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Contents of this issue on page 677

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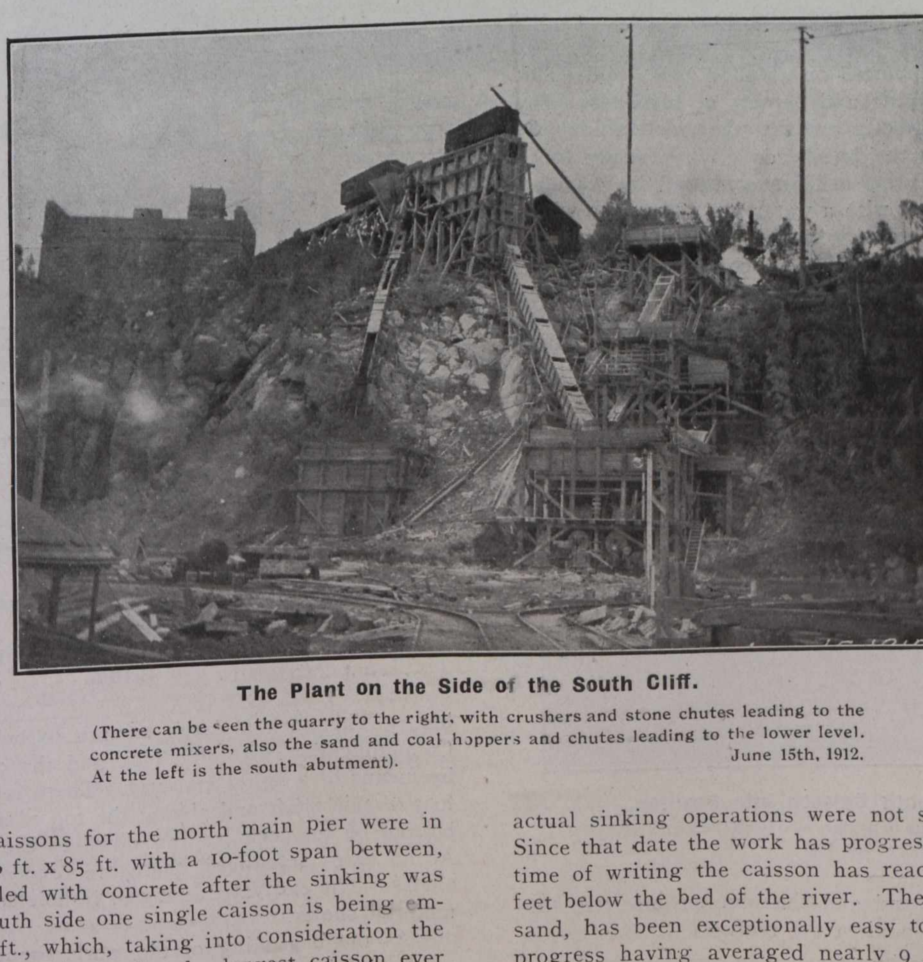
THE CONSTRUCTION OF THE SOUTH MAIN PIER OF THE QUEBEC BRIDGE.

By H. P. BORDEN, Assistant Engineer Quebec Bridge Commission.

Owing to the fact that the steel superstructure of the new Quebec Bridge is some 21 feet wider and nearly twice as heavy as the old bridge, it was necessary to construct entirely new piers for the new structure. This work has been going on for the past two years, and will probably require another year to finish.

The bridge has three approach spans, two on the north side and one on the south, having a total length of 409 feet, two anchor spans of 515 feet each; two cantilever spans 580 feet each, and one suspended span 640 feet in length, or a grand total of 3,239 feet face to face of abutment. The channel span is consequently 1,800 ft. centre to centre of main piers, being the same as the old bridge.

Last season the caissons for the north main pier were successfully sunk to a solid bottom some 80 feet below high water, or 50 feet below the bed of the river. This season the contractor has concentrated his efforts upon the sinking of the mammoth caisson for the south main pier. The caissons for the north main pier were in two sections each 60 ft. x 85 ft. with a 10-foot span between, this space being filled with concrete after the sinking was effected. On the south side one single caisson is being employed 180 ft. x 55 ft., which, taking into consideration the great depth it must go, is by far the largest caisson ever employed on a work of this kind. The caisson is being carried down to solid rock 85 feet below the level of the river bed and 100 feet below extreme high water.



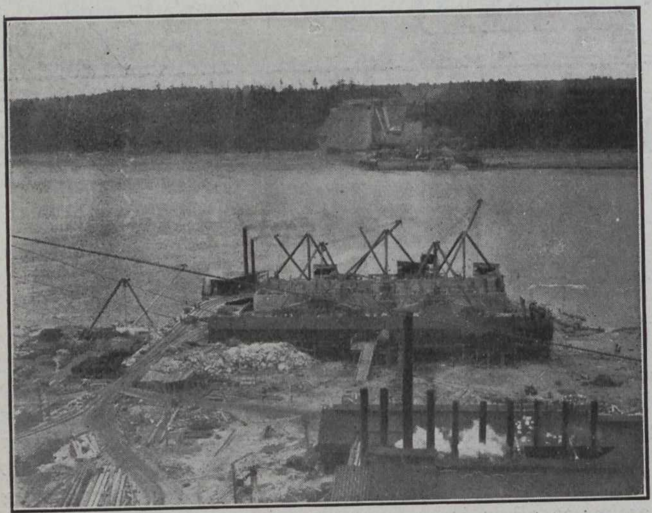
The Plant on the Side of the South Cliff.

