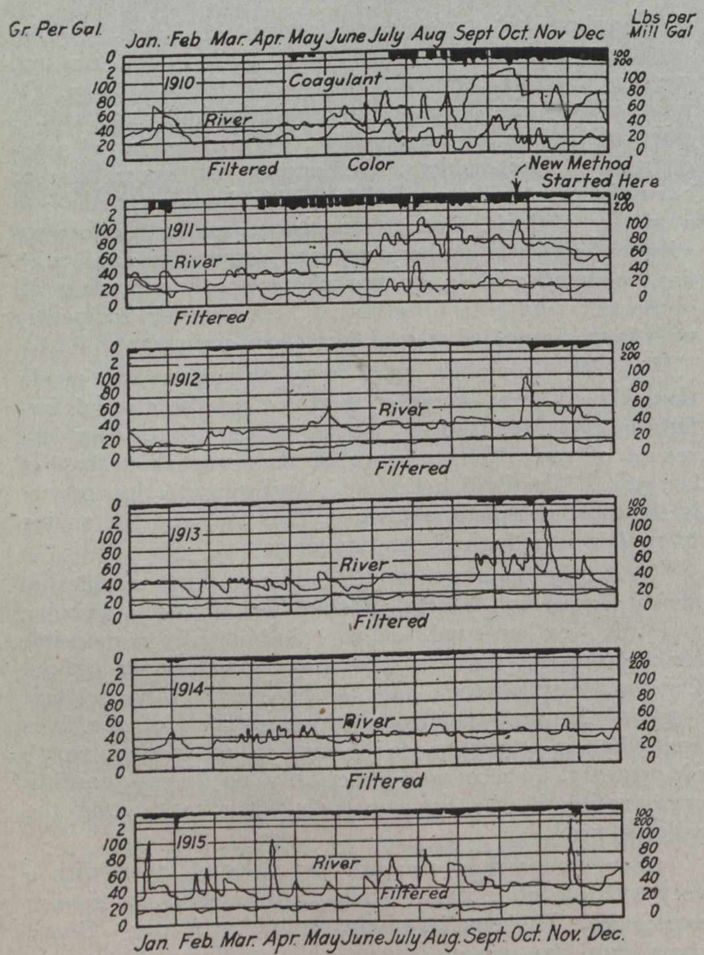


Fig. 1.—Coagulant—Grams per Gallon—Pounds per Million Gallons—Color—River and Filtered Water.

possible to produce satisfactory water. This method has been the application of over-doses of sulphate of alumina to the water intermittently. The filters, six in number, are of the slow sand type and of ½ acre area each. The water of Little River as it comes to the filters is that of a mountain stream usually clear, of low alkalinity, but with a varying color, which with the rise of the stream may increase several fold within a few hours. This color in the river water may be low enough for use without any reduction for a long period of time, when suddenly a rise in the stream will cause a large increase of color which makes the water objectionable for use.

In the chart (Fig. 1) the upper line represents the color of the river water by day, and the lower the color of the filtered water at the same time. These are plottings of daily results. The amount of sulphate of alumina in terms of both grains per gallon and pounds per million gallons is plotted above the color lines in such manner that the amount applied each day may be readily seen. This chart gives the comparison of the two-year period of 1910 and 1911, during which time coagulant was applied in the usual manner, with the years 1912, 1913, 1914 and 1915, in which the method to be described was used. The records for the six years are plotted in such manner that seasonal comparisons are also possible.

The Little River at the point of diversion has a catchment area of 48 square miles. Its elevation at this point is 496 ft. above sea level, and with steep slopes the ground rises to an elevation of from 1,500 to 1,700 ft. at the highest points of the watershed. The surface of the storage reservoir on Borden Brook is 1,070 ft. above sea level, and 1,000 ft. above Main Street in Springfield. The water is diverted from the stream in a deep and narrow gorge, and sent through a mile of tunnel to a sedimentation basin 8 acres in area with a capacity of 40,000,000 gallons, or between three and four days' supply. From this small reservoir the water is drawn to the filters. The water from the tunnel is carried by a concrete conduit to an arm at the greatest distance from the outlet. There are no baffles or other artificial obstructions in this reservoir. The coagulant is applied in solution to the water in transit in the concrete conduit at a point which causes it to travel with the current 540 ft., permitting some mixing before its submerged delivery into the basin. Water is constantly flowing from the river to this basin through the conduit and is drawn uniformly from this basin to the filters.

The determination of the amount of aluminum sulphate necessary for complete reaction is made in a series of 2-gallon bottles, from 15 to 20 in number, which are filled each day with the river water. To these are added, in uniformly varying increments, definite amounts of sulphate of alumina. For example, to the first bottle enough is added to give the effect of the rate of 50 lbs. per million gallons; to the next, 60 lbs.; to the next, 70 lbs., and so on by 10 lbs. per million-gallon increments to 270 lbs. Within a few hours all of the bottles with amounts of coagulant in excess of the "reaction point" will indicate complete color removal, and the precipitation of foreign matter will be complete, while all bottles containing less coagulant than this amount will be in a cloudy or murky condition, indicating incomplete reaction. The determination is made in this manner each day, permitting a study of the effects of the rise and fall of the stream, the effect of storms, melting snows, etc. This information is also of great value at times of sudden changes, when there is insufficient time to make the determination. The amount necessary is dependent on a number of different conditions. With waters of the same alkalinity there may be quite a marked difference in the amount necessary for reaction, varying with river conditions. It is not entirely dependent on the amount of color, as with the same color to be reduced it varies on different days. The amount of coagulant actually applied to the water is always a little in excess of the reaction point determined and during the period of application this is kept as nearly constant as possible.

With the amount or rate of coagulant application per hour thus known, it is still necessary to determine the number of hours per day during which it shall be added. Throughout most of the year, from four to six hours per day is sufficient, but at a time of flood, resulting in a very material increase in color, this period may be lengthened to twelve hours, or 50 per cent. of the time.

Generally speaking, the standard set for filtered water is that of no coagulation if the color does not exceed 25. Before the filtered water reaches this figure, coagulant is resorted to, and during such application the color is to be kept at 20 or below. By referring to the accompanying diagram it will be seen that, since the adoption of this method, it has been possible to make the line of color in the filtered water substantially straight or uniform throughout the year. Under the old method of constant coagulant use, it was found impossible, especially at times of low alkalinity or sudden changes, to add sufficient sulphate of alumina to reduce the water to a satisfactory color at all times. The addition of soda ash or lime was necessary for restoring alkalinity at such times. This is entirely unnecessary with the intermittent application, as but a small portion of the alkalinity is used in the formation of the floc. The first coagulation in the conduit and basin results in a water of substantially zero color, with at least a theoretically slightly acidic reaction. This treated portion of the water, which has entered the basin chemically active, with the precipitate or floc forming rapidly, is then followed by untreated water in a quantity, because of the longer period of time, in excess of the treated water.

The thorough mixing of this raw water with the treated water is brought about at the outlet of the submerged conduit as it displaces the basin water at this point. The second reaction begins at once and is carried to completion with a restoration of alkalinity to the entire supply, this action probably being consummated during the period which elapses before the next application of coagulated water. The floc of the treated water has not had an opportunity to settle when the raw water is admitted, and readily furnishes a base about which the additional precipitation resulting from this secondary reaction forms, and serves to carry down color, sediment, and bacteria mechanically, as well as through the chemical reaction which is taking place in every part of the untreated water as it mixes with the overdosed water.

The resultant reduction of color is, therefore, due to the effect of dilution of the higher colored water with water of no color; to the second reaction, which is, in reality, the completion of a reaction started under favorable conditions of overdosing, and which reaction chemically is always complete, as the excess of the applied coagulant is taken up by the alkalinity of the untreated water, resulting in the completion of the mass reaction; and also to the mixing of the floc of the fully treated portion with the mass of the entire day's water supply, before it has the opportunity to settle. The precipitate thus formed in a large part settles before it is carried to the filters.

The sedimentation basin was drawn off and cleaned after five years' operation of the filtration plant, and it was found that large masses of precipitated organic matter and aluminum hydrate had settled in the upper portions of the basin. This deposit covered the entire basin, varying from 3 to 4 ft. in depth near the inlet to a few inches in proportion to the distance from the point of entry to the basin of the raw water.

The average length of filter runs during the four years described in this paper of the use of this process were as follows:—

Table I.

	Filter runs after scraping.			Filter runs after raking.		
Year.	Number.	Average in millions of gallons per ½-acre bed.	Maximum runs in millions of gallons.	Number.	Average in millions of gallons per ½-acre bed.	Maximum runs in millions of gallons.
1912	22	76	90	26	76	84
1913	22	95	115	23	79	91
1914	26	85	152	24	77	157
1915	29	89	229	21	42	104

In conclusion, it may be said that the use of intermittent coagulation results in a saving in expense, uniform results of satisfactory quality, coagulation without exhausting alkalinities in soft waters, and coagulation without excessive overloading of the precipitated hydrate on the filter beds.

TOWN PLANNING AS A MONEY SAVER.*

THE wrong impression has been given to many people that the preparation of a plan for a city or a town is waste of money and effort because of the probable cost of executing the plan. It never seems to occur to such people that a plan may be prepared for the purpose of reducing municipal expenditure. The object of a plan is to ascertain in advance what are the best things on which to spend the money that is available, not to find out new things on which to spend more money than is spent without a plan. In Canada at present all town planning should be directed to secure greater economy in municipal administration.

Comparison is sometimes made between the planning of a factory and the planning of a city—It being argued that as the one is necessary so is the other. But the city is such a complex thing and so many of its parts and functions are inter-related and linked up with one another that there is much stronger reason for planning the city than planning a factory or a house. Yet, every sane person who builds a factory or a house has a plan prepared for it, while most cities are allowed to grow without plan. There is one comparison between the planning of the factory and the city that is worth noting. The first thing a man does who proposes to build a factory is to decide what amount he has to spend and what facilities and space he requires. He next computes how best to fit in his requirements with his finances. If he is a wise man he calculates on the requirements of the future as well as of the present, and sees that he has a site large enough for reasonable extension in the succeeding 20 or 25 years. He then engages architectural and engineering advice to prepare plans. The architect or engineer is told what money is available, and what provision has to be made. The latter then applies his skill to prepare a set of plans showing how the provision can be made for both immediate and future requirements; next he submits estimates of costs and, where necessary, advice regarding any increased area of site required for future expansion. If the sum immediately available for building is $100,000 the preliminary plan and scheme might cost from a few hundred to one or two thousand dollars—but it might have the effect of showing the manufacturer that he should only spend $80,000 instead of $100,000. The object of the plan being to enable the building to be properly constructed according to the best design, it may as likely show that the manufacturer can accomplish what

*Conservation of Life.

he wants at less than his rough estimate. Of course, it may equally have the opposite effect. But the point is that the preparation of a plan for a factory or a city does not in itself increase or lessen costs; it merely provides the necessary material and drawings to enable the cost, and the proper channels of expenditure, to be estimated. It is like preparing a city budget at the beginning of a financial year—the budget instead of increasing expenditure enables the city authority to "cut its coat according to its cloth," and may help in securing reductions in expenditure.