(There can be seen the quarry to the right, with crushers and stone chutes leading to the concrete mixers, also the sand and coal hoppers and chutes leading to the lower level. At the left is the south abutment). June 15th, 1912.

The caisson was floated into position last season and grounded on a prepared bed which is exposed at low water. It remained here all winter, guard piers of rip-rap being placed along its sides to protect it from the ice. The rip-rap was mostly broken concrete taken from the old pier in course of demolition situated just outside the caisson. Weep holes were provided in the roof over the working chamber to allow free movement of water during the high tides, and thus guard against any floating of the caisson when once properly grounded. As the water rose several feet each tide above this roof it was feared that if snow were allowed to accumulate ice would form and tend to strain the structure. To guard against this contingency, the caisson was entirely housed over, and as a further precaution steam pipes were led around the walls just above the roof of the working chamber, steam being supplied by a boiler on top of the caisson. It was found, however, that the steam heating was not necessary as the interior kept sufficiently warm to prevent ice from forming.

Owing to a very late spring, actual sinking operations were not started until June 15th. Since that date the work has progressed steadily, and at the time of writing the caisson has reached bed rock, some 85 feet below the bed of the river. The material, being mostly sand, has been exceptionally easy to penetrate, the rate of progress having averaged nearly 9 inches per day for the entire time. Some weeks, however, the rate has averaged as high as 15 inches per day.

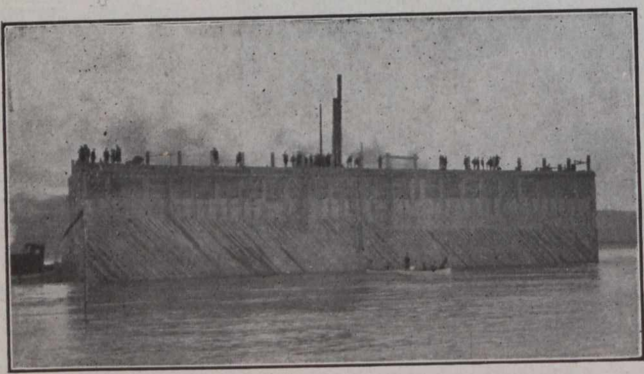
Owing to the unusual size of the caisson, extraordinary precautions were considered necessary to provide against any unequal settlement or any twisting or other movement of the caisson which might tend to open up the joints and seams and consequently allow air to escape. On this account it was decided that the ordinary method of sinking, where all the load is carried on the cutting edge, would not allow the movements of the caisson to be sufficiently controlled during the actual sinking. The rather unusual method has therefore been employed of carrying the entire



The Plant on the South Side, Showing Caisson During Sinking.
(The plant on the north shore across the river can be distinguished).
July 15th, 1912.

load on the bulkheads and the roof and no load at all on the cutting edge.

The caisson was supported on 40 sand jacks and about 25 posts 12 x 12 yellow pine and 54 sets of blocking. The jacks and posts bear directly against the roof while the blocking is piled under the bulkheads. When ready for a drop the blocking and posts are first removed by washing the sand from under them with a water jet. Then the whole caisson is lowered by operating each sand jack simultaneously. The sand jacks are of simple construction, consisting of a steel cylinder 29 inches in diameter closed in at the bottom. Near the bottom are two holes about 3 inches in diameter with a sliding cover. The plunger is a single piece of timber fitting easily into the cylinder. The cylinder is

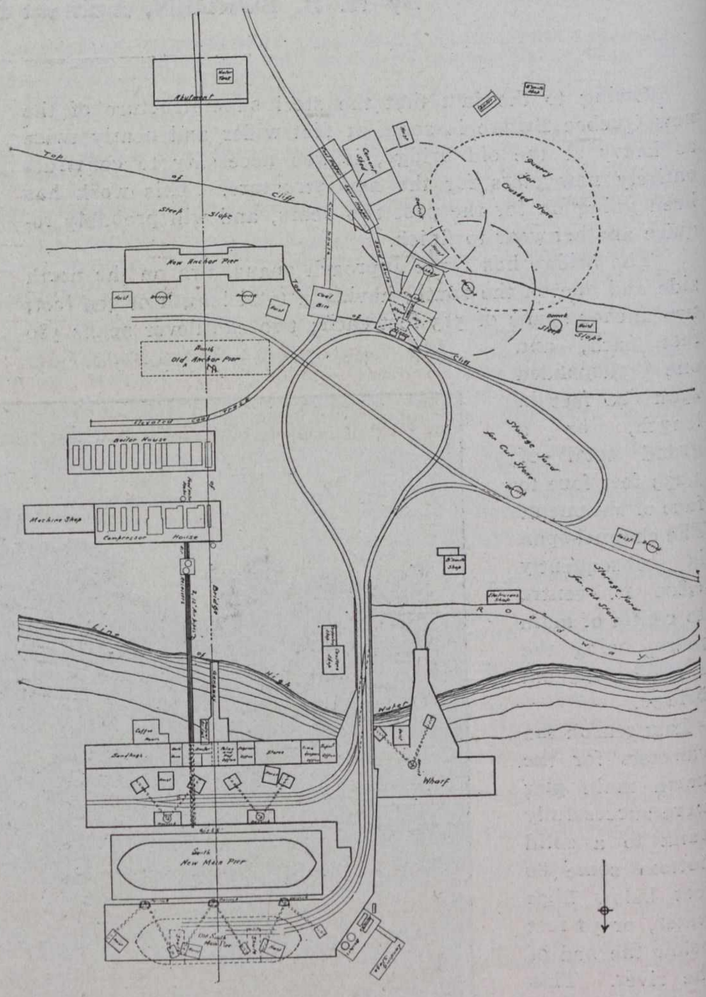


Floating the South Caisson into Position.
(Its huge proportion shows up in comparison with the men and boats).
May 28th. 1911

filled two-thirds full of sand and the plunger inserted, the upper end being blocked against the roof.

The operation of lowering consists in opening the lower holes and placing a water jet therein, thus working the sand out. These jacks have been found to work admirably on this work, the result being that the caisson has been sunk absolutely level and in its proper location. Before each drop a trench was excavated under the cutting edge to a depth of two or three feet. This space was then filled with clay, which tended to prevent the escape of the air, and further acted as a lubricant during sinking. This scheme was followed throughout the entire sinking and seemed to materially facilitate the operation. The material encountered varied from small boulders and sand at the top to practically 95 per cent. sand towards the bottom. The sand is blown out through four-inch pipes by means of the compressed air. Ten of these pipes are in use and remove the fine material very rapidly. The larger material is removed through the material shafts in half-yard steel buckets. It has been necessary to do very little blasting.

Owing to the great depth of the caisson, special means have been employed to enable the men to enter and leave the working chamber with the least possible loss of time and labor. To this end an open shaft extends down to a horizontal steel lock placed over the roof of the working chamber.

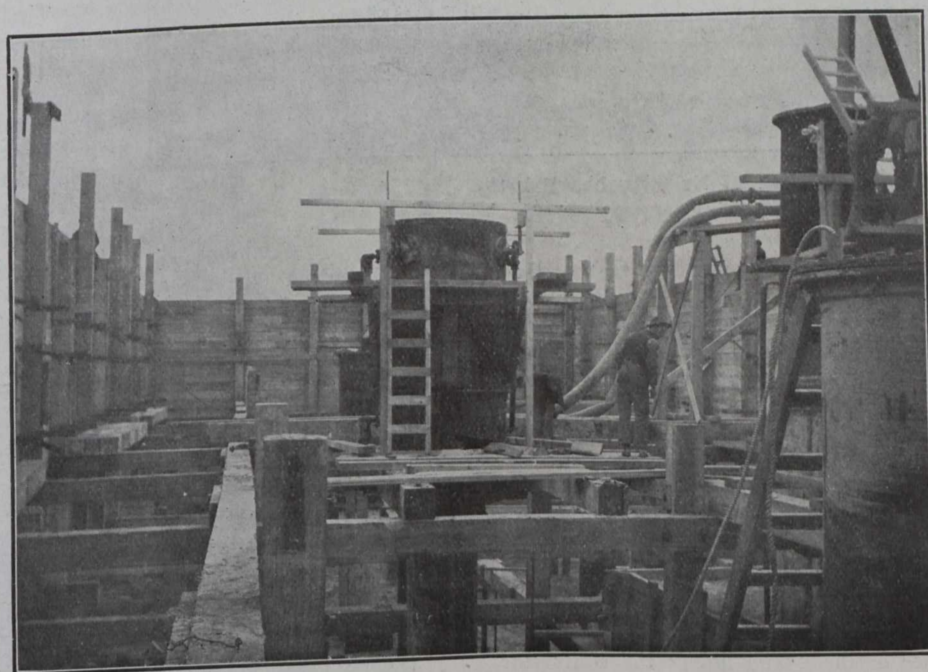


Contractors' Plant on South Side of River, New Quebec Bridge

This lock is large enough to hold the entire shift. Communication with this lock and the outside air is made by means of a spiral stairway. There is an air valve at the foot of this shaft and also at the top of another shaft in the bottom of the lock leading down to the working chamber. As an extra safeguard, there are four other 30-inch ladder shafts. The excavated material is hoisted out through three material shafts.

At the beginning of the work about 300 "sand hogs" were used in three eight-hour shifts of 100 men each. As the caisson was sunk and the pressure increased the length of the shift decreased. At 50 feet below average high water or a pressure of about 22 lbs. per square inch, a change in working hours was made to four shifts of six hours each. At 65-foot depth or 32 lbs. pressure six shifts of four hours was required. Again at 75 feet the shifts were changed to eight of three hours each. When the caisson reached its full depth of over 90 feet below average high water two one-hour shifts per day were required, this being the greatest length of time that the men could stand the very heavy pressure.