If a man were to build a house and pay an architect 2½ per cent. on the cost to prepare plans and estimates and another 2½ per cent. to supervise construction, the architect does not by the act of preparing the plans involve the owner in greater cost than 2½ per cent. of the estimated cost and for that he may save 10 per cent. on the owner's own estimates in the building if he is a good architect. On the other hand, if no plans were prepared and the work proceeded piecemeal, the owner may spend twice as much for the same house before he completed it.

In many of our cities and towns we are spending money on the wrong things, we are wasting money on non-essentials; and we are creating the beginnings of bad conditions for future generations. By the preparation of a town planning scheme at comparatively small cost we would save much money and wasted effort, and we could avoid mistakes which are caused by want of planning.

These financial advantages are in addition to the social advantages produced by town planning—the improved living conditions, the better facilities for transportation, etc., the higher standards of public health and citizenship, and the greater equality of opportunity. It is sometimes said that the financial side of these problems is unimportant; that the human side is all we need concern ourselves about. That is just as unsound a view as the opposite which puts all the emphasis on the financial side. The best methods of solving social problems are those which have a sound economic basis. If our method of feeding the hungry results in creating paupers may not the remedy be as bad as the disease? If our method of city planning destroys the individual initiative and helps the waster at the expense of the hard-working citizen, will it not be unsound? The great value of town planning, however, is that while it does not directly solve social problems connected with the land it is a necessary basis for any proper solution—it is the only method by which they can be solved at reasonable cost to the community on the one hand or without injury to legitimate rights in property on the other hand.

But no town planning scheme, and still less no paper plan unaccompanied by a proper scheme of regulations, can be effective or save money unless it deals with the control of building development and sanitary conditions. Indeed, a wasteful and irrational system of development may result from having a street plan of a town, if land speculation is permitted and there is no regulation regarding sizes of lot and density and character of buildings to be erected.

The number of commercial and passenger motor vehicles exported from the United States of America during the last fiscal year was 77,496, compared with 37,876 for 1915, 29,090 in 1914, and 11,803 in 1911.

Russia's available water power in Europe, including Finland, the Ural district and the Caucasus, is estimated at 10 million kilowatts, or over 13 million h.p., only about one-fortieth of which is at present utilized.

CANADIAN SOCIETY OF CIVIL ENGINEERS, TORONTO BRANCH.

An interesting meeting of the Toronto Branch was held at the rooms of the Society at the Engineers' Club on October 12, 1916.

The subject for the evening was "The Quebec Bridge" and Messrs. J. R. W. Ambrose and H. L. Steenbuch, who observed the operations in connection with the recent attempt to place the central span, addressed the meeting. Mr. Steenbuch gave a short historical review of facts in connection with the bridge and, by the aid of excellent slides, explained methods employed in the construction of the giant cantilever arms as well as of the central span. Mr. Ambrose confined his remarks more particularly to the central span, the method of floating it into place and raising it. These operations were illustrated by many photographs taken by the speaker, which gave a clear idea of the immensity of the task.

Both speakers laid particular emphasis on the apparent thoroughness and foresight with which every detail had been worked out.

At the close of the meeting a resolution was carried unanimously that the Toronto Branch convey to Mr. G. H. Duggan its sympathy and also its absolute conviction that success would crown the next effort to complete the bridge.

It was also resolved and unanimously carried that the Toronto Branch convey its hearty congratulations to Col. Mitchell, one of its most prominent members at present at the front, on his well-earned promotion to the position of First Staff Officer of the second British army in France.

The matter of the government employment of alien engineers was also considered and the following resolution carried:—

"That the members of the Toronto Branch condemn the practice of any government, federal, provincial or municipal, employing alien engineers to the exclusion of Canadians competent to do the work. And further, that a committee consisting of Mr. G. A. McCarthy, chairman; Mr. L. M. Arkley, secretary-treasurer; Prof. Haultain and Mr. J. R. W. Ambrose, be appointed to consider this question at a joint meeting of the Canadian Manufacturers' Association, Toronto architects and construction contractors."

LETTER TO THE EDITOR.

Consistency of Concrete.

Sir,—Referring to "Consistency of Concrete," page 181, issue of August 31, 1916.

The writer specifies a maximum amount of water of 6 lbs. per cubic foot of all loose materials in batch and resulting consistency of concrete to be that of a medium soft tooth paste. An apparently dry batch will become soft with mixing, so it should be mixed until the desired consistency is obtained. A desirable consistency may be obtained with 4 lbs. of water if the materials are damp and the mixing is continued for a long enough time—not less than one minute.

ERNEST McCULLOUGH, M.Am.Soc.C.E.

Chicago, Ill., September 6, 1916.

RAIL FAILURE STATISTICS FOR 1915.*

By M. H. Wickhorst,
Engineer of Tests, Rail Committee.

THIS report deals with the statistics of rail failures collected for the year ending October 31, 1915, furnished by the railroads of the United States and Canada in response to a circular sent out by the American Railway Association. The information furnished by each railroad showed the number of tons laid of each year's rollings from each mill, the equivalent number of track miles, and the total number of failures that occurred in each year's rolling from the date laid until October 31, 1915. It may be remarked that as a whole the returns this year were more complete and satisfactory than heretofore.

The failures were divided into four classes, namely, head, web, base and "broken." They were reported by the railroads on American Railway Engineering Association form M. W. 408 as revised in 1915. (See Manual for 1915, p. 104.) A copy of this form reduced in size is given with this report as an insert. The reports cover rollings for 1910 and succeeding years, and the ages of the rollings would average in the track about the years shown below:

1910—5 years.	1913—2 years.
1911—4 years.	1914—1 year.
1912—3 years.	1915—several months.

The tonnages represented by the statistics in this report are shown below:

Year rolled.	Bessemer.	Open-hearth.	Total.
1910	647,616	969,075	1,669,691
1911	317,818	805,489	1,123,307
1912	230,318	1,235,974	1,466,292
1913	122,974	1,403,848	1,526,642
1914	52,837	976,852	1,029,689
1915	13,295	621,603	634,898

The equivalent track miles are as follows:

Year rolled.	Bessemer.	Open-hearth.	Total.
1910	4,678.46	6,908.97	11,587.43
1911	2,263.75	5,717.42	7,981.17
1912	1,657.33	8,716.85	10,374.18
1913	998.05	9,670.54	10,668.59
1914	380.02	6,681.22	7,061.24
1915	99.12	4,187.14	4,286.26

It will be noted that the Bessemer rails have continually become a smaller proportion of the total amount reported on.

The failures were tabulated with reference particularly to the performance of the rails made by the different mills and were classified successively in the following order: Kind of steel (Bessemer or open-hearth), mill, year rolled, weight per yard, section and railroad. The totals were figured for the groups by the year rolled.

Lots of less than 1,000 tons (that is, less than 1,000 tons in any one year's rolling) were excluded from the tabulation, as they would unnecessarily extend the tables and not materially change the group totals and averages. The method of compiling the statistics was to make prints (generally blue-line whiteprints) of the reports submitted by the different railroads, after seeing that all the lines were fully filled out, and then cutting them up along the horizontal lines with a large card cutter or trimming board. These strips constituted the units in the tables, and after sorting in suitable order and collecting into the desired groups, the information was transcribed into tables on a typewriter, from which zinc plates were made for printing in the report.

Failures Classified by Mills.—The detail tabulations by mills and years rolled are given in Table 7, sheets 1 to 20, inclusive. A condensed table showing the failures of each year's rolling of each mill is given as Table I. First, it is interesting to note from this table the comparative performance of Bessemer and open-hearth rails for the several years' rollings. Figuring the failures per 100 track miles of open-hearth rails as 100 for each of the

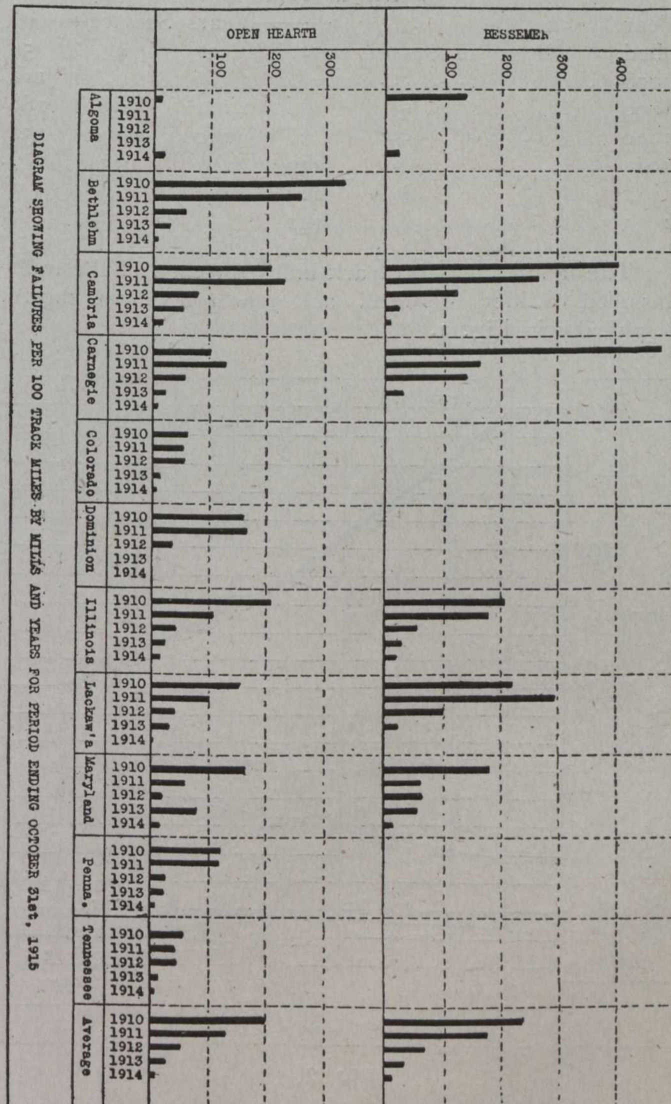


Fig. 1.

years 1910, 1911, 1912 and 1913, the relative failures of the Bessemer rails, together with the failures per 100 track miles, is shown below:

Failures of Open-hearth and Bessemer Compared.

Year Rolled	Years Service	Failures per 100 Track Miles Open-Hearth	Bessemer	Comparative Failures Open-Hearth	Bessemer
1910	5	153.1	236.9	100	154
1911	4.	115.5	178.8	100	155
1912	3	46.0	66.9	100	143
1913	2	24.8	35.2	100	142

It will be noted that the Bessemer failures per 100 track miles were about 50 per cent. greater than those of the open-hearth rails. It is probably also true that the

*Bulletin of the American Railway Engineering Assoc.

open-hearth rails were, in general, in more severe service, so that the actual difference under the same conditions may have been greater.

The comparison between open-hearth and Bessemer rails as obtained from the statistics in the 1913 and 1914 reports and this report are collected together below. The original comparisons in the 1913 and 1914 reports compared the failures per 10,000 tons, but below the comparison is on the basis of failures per 100 track miles, although the difference is small.

Bessemer Failures Compared with Open-hearth Failures Taken as 100.

Year rolled.	Years Service 2	3	4	5
1908	...	...	...	112
1909	...	...	195	188
1910	...	230	207	154
1911	249	291	155	...
1912	219	143	...	...
1913	142	...	...	...

The failures per 100 track miles for each of the mills classified by kind of steel and year rolled, are shown graphically in Fig. 1.

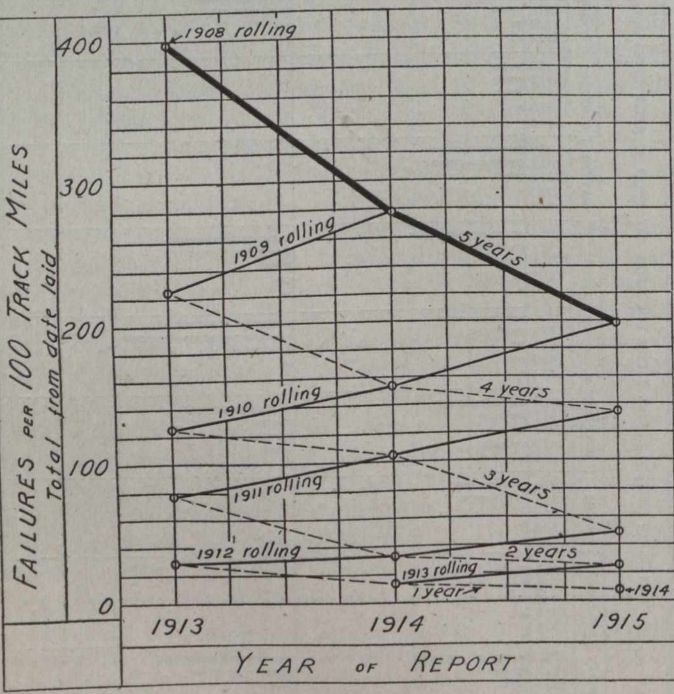


Fig. 2.

The heavy solid line shows the failures after five years for the 1908, 1909 and 1910 rollings. The dotted lines show the failures for less years' service. The light solid lines show the accumulated failures for successive years, each line representing a certain year's rolling.

The average weights per yard, compiled from tonnages used in this report are shown in Table 6.

Ranking of Mills.—In order to show more conveniently the relative number of failures from each of the mills and to show the ranking of the mills as regards the failure performance of the rails rolled by them, Table 3 has been prepared. Taking the average number of failures per 100 track miles of all the mills in each group (Bessemer and open-hearth), in any year's rolling as 100, the relative number of failures of each of the mills is shown for the years 1910, 1911, 1912 and 1913. The later rollings are not included because of being too young. The rank of each mill is also shown for each year's rolling.

Comparison With Previous Years.—One important purpose of these statistics is to enable comparisons to be made of the performance of rail rolled from year to year, and Tables 4 and 5 are given, showing the general records for the years 1913, 1914 and 1915, one table for Bessemer rails and the other for open-hearth rails. The final comparison is made on the basis of five years' service, but before closing the record of any one year's rolling, a comparison can be made on the performance of a less number of years in service.

The records are closed for the 1908, 1909 and 1910 rollings and it will be noted that both the Bessemer and open-hearth rails showed reductions in the number of failures in the successive years.

A summary of the general results as given in the reports for 1913 and 1914 and also this report, is given herewith as Table 2.

The average failures per 100 track miles of the rollings for the several years, including both the Bessemer and open-hearth rails, is given in the following table:

Year rolled.	Years Service 0	1	2	3	4	5
1908	...	....	....	.....	.....	398.1
1909	...	....	....	.....	224.1	277.8
1910	...	....	....	124.0	152.7	198.5
1911	...	....	77.0	104.4	133.3	.....
1912	...	28.9	32.1	49.3	.....	.....
1913	2.0	12.5	25.8	....	.....	.....
1914	1.2	8.2	....	....	.....	.....
1915	0.7	...	....	....	.....	.....

These results are also shown diagrammatically in Fig. 2. It will be noted that the 1908, 1909 and 1910 rollings show successively decreased numbers of failures compared on a basis of five years' service and the later rollings also show successive reductions in failures when compared on a less number of years' service. A study of the results shows this to be due partly to the gradual replacement of Bessemer by open-hearth rails, and partly to the improvement in both the Bessemer and open-hearth records.

Summary.—1. Statistics are given of rail failures collected for the year ending October 31, 1915, furnished by the railroads in response to a circular sent out by the American Railway Association. The information furnished by each railroad showed the number of tons laid of each year's rolling from each mill, the equivalent number of track miles and the total number of failures that occurred in each year's rolling from the date laid until October 31, 1915.

2. The basis of comparison is the number of failures per 100 track miles of rail laid that occurred in each year's rolling from the date laid until October 31, 1915.

3. As a general average, the failures for 100 track miles of Bessemer rails were about 50 per cent. greater than those of open-hearth rails, although it is probable that the open-hearth rails were, in general, in the more severe service.

4. A table is given showing the ranking of the mills as regards rate of failures for the rollings of the years 1910, 1911, 1912 and 1913.

5. A comparison with the statistics for 1913 and 1914 indicates, as a general average of all mills, a general gradual decrease in the rate of rail failures of rollings for the successive years since 1908, with which year's rolling the records started.

DIAGRAMMATIC STATISTICS FOR MUNICIPAL ENGINEERS.*

By Reginald Brown, M.Inst.C.E.

THE writer puts forward this paper with a certain amount of hesitation, as the subject is too wide to be dealt with as fully as it deserves in a small compass, but he offers no apology for introducing it for discussion among his colleagues, as it is a subject which is of interest to the whole of the profession, and probably no more suitable time can be found for its presentation than at an annual meeting of the institution.

The use of diagrams or charts to show at a glance the records and results of any particular department is invaluable, as by their use it is possible to gain a considerable amount of information with greater facility than by comparison of mere figures only. Such a method also enhances collective information, because of the facility in detecting inconsistencies requiring remedy.

To the individual municipal engineer the use of charts in his own work must, to say the least, be of benefit; but if standard charts could be devised by which comparisons with other towns could be made, possibly their value would be much increased, especially if the information contained therein is combined with the knowledge of the conditions under which the chart has been produced.

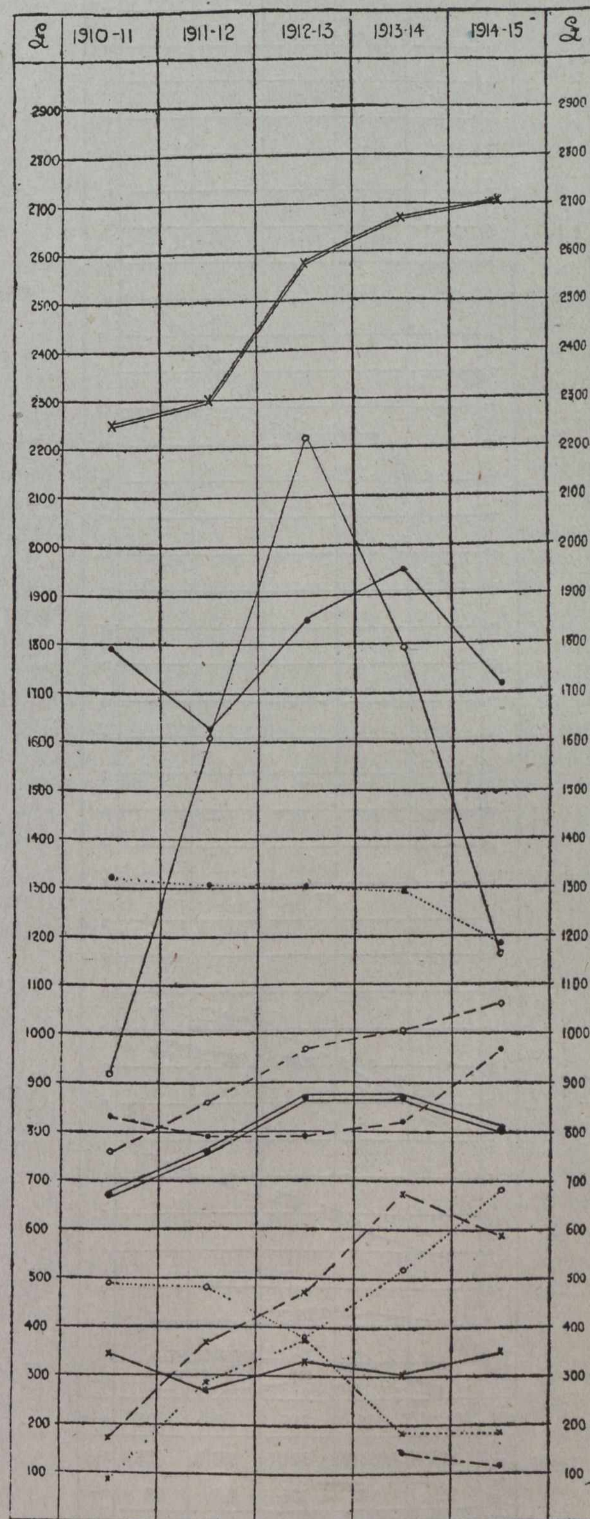
Unfortunately, there is a total absence of a set of general standard charts in the municipal engineering profession, but it does not stand alone in this respect by any means.