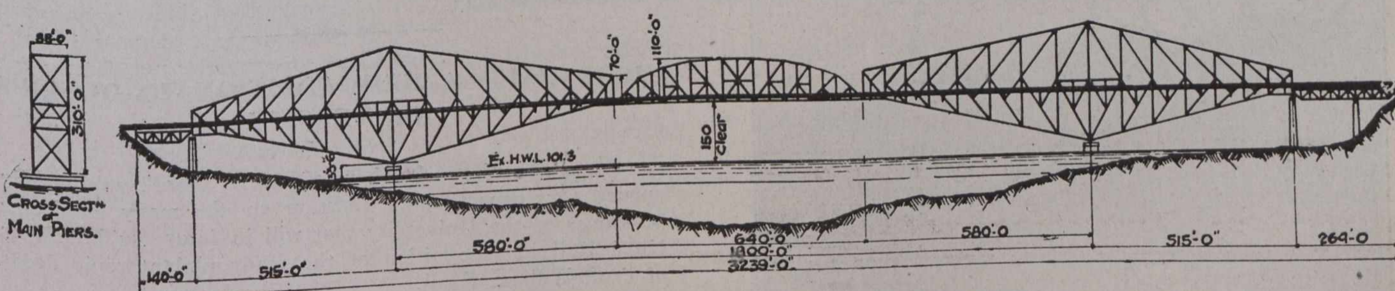
Outside the caisson the contractor has made provision for the care of the men in many ways. In addition to a bunk-house and dining-room, there is a dressing and coffee house where "sand hogs" coming out of the caisson may change their clothes immediately and be supplied with hot coffee. Next door is an hospital with cots and a qualified doctor in constant attendance. Adjoining the hospital is a steel hospital tank connected with the compressed air pipes where men who have come out of the pressure too quickly and are attacked by the "bends" can be placed immediately under pressure again before any serious or injurious effects can develop. The caisson is surrounded on three sides by a heavy platform supported on bents. On this platform is a double line of track leading to the concrete mixers and stone yards. The skips with the loaded concrete buckets run from the mixers to the caisson by gravity, the empty skips being hauled back by horses. Three 15-ton stiff-legged derricks are placed on each side of the caisson and are used to deposit concrete, stone, or hoist the



View of Interior of South Caisson.

(The large shafts are for material, while the smaller are ladder shafts for the men). June 15th, 1912.

The compressor plant consists of five Ingersoll-Sargeant direct compressors, four with a capacity of 1,250 cubic feet, and one with a capacity of 2,500 cubic feet per minute. This plant was used on the north shore last season. To this has been added, this season, two compound two-phase air compressors bringing the total capacity up to 13,100 cubic feet per minute. These two latter compressors were used only when the pressure got above 30 lbs. per square inch. The air is first compressed in the low-pressure cylinder up to 30 lbs. per square inch, then it is passed through a cooling chamber into the high-pressure cylinder where the compression is increased as desired. There is in addition a smaller high speed compressor for supplying air tools, etc. In the compressor house there is an automatic register indicating on a diagram the pressure at all stages of the tide during the whole 24 hours. Another gauge, by means of a finger operated by the tide, indicates on an adjustable scale what the pressure should be at any stage of the tide. By this means the operator can, by watching the finger, so adjust his compressors so that a pressure is intelligently maintained conforming to the height of the tide. The air is led from the compressor house into two receiving tanks, which tends to absorb the sound and shock from the compressors; thence into two 12-inch mains which are laid in a trough of cold, running water.



General Elevation and Cross Section of New Quebec Bridge.

(St. Lawrence Bridge Co. Ltd., contractor for superstructure).

loaded buckets through the material locks. On this platform is also the pump which supplies the water to the boiler plant and for various other uses as required.

The boiler and air compressor plant is situated near the foot of the cliff. A portion of this plant was brought over from the north shore last fall after the sinking of the north caisson was finished, but this has been increased nearly 100 per cent. in order to afford a greater reserve supply in case of break-down and also to furnish air for the increased number of blow pipes necessitated by the greater quantity of fine material encountered in the sinking.

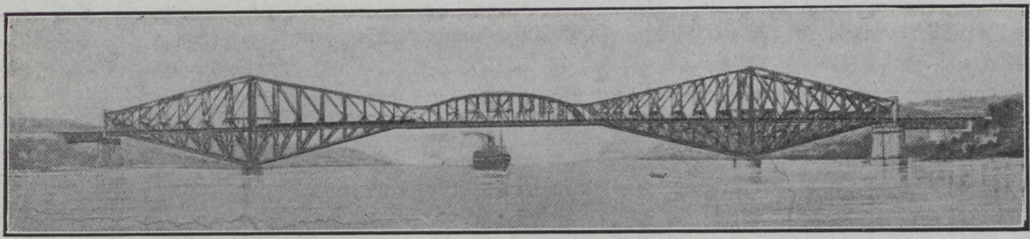
The air, therefore, enters the caisson comparatively cool, the temperature of the working chamber rarely exceeding 80 degrees Fahr.

The boiler plant consists of one 75, six 100 and three 125 horsepower horizontal boilers, and three 250 horsepower Heine water tube boilers with a total capacity of 1,800 horsepower. A number of 50, 75 and 100 horsepower boilers are also used throughout the work, crushers, mixers, derricks and pumps.

The whole plant, as well as the working chamber of the caisson, is lighted by electricity supplied by the city.

In case of break-down on the power line the contractor has provided a complete generator plant located on the compressor house. It is equipped with a 30- kilowatt General Electric Company generator capable of operating 16 arc lights and 100 sixteen-candle-power incandescent lights.