It would make this paper too long to put before the members the whole series of charts, etc., designed and used by the writer for record purposes, and he must therefore content himself with dealing with the subject in somewhat of a general manner, giving a few examples showing how information can be conveyed pictorially, and trusts that quite sufficient will be said to form a basis for destructive and constructive criticism.

General.—The writer has been in the habit for many years—and he is not alone in this respect—of keeping an accurate record of the costs incurred in the various branches of his department, and consequently can at a moment's notice ascertain how and why the costs have varied from year to year. This not only necessitates—in showing the particulars pictorially—the main headings for each year, but also charts for each heading containing the items making up the total of the heading, and although this involves a certain amount of labor, the advantages gained more than compensates for the trouble taken.

As an example of his meaning, the writer has (in Fig. 1) selected certain divisions of his department and given the comparative costs, etc., for five years, not only in chart form, but combined with detail figures—a combination which he considers to be of greater value than a mere chart or figures only. A glance at such a chart as this will direct one's attention to the abnormal increase or decrease in expenditure in any year in any particular department, and will cause the municipal engineer to inquire further the reasons of such increase or decrease.

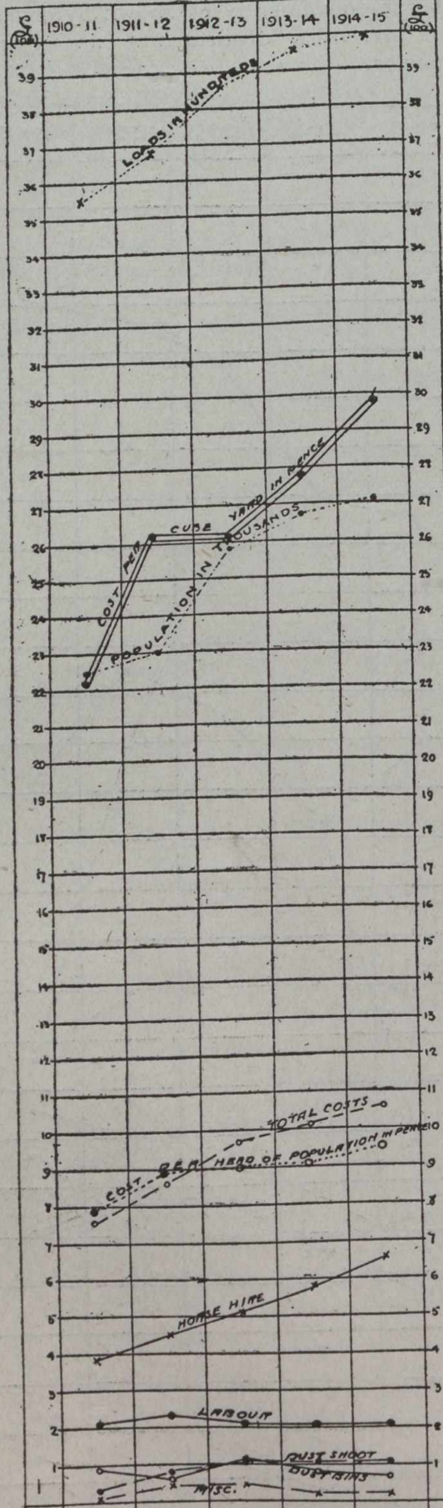
The writer has chosen, at random, removal and disposal of house refuse and as an example of the information which can conveniently be shown by charts, it being understood that other departments can be treated in a similar manner.



TOTALS AND POP^N in 1000 (not 100)	1910-11	1911-12	1912-13	1913-14	1914-15	
	1791	1629	1850	1953	1718	SEW DIS^L
	347	272	334	307	356	SEWERS
	918	1605	2225	1796	1169	HIGHWAYS
	835	790	790	820	968	SCAV^NG
	172	368	473	611	591	WATER^NS
	758	863	910	1007	1062	DUST^NG
	1324	1304	1302	1294	1183	PUB.LIGHT
	88	284	372	183	185	FIRE BGD.
	490	481	385	519	686	PARKS
				144	118	BATHS
	6721	7596	8699	8694	8036	TOTALS
	22500	23000	25800	26700	27050	POP^N

Fig. 1.—Showing Costs of Various Departments.

*Paper read before the Institution of Municipal and County Engineers.

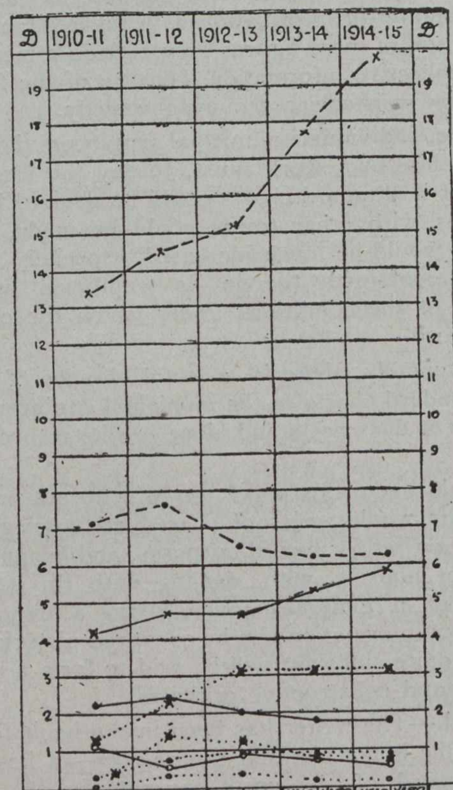


	1910-11	1911-12	1912-13	1913-14	1914-15	
LAB.	212	236	215	206	208	•—•
HORSE HIRE	396 (8/-)	447 (8/-)	501 (9/6)	587 (9/-)	658 (10/-)	×—×
DUST BINS	99	58	106	88	69	o—o
DUST SHOOT	37	77	103	102	104	•--•
MISC.	14	45	44	24	23	×--×
TOTAL	758	863	969	1007	1062	o--o
POPN.	22500	23000	25800	26700	27050	• •
LOADS	3553	3678	3868	3967	3995	×···×
COST PER HEAD	7·93	8·96	9·00	9·04	9·42	o···o
COST PER YARD CUBE	22·25	26·16	26·09	27·80	29·82	

Fig. 2.—Removal and Disposal of House Refuse.

Refuse Removal and Disposal.—As previously stated, to read a chart properly one must understand the conditions under which the chart has been constructed. Thus, in the writer's district, the work of "dusting" is carried out on the principle of "direct labor and contract." The district is divided into five sub-districts, which are attended to by two men and horse and cart. One of the men is employed direct by the council, which provides a "two-yard" covered cart, the other man with horse and harness being provided under contract at a "rate per day." The refuse is carted to shoot, but this matter is referred to hereafter in discussing details.

Fig. 1 shows there has been a great increase in the cost of this work during the five years under review, but does not convey any idea of the items which have caused the increase. To do this, Fig. 2 is required, and this at a glance will show that the increase has largely taken place in two items—*viz.*, cost of shoot and horse hire. A study of the items separately will be of interest.

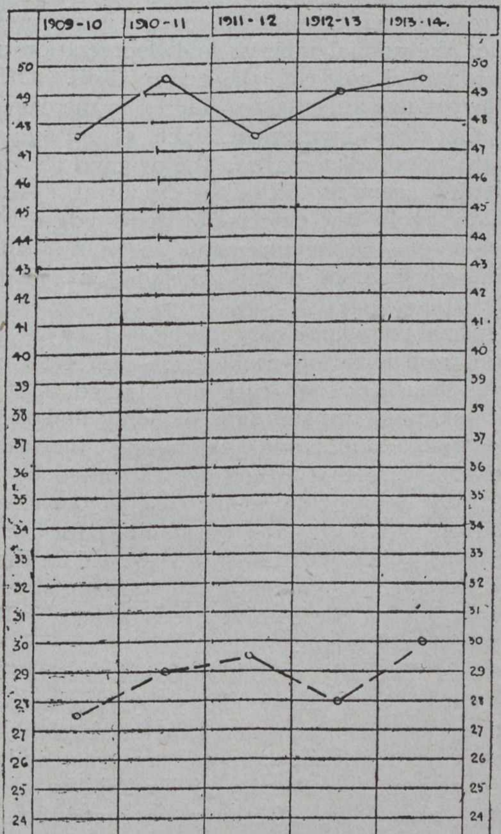


	1910-11		1911-12		1912-13		1913-14		1914-15		
	HEAD	YARD	HEAD	YARD	HEAD	YARD	HEAD	YARD	HEAD	YARD	
LABR.	2·26	7·16	2·46	7·68	2·0	6·50	1·85	6·23	1·84	6·25	•—• •--•
HORSE HIRE	4·22	13·37	4·70	14·58	4·66	16·15	5·28	17·76	5·74	19·76	×—× ×--×
DUST BINS	1·05	[illegible]	·60		·97		·78		·61		o—o
SHOOT	·39	1·25	·80	2·43	·96	3·11	·91	3·09	·92	3·12	•···• ×···×
MISC.	·01	·47	·40	1·47	·41	1·33	·22	·72	·21	·69	o···o

Fig. 2B.

Labor.—In spite of the fact that the population has increased, and hence the number of loads removed, the labor item remains practically the same, and the cost of removal on this item is probably carried out as economically as possible under the circumstances. Fig. 2B shows that in labor the cost per head of population has been reduced by .42d., and if represented by yards by .91d.

Horse Hire.—The charge for horse hire has gone up considerably. In 1910-11 the price paid per day for horse and man was only 8s., whereas in 1914-15 it had increased by 25 per cent. to 10s. (1915-16 the charge is 13s. per day). The effect of this upon the cost of removal



	1909-10	1910-11	1911-12	1912-13	1913-14
A	98·91	98·77	99·59	103·74	97·5
B	58·53	57 33	60·38	62·86	57·74
C	42·73	41·5	43·79	46·09	41·54
D	15·8	15·83	16·59	16·77	16·20
E	38 13	38 92	36·53	37·97	35·62
F	2 25	2·52	2·67	2·91	4·14
G	34·67	34·67	32·85	33·5	33 5
H	33 00	34·75	32·25	34·5	34 5
J					
K	47500	49500	47500	49000	49500
L	27500	29000	29500	28000	30000
M	19500	20000	17500	20500	19 000
N					
O					
P	500	500	500	500	500
R					

Fig. 3.—House Refuse Collection and Disposal.

EXPLANATION.

A to F—In pence per load. G—In pence per ton. H—In pence per ton. A to H—Marginal × 10. K to P—Marginal No. × 1,000.

A—Total cost collection and disposal. B—Collection only (including collectors, shooters, horse and stable, proportion of clerks, &c.) C—Cost collection (horse and stable only). D—Cost collection (B—C). E—Cost Disposal (all shoots). F—Cost other charges. G—Barge rates. H—Rail Rates. J—(——). K—Total loads collected and disposed of. L—Total loads collected and disposed of by barge. M—Total loads collected and disposed of by rail. N—Total loads collected and disposed of by destructor. O—Total loads collected and disposed of to chargeable shoots. P—Total loads collected and disposed of to free shoots. R—(——).

is such that—as shown in Fig. 2B—the charge per head of population and per cubic yard has increased from 4.22 and 13.37 respectively in 1910-11 to 5.84 and 19.76 respectively in 1914-15.

Obviously, however, this cannot all be due to the charge per day for horse hire, as the rate has only increased 25 per cent. while the cost per yard has increased more than 50 per cent. Hence part of the increase is due to some cause outside this—*viz.*, extra horse hire due to longer distance of cartage to shoot. As 3¼d. per yard is paid for "shooting" refuse in a brickfield outside the district, Fig. 2B shows clearly it was not until 1912-13 that practically all the refuse was disposed of in this manner, in previous years the shoots being "haphazard" ones. The extra cost of cartage is a very serious one, as it is entirely due to distance of shoot (the ordinary labor being the same) and extra charge for horse hire.

The obvious conclusion is that if the amount is to be reduced some other and cheaper method of collection (cartage) must be adopted, if possible, and the authority carry out the whole work by direct labor. One other interesting fact may be mentioned. The writer's authority has for many years past provided portable dustbins to each house at the cost of the general ratepayer. The charts show the cost to be very moderate, the average per head of population per annum being .80d., or, say, 4d. per house of five persons, and, considering the first cost of the bins to be 4s. 5d. each, the average life of each bin may be taken as thirteen to fourteen years. The actual life of a bin, of course, depends upon the care with which it is used; some bins in the writer's district have been in use more than twenty years, and are still in good condition.

As the number of loads of refuse is carefully checked, it may interest the members to know the amount of refuse made per head per annum:—

In 1910-11, 8.53 cubic feet.
In 1911-12, 8.63 cubic feet.
In 1912-13, 8 cubic feet.
In 1913-14, 8 cubic feet.

The results are consistent with the growth in population. The writer thinks, however, that the slight decrease is due to the gradual increase in the use of the "gas cooker" in the summer and the greater care experienced by the householder in burning all combustible material in the kitchen in the winter months; this is evidenced by careful observation of the class of material removed, and the record uniform number of loads removed each week.

As another and probably better illustration, the writer is able to give, by the courtesy of W. Oxtoby, M.Inst.C.E., the borough engineer of Camberwell, a valuable chart (Fig. 3) showing the various particulars relating to house refuse as obtainable in that district. The diagram speaks for itself.

The Spanish Government maintains 27,340 miles of highways and has more than 3,000 miles under construction at the present time.

Nathaniel M. Jones, of Bangor, Me., announced recently the sale of the largest pulp and paper mill in the Canadian Maritime Provinces to a syndicate of Maine and New York men. The property, for which it is said $2,000,000 will be paid, includes mills at the Reversing Falls, near St. John, N.B., and large timber lands in New Brunswick. The syndicate includes Hugh Chisholm, of Portland, President of the Oxford Paper Company, and Maynard S. Bird, also of Portland.

ELECTRIC POWER TRANSMISSION ECONOMICS.*

By George P. Roux,
Consulting Engineer, Philadelphia, Pa.

SINCE the introduction of scientific management in the operating departments of light and power companies a great improvement has been made in both the quality and the economy of the electric service. Systematic cost keeping automatically exposes every weak spot in operation and institutes a study and analysis of its cause with the purpose of prescribing a remedy. These scientific methods, which are merely the application of common sense in the conduct of the business, were primarily directed toward improving the efficiency of the working force and were later extended to inanimate things, such as raw materials, tools, instruments, machinery and equipment; so that by keeping adequate records of their useful performances a selection based on merit could be made with a view to securing still better results.

The efficiency of a physical property is a broad subject, just as essential to the economical success of a business as is labor efficiency; it is a very fertile soil which, when properly tilled, yields a generous harvest of valuable information that is helpful in reducing the costs of operation and maintenance, and improving the reliability of the service.

In the transmission and distribution of electrical energy peculiar conditions are met which increase the ultimate cost of the product, due to two causes, *viz.*, losses in transportation, and losses in conditioning for transportation and distribution. The ultimate cost of the product or commodity depends on the efficiency of the system of delivery. In the distribution of electrical energy it is a very important item, represented by the ratio of input to output of the electrical energy at each end of the system, or at the power house and the customer's premises where it is sold according to the units metered and delivered.

The transportation of electrical energy is widely different from other problems involving traffic; here the flow is continuous from end to end, while in railway transportation the traffic is intermittent and can suffer demurrage if necessary without great inconvenience. The means of transportation consisting of tracks and rolling stock can be increased to meet the demand imposed by the volume of the traffic; improvements, additions, and repair and maintenance work can be undertaken without seriously impairing the operation; while in a power transmission system provisions and work of this nature are almost impossible to be carried out except at great expense and with considerable annoyance and difficulties.

The losses occurring in the transportation of electrical energy are governed by the resistance of the conductor through which the energy flows and also by its degree of staunchness; that is, its insulation properties. The resistance of a circuit intended to transmit alternating current depends primarily on the material used for the conductors, and on their cross-section, both factors affecting the investment, which in turn is subject to financial considerations that prescribe an expenditure for construction that will net the largest return on the capital invested. A reduction in the transmission losses cannot be secured except at the cost of an increased investment, and a point is reached where any additional reduction in these losses becomes an expensive saving represented by interest on the capital invested and depreciation charges.

*General Electric Review, October.

The maximum transmission economy is attained when the sum of the annual interest and depreciation charges equals the annual cost of the energy loss. Other important factors must also be considered in the calculations affecting the initial investment, such as voltage regulation and the possible increase in the demand for electrical energy at the receiving end of the circuit at a later date, all of which involve the exercise of good judgment in the appreciation of the requirements to be fulfilled in the design and construction of the transmission and distribution lines.

No special or definite rule can be laid for the solution of electric transportation problems; each case must be considered separately and carefully studied, first on the basis of maximum transmission economy and then from the investment standpoint, estimating the additional capital expenditure that would be warranted by the immediate traffic to provide an increase in power-carrying capacity from the start, and possibilities for further increases; bearing in mind that it is very seldom that a line has been designed in excess of the subsequent traffic requirements, but on the contrary it is generally found to be ultimately inadequate.

There is naturally a limit imposed on the power-carrying capacity of electric lines by engineering considerations, such as strength of materials, stability and permanence of the supporting structures, and the important question of continuity and reliability of service, which may always be effectively improved by double-tracking the circuit.

Transportation Losses.—Neglecting certain constants only slightly affecting overhead transmission lines at voltages below 60,000 volts and at altitudes less than 3,000 feet, the total loss of energy in a transmission line is the sum of: Ohmic resistance loss; dielectric or leakage loss; inductive reactance loss.

The ohmic resistance loss depends entirely upon the conductivity, permeability and shape of the conductor and its temperature constant. This loss is generally a function of I^2R, in phase with the current. The true resistance (R) to the flow of alternating current, which is affected by the frequency of the current owing to skin effect, is slightly increased at ordinary operating frequencies, as shown in Table I.

The effective resistance of magnetic materials, such as iron wire, increases in a considerably greater proportion than that of non-magnetic material, due to the interference of eddy currents that are generated perpendicularly to the direction of the magnetic flux and that reduce the effective conductivity of the material to a very thin layer near its surface.

The dielectric loss in overhead transmission lines of voltages not exceeding 60,000 volts can be neglected when the conductors are properly insulated and are free from outside interference. It is appreciable, however, under certain weather conditions, inasmuch as there is no absolute dielectric material, but some of relatively high resistance that are used to insulate others of lower resistance. In insulated cables the leakage current through the insulating material, the lead sheath losses and the hysteresis losses in metallic conduit should all be considered, as well as the effect of capacity and low inductance. These losses are practically in phase with the current and can be added to the resistance loss.

Inductive reactance losses are those produced by a phenomenon of electromagnetic waves at right angles to a current changing in value or direction, as with alternating current. These losses are necessarily supplied by the current circulating in the conductor, from which originates the magnetic field, and they depend primarily on the frequency of the change in velocity or direction and on the intensity of the current itself. They are also affected

Table I.—Resistance of Hard Drawn Copper and Aluminum Stranded Conductors. Conductivity: Copper, 97.3 per cent.; Aluminum 61 per cent. Temperature, 20 Deg. Centigrade or 68 Deg. Fahrenheit.

Gauge B. & S.	EFFECTIVE RESISTANCE IN OHM PER MILE OF WIRE — Copper D-C.	Copper 25-Cycle	Copper 60-Cycle	Aluminum D-C.	Aluminum 25-Cycle	Aluminum 60-Cycle
0000	0.2704	0.2706	0.2715	0.4330	0.4332	0.4337
000	0.3418	0.3420	0.3427	0.5438	0.5439	0.5444
00	0.4309	0.4310	0.4316	0.6893	0.6895	0.6898
0	0.5434	0.5435	0.5441	0.8670	0.8671	0.8674
1	0.6851	0.6852	0.6856	1.0932	1.0932	1.0935
2	0.8655	0.8656	0.8658	1.3786	1.3786	1.3788

by the spacing of the conductors (mutual inductance), and by their size, shape and permeability.

Like the ohmic resistance loss, the inductive reactance loss can be written as I^2Ri, where $Ri = 2\pi fL$, f being the frequency of the current and L the coefficient of mutual self induction of the conductor.

The resultant of the ohmic resistance and the inductive reactance represents the equivalent resistance or impedance of the circuit, and can be written:—

$$Z = \sqrt{Ro^2 + Ri^2} = \text{impedance.}$$

The effect of capacity reactance in a transmission line is to compensate for the lagging current produced by the inductive reactance, not only that of the line but also that of the load connected thereto, to the extent that the leading wattless component of the current charges the condenser represented by the line.

The capacity, and hence the charging current, of a line increases with its cross-section, and as the separation between the conductors decreases. It is of special importance in insulated cable installations and its effect on the regulation and losses should be taken into consideration in such cases, as well as when treating long transmission lines of high voltage carrying a relatively small current with respect to the power transmitted.