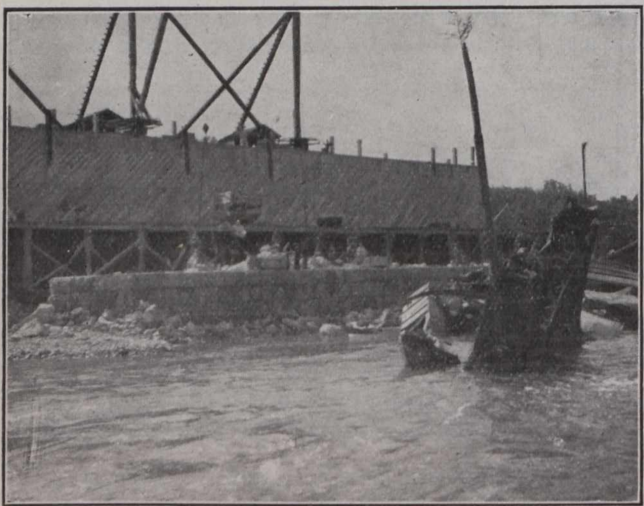
The concrete masonry plant is situated at the foot of cliff which rises almost perpendicular for 125 feet. Half way up the cliff a No. 5 and No. 8 rock crusher is situated. The stone is quarried directly on the brow of the cliff, and is so situated that one derrick can pick up the buckets of stone from the quarry and dump it into the chute leading to the crushers. Coming from the crushers the broken stone is led through a revolving screen, thence through another chute to a hopper opening onto the mixing platform. Two Smith mixers are used, each having a capacity of 1⅓ cubic yards. The sand is brought to the brow of the cliff in cars and dumped into a large hopper. A chute leads from this hopper directly to the mixing platform. The coal is brought to the lower level in the same manner and is carried to the boiler house in side dump cars.



Sketch of New Quebec Bridge
as it will appear when finished).

For the convenience of the "sand hogs" the contractor has erected a bunk-house adjacent to the work with sleeping accommodation for about 100 men. A dining-room is run in connection, which will accommodate about as many more.

The south main pier, when completed, will contain about 35,000 cubic yards of masonry. For a height of 75 feet above rock, or some 6 feet below low water, it will consist of a solid mass of concrete the full size of the caisson.

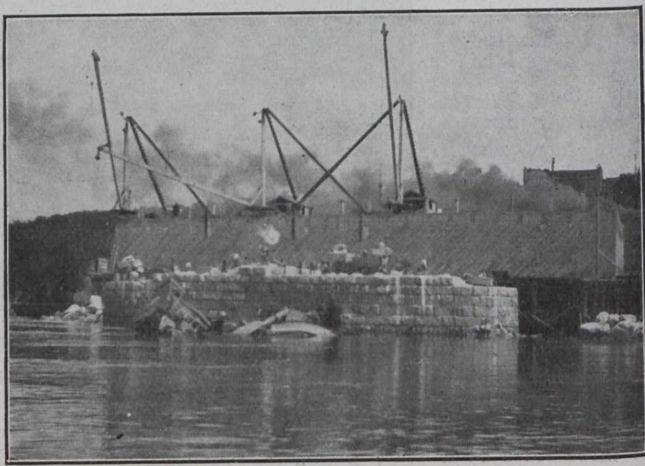


The Work of Demolishing the Old Main South Pier.
(A portion of the wreck of the fallen structure is seen in the foreground).
August 25th, 1911.

From this point the shaft of the pier will start having a solid granite face and backing of concrete. The upper 18 feet will be of solid granite.

The concrete used for the main body of the caisson is composed of one part cement, two and one-half of sand, and five of broken stone. For sealing the working chamber a somewhat richer mixture is specified, viz., one of cement, two and one-half of sand, and four of stone. Displacer stones one-half a cubic yard and over are used in the concrete, no two stones to be closer than 9 inches vertically or 12 inches horizontally.

The work is under the supervision of a board of engineers, appointed by the government, of which Mr. C. N. Monsarrat is chairman, having associated with him Mr. Ralph Modjeski, of Chicago, and Mr. C. C. Schneider, of Philadelphia. Mr. J. D. Wilkins is resident engineer for the board at Quebec, and has charge of all inspection. Messrs. M. P. and J. T. Davis, of Quebec, have the contract for the masonry, Mr. S. H. Woodard, of Noble and Woodard, consulting engineers, New York, being superintending engineer for the contractors in charge of the entire work.



The South Caisson in Place, Behind the Old South Main Pier.
August 10th, 1911.

NICOL HALL, A NEW ADDITION TO QUEEN'S UNIVERSITY.

On Wednesday, October 16th last, there was formally opened for inspection an addition to the many handsome buildings of the University that will in future be known as Nicol Hall in recognition of the many philanthropic deeds of Prof. William Nicol.

This building will be occupied by the mining and metallurgical departments and the basement of the building is given over to the fire laboratories, gasoline furnaces, gold and silver work, balance-room with chemical laboratories, metallurgical laboratory, equipped with roasting furnaces, blast furnaces and accessory appliances, etc.

On the main floor there is a large classroom, with accommodation for eighty students; there are research laboratories, and Prof. S. F. Kirkpatrick's room. The halls are very bright and it is the intention to use them for a museum.

The second floor contains a drafting-room, lecture-room, with the office and library of Prof. John Gwillim.

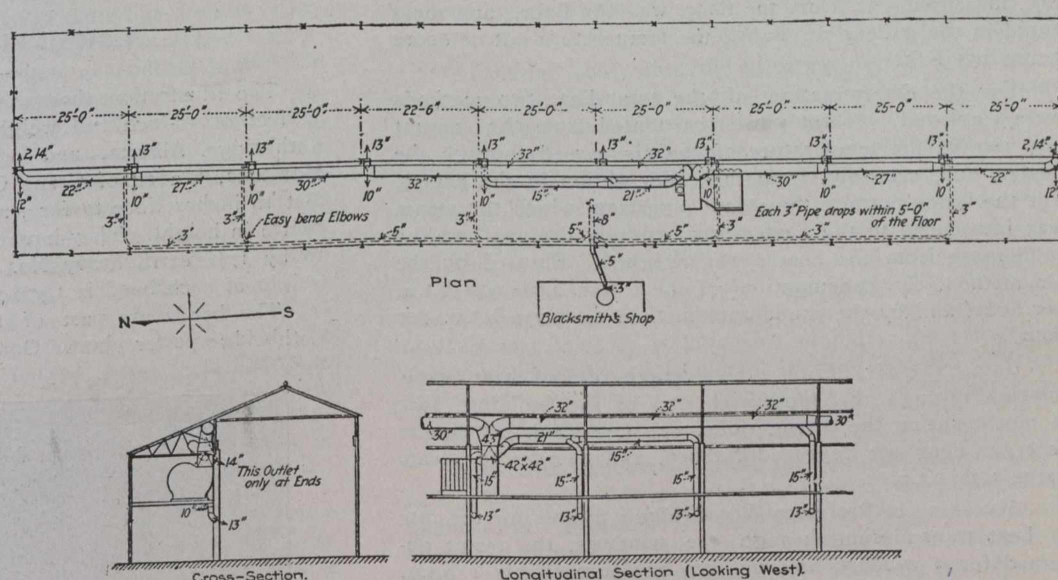
The third floor has not been fitted up as yet.

HEAT TRANSMISSION THROUGH CORRUGATED IRON.

An investigation to determine the coefficient of heat transmission through corrugated iron sheathing has recently been conducted by the Green Fuel Economizer Company, of Matteawan, N.Y., with the view of securing reliable data to be used in the calculation of the heating requirements of such buildings. Experiments were made in a shop of the company, used for the manufacture of fans and blowers.

The building is 225 ft. long by 48 ft. wide, with an average height of 32 ft. There are continuous windows on one side 15 ft. high and on the opposite side 19 ft. high. Otherwise the building is covered with corrugated iron of single thickness without lining. The crevices at the eaves are filled with asbestos and the corrugated iron is cemented in at the bottom, and other measures have been taken to make the building as air tight as possible. The exposure of the windows is east and west, the smaller windows being on the east side.

A study of the available data on the subject showed the coefficient for the rate of heat transmission through single windows with a southern exposure to be 1 b.t.u. per square foot per hour per degree difference in temperature between inside and outside, according to Prof. Homer Woodbridge. For northern exposure the same authority suggests adding 35 per cent., for eastern exposure 15 per cent. and for western exposure 25 per cent. According to Mr. Ludwig Dietz, quoting Dr. Rietschel, of Berlin, and also the specifications of the Prussian Government, the coefficient for single windows is 1.026, with an increase of 10 per cent. for northern, northeasterly or northwesterly exposures and 10 per cent. for especially strong winds. The only figure for corrugated iron without sheathing that has been found is one of 2.132 by Dr. Rietschel, but without any statement as to whether this refers to superficial wall area or to the actual surface of the iron.



Plan and sections of New Fan Building, Green Fuel Economizer Company.

The formula commonly employed for the determination of the coefficient of heat transmission from one fluid to a solid substance and from the solid to a second fluid is of the form,

$$k = \frac{1}{\frac{1}{Ai} + \frac{1}{Ao} + \frac{x}{e}}$$

wherein Ai is the transmission from the inside fluid to the wall surface and Ao is the coefficient of heat transmission from the outside wall surface to the second fluid, e is the conductivity of the material in heat units per square foot per hour per degree difference per inch of thickness, and x is the thickness in inches.

For the value of Ai and Ao Mr. Grashof gives the following equation:

$$a = c + d + \frac{(40\,c + 30\,d)}{10{,}000}\,T$$

in which c depends upon the velocity of the fluid. Dr. Rietschel gives for air at rest c = 0.82; in slow motion, as in contact with cold windows, c = 1.03; in rapid motion, as outside of buildings, c = 1.23. d for glass is given as 0.60 and for sheet iron as 0.57. T for single windows is given as 36, no value being given for iron.

Calculating from the above values, we find that for a single glass window Ai is 1.84 and Ao is 2.07. For sheet iron the value for Ai equals 1.81 and for Ao equals 2.04.

For e Dr. Rietschel gives 190 for iron and 6.6 for glass. It will therefore be seen that the third term in the denominator of the expression for k can be neglected for iron and is practically negligible for glass.

Using the values of Ai and Ao just found, k for a single window works out as 0.958 and for a single thickness of sheet metal as 0.955, practically the same.

This, however, is not taking account of the additional surface of the sheet metal wall due to the corrugations. The corrugated metal used in the building under discussion has one corrugation to every 2½ in., the depth of the corrugation being 1 in. The actual surface of the metal is approximately 1.35 times the superficial area. This would make the rate of heat transmission for corrugated sheet iron, figured on the basis of superficial area, approximately 1.35 times 0.955, or 1.29.

According to the engineers conducting the test the values obtained by Grashof's method for both glass and sheet iron are lower than the values used in ordinary practice. This may possibly be explained on the hypothesis that the constants used in ordinary practice have been increased to account for losses due to leakage, the opening and shutting of doors, etc. Weight is lent to this view by the results of the tests which follow, bearing in mind that the construction of the present building makes it practically air tight. At the same time the values obtained were slightly greater than Grashof's formula would call for. The sheet-metal-working machinery and shafting housed in the building were in constant operation during the test, producing heat which was not measured, while, on the other hand, doors were being opened for the passage of men and materials on an average of once every ten minutes.