Thus in an alternating current circuit the ohmic resistance loss is substituted by an impedance loss, in phase with the current, which is the resultant of the ohmic resistance, hysteresis, and eddy current losses of the circuit, and denoted by Ro; and of an inductive reactance (Ri) having a negative sign, or of a condensive reactance (Rc) having a positive sign, both being at 90 deg. to the ohmic resistance Ro.

The impedance can then be expressed as follows:

$Z = Ro - jRi$, for an inductive reactance,

and $Z = Ro + jRc$ for condensive reactance

Inasmuch as the vectorial sum of these two quantities is in either case the hypotenuse of a right-angled triangle, they can be more conveniently written thus:

$$Z = \sqrt{Ro^2 + Ri^2} \text{ and } Z = \sqrt{Ro^2 + Rc^2}$$

The impedance of a conductor carrying alternating current can, in most short lines, be treated as the ohmic resistance of direct current circuits for the determination of losses and voltage regulation.

When a current I is not in phase with the voltage, but is either lagging or leading, it consists of a power component Io, and of a wattless component Ix, at right angles to Io, and such a condition can be expressed by

$$I = \sqrt{Io^2 \pm x^2}$$

The line drop then becomes by Ohm's law:

$$e = \sqrt{(IoRo + IxRi)^2 + (IxRo - IoRi)^2}$$

for a lagging current and inductive reactance,

$$\sqrt{(IoRo - IxRi)^2 + (IxRo + IoRi)^2}$$

for a lagging current and condensive reactance

$$\sqrt{(IoRo + IxRi)^2 + (IxRo - IoRi)^2}$$

for a leading current and inductive reactance

$$\sqrt{(IoRo - IxRi)^2 + (IxRo + IoRi)^2}$$

for a leading current and condensive reactance where

$e = IZ$

Along with the line constants must be considered the character of the load, as the complete circuit consists of the line with the load at the receiver's end in series with each section. The treatment of such problems requires the analysis of each section separately.

Knowing the resistance, inductive reactance and condensive reactance of a conductor per unit of length, the impedance can be calculated and then the losses and line regulation can be determined for any line voltage, load and power-factor.

The constants of a transmission line carrying alternating current can be determined from Table IA.

To apply these formulæ to a practical case, we will assume, for instance, a three-phase, three-wire overhead transmission line 10 miles long, to transmit 1,000 kw. at 60 cycle, 13,200 volts, at an average power-factor of customer's load 0.8, and with the necessary step-up and step-down transformers and substation equipment. The average annual load-factor is assumed to be 20 per cent., the revenue per kilowatt hour averaging 1.25 cents, and the ratio operating expenses to revenue 60 per cent.

Find: The permissible investment; the gauge of the conductors; the regulation of the line; the transmission losses.

Table IA.

		Single-phase	Two-phase	Three-phase
True power	W	$EI\cos.\phi$	$2EI\cos.\phi$	$EI\sqrt{3}\cos.\phi$
True power losses	w	$eI\cos.\phi$	$2eI\cos.\phi$	$eI\sqrt{3}\cos.\phi$
or	w	$I^2Z\cos.\phi$	$2I^2Z\cos.\phi$	$I^2Z\sqrt{3}\cos.\phi$
The current per wire	I	W/E	$W/2E$	$W/E\sqrt{3}$
The true current per wire	Io	$I\cos.\phi$	$I\cos.\phi$	$I\cos.\phi$
The wattless current per wire	Ix	$I\sin.\phi$	$I\sin.\phi$	$I\sin.\phi$
The potential drop per circuit	e	IZ	IZ	IZ
The impedance per circuit	Z	e/I	e/I	e/I
The impedance per wire	Z^1	$e/2I$	$e/2I$	$e/I\sqrt{3}$
The per cent. potential drop	P	$100e/E$	$100e/E$	$100e/E$
The per cent. efficiency	F	$\frac{100\,W}{W-w}$	$\frac{100\,W}{W-w}$	$\frac{100\,W}{W-w}$

Permissible Investment.—From the information available the anticipated annual gross income is:

$1{,}000 \times 0.2 \times 8{,}760 = 1{,}752{,}000$ kw.h. at $0.0125 =$ \$21,900.

With a ratio of operating to gross income of 60 per cent., the net annual revenue is:

$21{,}900 \times 0.4 =$ \$8,760.

The capital invested must earn a salary for the service it renders. Those who are responsible for its management are entitled to a compensation in the form of a profit; furthermore, the capital must be protected by a life insurance on the physical property it represents, to be taken care of by an allowance for depreciation, insurance, etc., and finally the investment is subject to fiscal taxes, all of which must be satisfied from the net earnings as follows:

6	per cent. interest on investment.
2	per cent. profit.
5	per cent. depreciation.
1.5	per cent. taxes.
0.5	per cent. insurance.
Total 15	per cent.

The above net revenue, therefore, corresponds to a capital investment of:

$$\text{Permissible investment, } \frac{8{,}760}{0.15} = \$58{,}400.$$

This capital is to be invested in the contemplated improvement as follows, based on present market prices:

1,000 kw. in step-up transformer installation, complete with switchgear and protective apparatus	\$ 8,000.00
1,000 kw. in step-down transformer installation, also complete with some housing provision for the secondary switchgear and metering devices	12,000.00
Balance applicable to line construction	38,400.00
Total investment	\$58,400.00

Gauge of Conductors.—The line and right-of-way, exclusive of conductors, may be estimated as costing today, with a substantial type of construction using wooden poles, approximately (although varying according to localities) \$2,500 per mile, or a total of \$25,000, leaving for the conductors \$13,400, which, with copper at 30 cents per pound, equals 44,666 lbs., or 1,488 lbs. per mile of wire, corresponding to No. 1 B.&S. copper conductor.

Regulation.—With a 24-in. spacing between wires, at 60 cycles, a No. 1 B.&S. stranded copper conductor at 20 deg. Cent. has an ohmic resistance of 0.6856 and an inductive reactance of 0.644 ohms per mile.

Impedance per mile of circuit:

$$Z = \sqrt{0.6856^2 + 0.644^2} = 0.936 \times 1{,}732 = 1.61 \text{ ohms}$$

and for 10 miles a total impedance of 16.1 ohms.

Line drop at full load,

$$e = \frac{43.7}{.8} \times 16.1 = 880 \text{ volts}$$

$$\text{Per cent. line drop } \frac{100 \times 880}{13{,}200} = 6.66$$

and also regulation at 0.8 power-factor, and at unity power-factor $6.66 \times 0.8 = 5.328$ per cent.

Transmission Losses.—At full load the power loss in transmission is:

$880 \times 54.7 \times 1.732 = 83.432$ kv-a., or $83.432 \times 0.8 = 66.748$ kw.

or

$54.7^2 \times 1.732 \times 16.1 = 83.432$ kv-a., or $83.432 \times 0.8 = 66.748$ kw.

or 6.66 per cent. of the full load output. The transmission efficiency of the line:

$$\frac{100 \times 1{,}000}{1{,}000 + 66.748} = 93.74 \text{ per cent.}$$

The annual transmission losses at full load are: $66.748 \times 8{,}760 = 583{,}460$ kw.-hr., or 6.66 per cent. of the full load output.

The immediate load-factor is expected to be only 20 per cent. of the output, and consequently the annual losses will be a fraction of the above full load losses, although not in the same proportion as the load-factor.

Transformation Losses.—The losses in voltage or phase transformation occurring in transformers depend not only on the efficiency of the apparatus but also on the load characteristics throughout the daily operation; that is to say, on the power-factor of the load and on the load-time curve.

When a transformer is connected to a circuit, the winding so connected is equivalent to a resistance across the line completing the circuit; the energy consumed in that part of the circuit is in proportion to its impedance and consists of exciting current. The energy loss in a transformer is made up of core or iron losses through the magnetic circuit and of copper loss in the electric circuit. The core losses for a given voltage and frequency are practically constant, so long as the properties of the magnetic material remain unchanged, while the copper loss varies with the resistance of the secondary circuit; that is, in proportion to the load or to the volt-amperes, slightly affected by variation of temperature and changes in the frequency of the current.

The energy losses and efficiencies of station transformers operating on 60-cycle circuits are tabulated in Table II.

Table II.—Efficiencies of Average Station Transformer.

% Load	5	10	20	25	30	40	50	60	70	75
% Core loss	20.00	10.00	5.00	4.00	3.33	2.5	2.0	1.66	1.43	1.33
% Copper loss	.05	.10	.20	.25	.30	.40	.50	.60	.70	.75
% Total loss	20.05	10.10	5.20	4.25	3.63	2.90	2.50	2.26	2.13	2.08
% Efficiency										
at 1.0 P.F.	82.39	90.82	95.05	95.92	96.49	97.18	97.56	97.88	97.97	97.96
at 0.8 P.F.	79.96	88.79	93.89	94.95	95.66	96.97	96.98	97.25	97.40	97.46

% Load	80	90	100	110	120	125	130	140	150
% Core loss	1.25	1.11	1.00	0.909	0.833	0.800	0.779	0.714	0.666
% Copper loss	.80	.90	1.00	1.100	1.200	1.250	1.300	1.400	1.500
% Total losses	2.05	2.01	2.00	2.009	2.033	2.050	2.079	2.114	2.166
% Efficiency									
at 1.0 P.F.	97.99	98.03	98.04	98.03	98.01	97.99	97.97	97.93	97.88
at 0.8 P.F.	97.50	97.54	97.56	97.55	97.52	97.50	97.45	97.42	97.36

THAWING EXPLOSIVES.

WHILE the following observations on the subject of thawing explosives, taken from a report on mining operations in the province of Quebec, are more directly connected with mining work, there are parts of the article that will be found of interest and value to engineers and contractors who in the course of their work find it necessary to employ explosives.

On the market to-day, there are different kinds of dynamites, which may be put under three headings: The ordinary dynamite, which crystallizes, or, as commonly said, freezes between 46° F. and 52° F.; the "low-freezing" dynamite or ammonia dynamite, which does not freeze above 35° F.; and another dynamite called non-freezing, which freezes at below 10° F.

Frozen dynamite is less sensitive to shock and consequently becomes less efficient. On the other hand, by vigorous friction, it may explode, and, therefore, is dangerous. In cold weather, dynamite must be thawed before using. This proceeding is not dangerous if done along the lines of approved methods. Accidents are known to have occurred by thawing dynamite improperly.