The total surface of the building is made up of approximately 7,538 sq. ft. of window, including the sash, 8,247 sq. ft. of wall surface and 11,925 sq. ft. of roof, the walls and the roof being given in superficial area. The total of wall and roof areas is 20,172, which, increased by the factor 1.35 to account for the corrugations, gives 27,130 sq. ft. total metal surface. The total superficial expanse of the building is 27,710 sq. ft., and the total actual surface, counting the metal in the corrugations, is 34,658 sq. ft.

The building is heated by a Green's hot-blast heater, consisting of an engine-driven centrifugal fan drawing through a "Positivflo" heater made up of six sections of four rows of pipe each, the sections measuring 7 x 8 ft. The heater is ordinarily drained of condensate and air by a Dexter vacuum system. There are altogether 6,816 lineal feet of 1-in. pipe in the heater, or 2,272 sq. ft. of heating surface. The air is distributed throughout the shop by circular sheet iron conduits with outlets directed down into the zone occupied by the workmen.

The fan and heater had been running for about two hours when the first readings were taken at 8:30 a.m., and the temperature of the shop was maintained constant until readings were discontinued at 11:30 a.m.

During the test the fan was run at 258 r.p.m., receiving 22,416 cu. ft. of air per minute, figured to 50° Fahr., the air actually being received by the heater at 73° Fahr. and delivered from the fan at 156° Fahr. The temperature of the steam in the heater was 212° Farr. The temperature of the air delivered from the farthest outlet was found to be 141½° Fahr. Under these conditions the temperature of the building, measured 3 ft. from the floor, was 66° Fahr., and measured in the gallery 70° Fahr., the temperature out of doors being 15° Fahr.

For the determination of the total heat two methods were employed. First it was calculated from the amount and rise in the temperature of the air passed through the heater, and, secondly, from the condensation in the heater. For the latter purpose the steam pipe from which the steam was introduced to the heater was carefully drained and the condensate from the heater was weighed. Figured by the air method, the consumption of heat was 2,084,000 b.t.u. per hour, and by the condensate method 2,029,730 b.t.u. per hour.

Using the air figures, the average rate of heat transmission through the superficial area of the building, that is, not counting the corrugations, was 1.42 b.t.u. per square foot per hour per degree difference, and using the steam value 1.38 b.t.u.

According to Professor Woodbridge's figures for the rate of heat transmission through the windows, the result obtained for a window on southern exposure equals 1 b.t.u. per square foot per hour per degree difference, which, however, is to be increased 15 per cent. for eastern exposure and 25 per cent. for western exposure, or in the present case an average of approximately 20 per cent. Figuring the window surface as 1.2, the value for the corrugated iron, figuring superficial area only, is 1.5, or figuring the whole surface of the iron 1.13, that is, less than an equivalent amount of glass surface. According to the engineers the explanation in that case may be that the corrugations in the iron protect the surface to a certain extent, that is, that the rate of heat transmission per square foot of actual surface through corrugated iron is less than it would be if transmitted through a flat iron surface.

Using the value obtained by Grashof's method for the glass windows, namely, 0.958, the value for the actual iron surface equals 1.19, but, in the opinion of the engineers, on the basis of this formula, there would be no reason for expecting any such difference between the iron and the glass.

Allowing for the many undeterminable conditions, it is suggested that in calculating the heat supply for buildings of this kind provision be made for a coefficient of transmission of 2 b.t.u. for the whole wall and roof area.

The coefficient of transmission through the surface of the hot-blast heater in this test was 9.41 b.t.u. per square foot per hour per degree average difference in temperature between the air and the steam, figured by the ordinary arithmetical method in which the average difference in temperature between the steam and the air is assumed to be the difference between the steam temperature and the mean of the air temperature on entering and leaving.

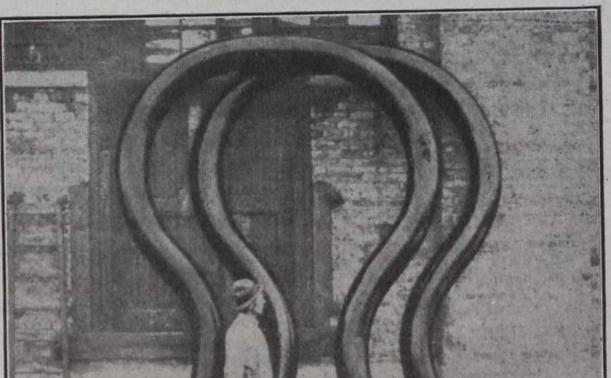
Figured according to the logarithmic formula, which takes account of the fact that the air arises more rapidly in temperature in passing over the first rows of tubes than in passing over the later rows of tubes, the value is 10. The mean physical velocity of the air through the heater was 1,210 ft. per minute.

In a subsequent test, with air entering at 72° Fahr. and leaving at 166° Fahr. and steam at 213° Fahr., in which the velocity of the air was 760 ft. per minute, a coefficient of transmission of 7.5 (logarithmic) was obtained. Ten and seven and a half are in the ratio of 0.64 powers of the respective velocities, that is, the coefficient did not vary directly as the velocity, as frequently asserted. If instead of mean velocity flow in pounds of air per minute through the heater is used, which amounts to the same thing as velocities reduced to a standard temperature, the coefficients are found to be in the ratio of the 0.62 powers of the rates of flow.

LARGE PIPE BENDS.