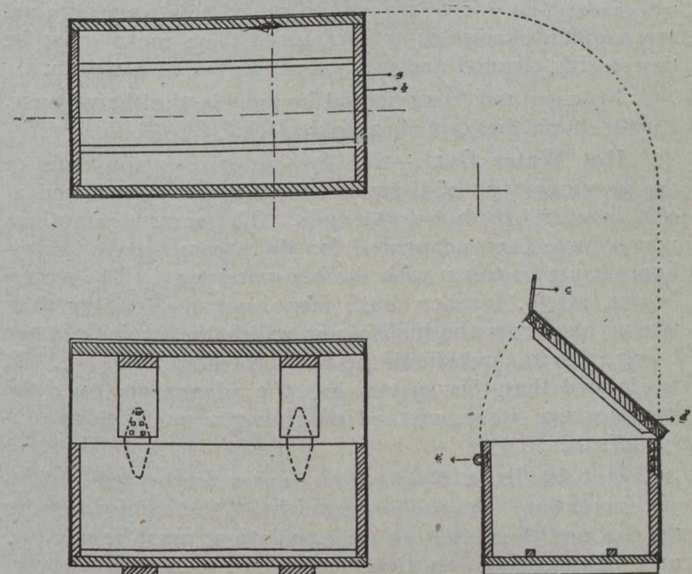
The thawing must be done slowly and by indirect heat. Dynamite should not be thawed by placing cartridges near a boiler, steam-pipe, stove, hot-iron plate, hot bricks or stone, near a fire, in hot water, in direct contact with steam, or in exposure to the sun heat. It is hardly necessary to state that it is imprudent to thaw dynamite by body heat, by carrying the cartridges inside of one's boot or inside one's clothes.

Never any more than the amount necessary for one shift should be thawed at the one time. The dynamite will lose its strength if repeatedly thawed and frozen. While being thawed, explosives should be kept in a horizontal position so as to prevent the nitroglycerine segregating at one end of the cartridge and exuding.

Frozen dynamite can be told from thawed dynamite by the rigidness and hardness of the former and the rather soft and plastic appearance of the latter.

Small quantities of dynamite may be thawed by using a water-jacketed vessel. The water used should not be warmer than what can be endured by the wrist. It should never be above 130° F. A cover should be provided for the thawer. Do not put the cartridges in the water. Warm water will give off a certain amount of water vapor which is injurious to dynamite, especially ammonia dynamite. When carrying the thawed dynamite to the place where it is to be used, take care to have it well wrapped in heavy cloth.

When more than a few sticks are needed, they may be thawed in a manure thawing-box. A tight box large enough to receive 200 lbs. of explosives is surrounded by some eighteen inches of fresh manure. This is a cheap but slow process. The cartridges should not be placed directly in the manure piles, as dynamite may absorb moisture, and, in the event of fermentation, may develop an unsafe temperature.

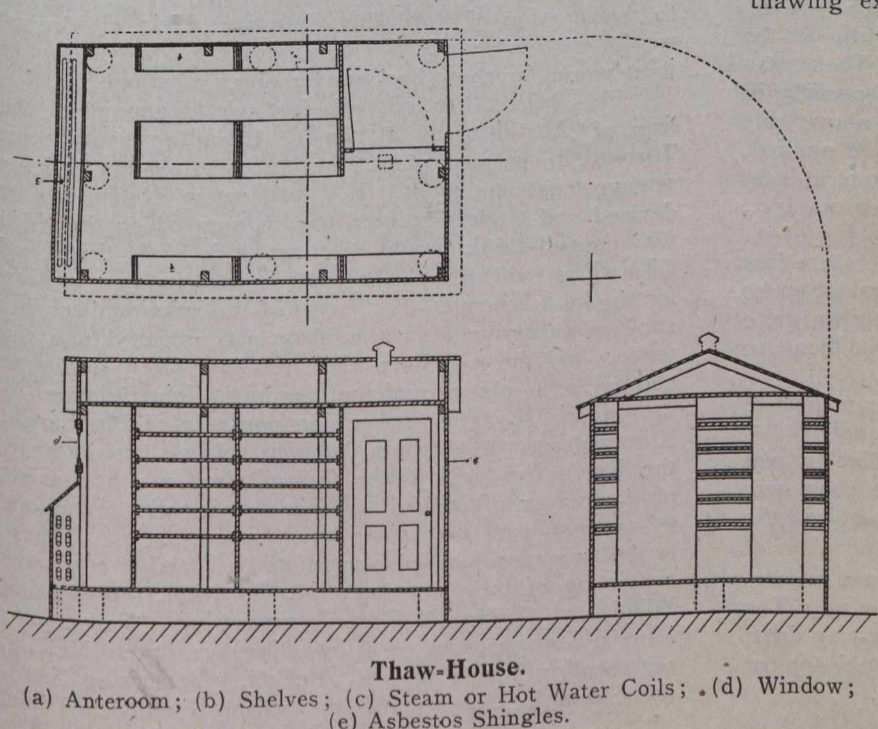


Chest for Keeping Small Quantities of Explosives.
(a) 1½-inch Board; (b) Asbestos Shingles or Corrugated Galvanized Iron Sheets; (c) Hasp; (d) Hinges; (e) Staple.

Low Pressure Steam Heat.—The safest means of thawing explosives is by low pressure steam, which is usually available from the exhaust of the engine room. This pressure should not exceed three pounds to the square inch. Every mine or quarry thawing explosives should be provided with a separate place for that purpose on the surface, or with a special underground chamber, such as a part of an unused drift or cross-cut.

Building.—A thaw-house situated at a suitable distance from dwellings and public roads, well protected from burglars, cold, fire, water and bullets, should be built not less than one hundred feet from the powder-house. What has been said as to the construction of the powder-house applies to the building of a thaw-house. Besides being well protected from the cold, it must be well ventilated. The ventilators should have trap-doors to regulate the draft. A recording thermometer should be placed inside the thaw-house, and the man in charge should see that the temperature is kept uniform.

The cartridges should be laid flat on shelves, and the heater so placed that no dynamite can accidentally fall on it. If



Thaw-House.
(a) Anteroom; (b) Shelves; (c) Steam or Hot Water Coils; (d) Window; (e) Asbestos Shingles.

dynamite is exposed for a long time to a temperature of 90° or higher, it becomes more sensitive to shock and may lose strength by exudation. In some thaw-houses, the steam coils are placed at one end of the building, in others, in the centre with the shelves on the walls, in others again, along the walls while the shelves are in the centre. The United States Bureau of Mines has advocated the construction of an extension in which the steam pipes shall be placed. The racks must be placed some distance away from the heating pipes. The building should have an ante-room opening into the room where explosives are thawed, to guard this room against any sudden change in temperature. The racks must be thoroughly cleaned and washed at least once a month.

No caps and fuses should be kept in the thaw-house. Fuses should be kept in a cold place.

Hot Water Heat.—The low-pressure steam coils of the previous type of thaw-houses, have been replaced at certain mines by hot-water coils. The same precautions which have been advocated for the steam type of thaw-house must be taken with the hot-water type. The water-heater, stove, furnace, etc., must not be nearer than twelve feet from the building in which the explosives are being thawed, and should be well protected from fire. It is claimed that this system has the advantage, over the low-pressure steam method of giving a much more uniform heat.

Hot-Air Heat. Some thaw-houses are heated by hot-air circulation. As for hot-water heat, the stove warming the air, and thus creating the circulation, must be situated at a distance not less than 12 feef from the thaw-house. This system, which has the advantage of being cheap, is not to be recommended, since as for hot-water heat, the source of heat is too near the thaw-house. It is difficult to regulate the heat. The conduit of hot-air may at a certain moment, if a defect in the chimney occurs, give passage to the smoke and gases, and perhaps also flames, from the stove, which could create quite a nuisance in the thaw-house, and perhaps be the cause of an explosion. As a general rule, wood-burning stoves or furnaces should not be erected near thaw-houses, as they often give out sparks during a strong wind, which might set fire to the surrounding buildings.

A better method of warming the air used for thawing explosives is by the use of an electric heater, either of the electric resistance or cluster lamps types. These two methods have been employed with success especially in underground thawing rooms. Again, the above rule given for the previous types of heater is to be applied. The electric heater must be placed at a distance of at least 12 feet from the explosives, in a special fire-proof box, room or building.

It must be remembered that electric heaters are less efficient and less safe than low pressure steam. Sparks and flashes may be produced, which are sufficient to ignite a fire and cause an explosion. It is also very difficult to regulate the temperature.

Of all these methods the low pressure steam heat is by far the safest.

The extra expense of constructing a pipe line to take in the steam from the exhaust of the engine room will always be warranted by the satisfaction obtained and the safety secured in thawing the explosives.

Underground Thaw-house.—No more than a twenty-four-hour supply must be taken down into a mine. The thawing-room must be located in an out-of-the-way drift, in such a way that an accidental explosion would not cut off the escape of the men working in the mine.

A very serious danger in an underground magazine and thaw-house is lightning, which may cause the explosion of the dynamite stored therein. Cases such as this are known to have happened.

CITY ENGINEERS MUST DESIGN MONTREAL AQUEDUCT POWER HOUSE.

The city engineers of Montreal must prepare plans for the power house in connection with the aqueduct enlargement, according to a decision reached last week by the aldermanic committee appointed to study the recommendation of the board of control, asking for a special credit of $45,000 to engage consulting engineers for the preparation of the plans.

The aldermen thought that there are enough employees on the city engineering staff to make it unnecessary to pay extra for such plans. The aldermen said that the board is at liberty to retain the services of one or two engineers, should the present city engineers be unfit, but they thought that there was every reason to believe that the present staff could cope with the situation, although it should be necessary to have these plans approved by some expert.

The recommendation for the credit of $45,000 came from Controller Cote and the only controller who opposed it was Mr. Villeneuve. At the time, Mr. Cote stated it was his intention to ask Henry Holgate, a consulting engineer, to undertake the preparation of the plans. Members of the aldermanic committee stated that they had no objection to Mr. Holgate personally, but were against the principle of hiring "outside" engineers.

FORD CITY PLANS OWN WORKS.

Ford City may withdraw from the Essex Border Utilities Commission and construct their own waterworks and sewers instead of building jointly with the city of Windsor and the towns of Walkerville, Sandwich and Ojibway, and the township of Sandwich West. Owing to the location of Ford City, however, their withdrawal would not necessarily interfere with the construction of joint works by the other municipalities mentioned.

The Ford City council last week appointed the firm of Aird Murray & Lowes, consulting engineers, Toronto, to prepare plans for a sewer system and for sewage treatment plant. If a satisfactory system can be devised and tenders secured for the sum which the Ford City council think should be spent, it is likely that Ford City will go ahead with the work at once without waiting for the joint scheme. If the cost of the individual scheme appears excessive after the plans are prepared and the tenders are opened, Ford City will then likely decide to stay with the other municipalities in the joint scheme.

Morris Knowles, consulting engineer of Pittsburgh, is consulting engineer for the joint scheme appointed by the Essex Border Utilities Commission, which consists of the mayor of each of the six municipalities and one other member representing each municipality. These twelve commissioners also appointed a board of engineers consisting of the following: M. E. Brian, representing Windsor; Owen McKay, representing Walkerville; Morris Knowles, representing Ojibway; Owen McKay, representing Ford City; R. McColl, representing Sandwich; and J. J. Newman, representing Sandwich West.

Editorial

THE INTERNATIONAL JOINT COMMISSION.

To devise some practical method, other than war, for securing and administering justice in the dealings of nations with each other, would be an achievement in the world's progress, and a contribution to civilization more important, more desirable and more humane than any other. It would conserve human life, the wealth and productive resources of nations, and it would promote universal happiness among all mankind to a greater extent now than ever before, because of the increased cost and destructiveness of war. These observations were made by Hon. Jas. A. Tawney, one of the United States members of the International Joint Commission, in a speech about a year ago before the Canadian Club at Ottawa, and we all most certainly agree with Mr. Tawney in his estimation of the importance of finding some method of avoiding all wars that can possibly be avoided.

To formulate a plan of procedure for this purpose, and to apply it effectively to the just and lawful settlement of international controversies, is commanding serious and universal consideration. The activities of the International Joint Commission are, therefore, particularly significant at this time. This commission has just concluded a session at Ottawa at which two most important problems affecting Canada and the United States have been settled with entire amity, *viz.*, the Lake of the Woods Levels and the Pollution of Boundary Waters. Announcement will probably be made at an early date as to the decisions of the commission in these cases. We understand that Hon. Jas. A. Tawney and Mr. C. A. Magrath are now engaged in drafting the commission's findings.

The International Joint Commission has been actively and successfully engaged for five years in finally determining important questions of difference between the people of Canada and the United States, or between their governments. By the treaty of January 11, 1909, between England and the United States, the first step towards the solution of the great problem of administering international justice through a local international judicial tribunal, so far as justiciable questions are concerned, was taken when the International Joint Commission was created and clothed with final jurisdiction.

In this commission we have a miniature Hague tribunal which has given to the world a practical, workable plan for the establishment and conduct of the business of international tribunals of this character.

It would be well to enlarge the field of the International Joint Commission's activities and the scope of its powers. There are many disputes which the International Joint Commission could readily settle over which it has no authority at present, and there should be an amendment to the treaty giving the Commission wider powers along many lines. As one instance, while the Commission has full authority over boundary waters, it has but little authority over streams which are feeders of boundary waters. For example, the St. Croix River is a boundary water between New Brunswick and Maine. If a supposed important tributary river lying entirely in the state of Maine were normally to discharge a considerable volume of water into the St. Croix River, any diversion of the tributary's flow might seriously affect the level of the St. Croix River, and Canadian interests would be affected thereby. Yet the International Joint Commission could not, under its present powers, restrain the people of the state of Maine from diverting that tributary river. The same argument applies, of course, to Canadian diversions which might injure United States interests.

EFFICIENCY AND COSTS.

Efficiency has been talked and worked extensively on this continent. Where commonsense has remained with it, efficiency has saved money, but efficiency so-called has often proved an expensive fad. Real efficiency experts there are whose services are worth money. Others there are who, like the professional merger maker, are costly articles. Efficiency in business has been analyzed from index files upwards. The simple file of old has not lost all claim to efficiency in practice. The elaborate modern system seems to require an extensive staff to operate it and largely is theory. A Toronto firm once hired a corps of efficiency experts to tell them how to run the business. So efficient was one of the experts that a week later he had obtained a job behind a lunch counter.

The secret of efficiency, after all, is costs. A knowledge of what any item in a factory costs to make and to market, the knowledge of costs generally, is the cornerstone of a knowledge of business. Many concerns that report to the federal commission of the United States, manufacture four or five different articles. In these reports the commission ask them to give the sales of each product separately. Nine times out of ten they cannot do more than give the total for all their products together. "If," as Mr. H. M. Hurley, chairman of the commission, says, "they do not departmentalize their sales accounts they certainly do not departmentalize their costs; hence they make prices on particular articles without knowing what those articles cost. Since they cannot tell where they are making money and where they are losing it, they cannot tell where to introduce economies."

The question of costs is something about which Canadian institutions have much to learn. The waste and loss of money through the lack of such knowledge has been appalling. One moderately sized Canadian factory, for example, had until recently only a vague idea of its costs. It possessed an office staff almost big enough to run the business of the United States Steel Corporation. Dividends do not grow on such practices.

ORGANIZATION FOR COUNTY ROAD IMPROVEMENT IN ONTARIO.

Alive to the importance of doing whatever is possible to prepare for the employment of the men who have gone to the front and who will ultimately return to this country, the Department of Highways for Ontario has issued a pamphlet, entitled "County Roads," and is circulating these pamphlets very widely throughout the province. There is no doubt but that road-building can be made to play an important part in the solving of this problem, provided the various counties in the province will take advantage of the Highway Improvement Act, by which they can assume a system of roads for construction and maintenance under a plan which is essentially sound in principle and at the same time not burdensome in cost. So far there are twenty-one counties operating under the Act, but it is very desirable that the remaining sixteen counties in the province should take advantage of the opportunities under which they can secure the highway improvements given. At the same time, in doing this they would be helping to solve one of the problems which will be a very real one during the period of readjustment at the close of the war. In order, however, that this might be done so as to render the maximum of service to our men in the field, and also the counties concerned, organization should be carefully considered and created now and not left over indefinitely. We heartily commend the careful reading of this pamphlet to all county councils who are not now taking advantage of the organization which the Department of Works and Highways is willing to place at their disposal. Road-building is necessarily a slow process. It takes a good many years to complete a county road system, and the work should, therefore, be financed on the annual basis. The Act is sufficiently flexible to meet special conditions on an equitable basis. The provincial subsidy is 40 per cent. of the total expenditure. For every thousand dollars spent by the county the province contributes $666, and the county thus has $1,666.66 available. Furthermore, the province also contributes 20 per cent. of the total cost of maintenance.

PERSONAL.

F. W. BLYTHE, for fifteen years district manager of the Canadian Allis-Chalmers, Limited, at Winnipeg, has been promoted to the head office of this company at Toronto.

CHARLES LEWIS WILSON, assistant general manager, Toronto and York Radial Railway, has been elected vice-president of the Canadian Electric Railway Association for the current year.

WILL HAYLMORE, superintendent at the Coronation gold mine, on Cadwallader Creek, in the Bridge River section of Lillooet district, British Columbia, has joined the 6th Field Company, Canadian Engineers, for overseas service.

O. J. ROOT, president of the Root and Vandervoort Engineering Co., East Moline, Ill., who is making a business trip through Canada, paid a visit to Toronto on his way to St. John, N.B.

W. L. McFAUL, formerly assistant in the city engineer's department, Sault Ste. Marie, has been appointed city engineer to succeed W. W. Van Every, who has been appointed manager of the Sault Ste. Marie Water and Light Commission.

Dr. J. S. PLASKETT, Dominion Government observer, delivered a lecture on October 4th before the Victoria Branch, Canadian Society of Civil Engineers, on the new observatory and telescope in process of completion at Little Saanich Mountain, Victoria, B.C.

J. F. S. MADDEN, formerly manager of the Canadian General Electric Company at Winnipeg, has been promoted to the head office of the company at Toronto. Mr. Madden was a member of the Winnipeg branch of the Electrical Section of the Canadian Society of Civil Engineers. He will be succeeded at Winnipeg by GEORGE R. WRIGHT, formerly assistant district manager of the company at Vancouver.

W. P. KELLETT, of Brantford, Ont., has been appointed a member of a board of engineers which is soon to make a valuation of all railway properties in Canada, under the direction of the commission recently appointed to inquire into railways and transportation. Mr. Kellett is connected with the Dominion Steel Products Company, Brantford, whose plant is now under construction, and was formerly chief engineer of the Lake Erie & Northern Railway, which is now part of the C.P.R. system.

Lieut.-Col. CHARLES H. MITCHELL, D.S.O., of Toronto, has been appointed to the position of First Staff Officer of the second British army in France, the most important post yet given to a Canadian by the British military authorities. Before the war, Colonel Mitchell was an officer in the Corps of Guides, and was head of the firm of C. H. & P. H. Mitchell, consulting engineers, Toronto. He is also a former chairman of the Toronto branch of the Canadian Society of Civil Engineers.

OBITUARY.

ROBERT BURNS McLELLAN, a civil engineer of Vancouver, died recently at the age of 27. Mr. McLellan was a graduate of McGill University where he obtained the degree of B.Sc., and in partnership with Mr. R. Horie had opened an office in Vancouver as civil engineer and land surveyor.

Private JOHN SANDFORD TAYLOR, who is reported to have lost his life at the front, was born at Bothwell, Ont., and educated at St. Andrew's College and at the University of Toronto. At the latter institution he qualified as a mining engineer. He practised his profession subsequently in the Porcupine district. Private Taylor went overseas with the Borden Armored Battery in April, 1915.

Major JAMES SHEPPARD, of Queenston, Ont., superintendent of the Welland County good roads system for the past three years, was struck and killed by an M.C.R. train on October 10th while driving his auto over the railway crossing at Brookfield. Mr. Sheppard was 72 years of age and had been a resident of Queenston for over 50 years. He was a delegate to and a director of the first good roads association organized in this province, becoming vice-president and manager. Later he was demonstrator with the Sawyer-Massey Co. for its road machinery, and had charge of the building of one mile of sample macadam road in each of twelve eastern Ontario counties. After that he was sent to British Columbia by the Dominion Government to aid in the promotion of good roads. He had also built Dundas Road in York County, Ont., and Queen Street from Toronto to Etobicoke, Ont. Last year alone, $232,000 was spent on good roads in Welland county under his supervision.

COMING MEETINGS.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, Toronto Section. Meeting will be held at 8.15 p.m. on Friday, October 20th, 1916, at the Engineers' Club, when an address will be given on "Accident Prevention," by Charles B. Scott, general manager, Bureau of Safety, Chicago. Secretary, Wills Maclachlan, 910 Excelsior Life Building, Toronto.