The illustration shows two "N" bends each containing 34 feet of 10-inch full weight pipe, made for the city of Lethbridge, Alberta, and ordered through the Winnipeg, Manitoba, branch of Crane Co. These bends measure 11 feet 10 inches, face to face, and 10 feet 11 inches, centre to centre in height. They have a 3-foot 2-inch radius with four 10 by 17½ extra heavy No. 295 E. welded flanges. The weight of each bend is 1,570 pounds.

The bends are part of the main steam piping in the Lethbridge power plant. One bend is in a vertical position,



Large Pipe Bends for Lethbridge, Alberta.

supported from the roof truss; the other lies horizontally, supported from I-beams in the fan gallery. The working steam pressure of the line is 160 pounds, with superheat of 130 degrees. The engineer of the plant preferred to take care of expansion with these large N shaped bends rather than with sliding expansion joints. The specifications called for piping having a tensile strength of 58,000 pounds to the square inch, an elastic limit of 34,000 pounds per square inch, elongation of 22 per cent. in 8 inches, and a reduction in area of 55 per cent. Owing to the large size of the bends they had to be welded at the top of the bend, there being about a foot of straight pipe at that point.

CHEMISTRY OF SEWAGE PURIFICATION.*

By Dr. Arthur Lederer.†

Sewage may be purified in part either by mechanical, chemical, or biological means, in combination or separately. Thorough knowledge of all the agencies at work in the biological purification of sewage has not been attained. The clarification of sewage by chemicals is easily explained by the reaction taking place, and the mechanical action of the floc formed. Since biological treatment is very largely used, more time will be devoted to that general process.

Unless specifically stated to the contrary, the remarks in this paper refer to dilute domestic sewage, and not to trade wastes. The treatment of sewages containing trade wastes, or of trade wastes themselves, is a problem in itself, requiring many different processes. The chemistry of the purification of trade wastes depends largely on the character of the wastes. As a rule, such wastes do not interfere with the common methods of disposal, unless they are present in in excessive quantities, or are poisonous, either to men, animals, or fish.

Physical Characteristics.—The physical characteristics of weak domestic sewage, from a large sewerage area as represented by the area draining to the 39th Street testing station, in Chicago, are subject to variations, depending, in part, on the rain-fall or snow-fall. In dry weather the sewage appears turbid, with a yellowish cast from the urine and feces; a perceptible quantity of settling suspended matter is present, in color ordinarily light gray, changing to dark gray, or even black in the storm-water sewage. The odor of the fresh sewage is slightly gaseous, but not at all repugnant as might be supposed. Other sewages might show different physical characteristics, depending upon the water consumption and other factors. As a rule, American sewages are far more dilute than foreign sewage, because of the great waste of water in the United States. A European sewage may, therefore, have not only a more repugnant appearance, but will often possess a strong putrid odor. The development of such an odor depends upon the amount of oxygen in solution.

Changes in Sewage on Decomposition.—The sewage handled at the 39th Street testing station contains some oxygen in solution, as well as nitrites and nitrates, during the greater part of the year, in particular during the winter. Such a sewage is called a fresh sewage. When the oxygen content—the dissolved oxygen as well as the oxygen in the nitrites and nitrates—becomes exhausted, the sewage turns stale, and the organic matter begins to break down, marking the first step toward the ultimate mineralization of the organic putrescible matter,—a change due mainly to the powerful activity of bacteria and enzymes. At this stage the free ammonia gradually increases, combining with the carbon dioxide to form ammonium carbonate. The organic carbon is oxidized as long as free oxygen persists in the sewage. Eventually anaerobic decomposition follows, resulting in the formation of gaseous decomposition products, of which hydrogen sulphide is very prominent. Free nitrogen is likewise released. The sewage becomes septic. The larger the proportion of putrescible matter present, and the smaller the amount of oxygen in solution, the quicker does a sewage become septic. The carbonaceous and nitrogeneous compounds present in the sewage are further attacked by anaerobic micro-organisms,—an action which frequently produces a nuisance.

The term septic has never been strictly defined, but may cover the lack of oxygen in the fluid, and the toxic or septic effect of anaerobic decomposition products upon aerobic organisms. Sometimes reference is made to an over-septic condition, which, to the writer's understanding, is one based upon the inhibition of the growth of anaerobic organisms by their own decomposition products. The term to-day is used vaguely, and requires standardization.

Physical Record.—In our laboratory we record the physical properties, as well as the quantities of settling suspended matter in the sewage, and any peculiarity in color. Sometimes the color becomes distinctly yellowish, a reddish precipitate gradually settling out. In such a sample the alkalinity is found to be low, and the sulphates high. We have traced this to the discharge of pickling liquor wastes from a wire works.

Preservation of Samples.—The odor of samples of sewage, or purified effluents, is not recorded as a routine procedure. The reason is that the samples are collected over 24 hours for crude sewage, and over 48 hours for other effluents. To avoid change in the chemical constituents, a preservative is added,—in our case chloroform to the amount of 10 c.c. to one gallon of sewage. The chloroform effectually hides any odor present, unless hydrogen sulphide occurs in large quantities. As an additional precaution, the samples are kept in cold storage up to the time of analysis.

Exhaustive study into the question of the preservation of sewage samples has shown us that, even in a storage period as short as 6 hours, perceptible changes will occur in the nitrogeneous constituents of a fresh unpreserved sewage. At room temperature, the addition of 10 c.c. of chloroform to one gallon of sewage checks the decomposition to some extent, but even in such cases, immediate analysis is often desirable to obtain accurate results. Cold storage alone is a fair preservative. The combination of chloroform and cold storage is the best obtainable method at present. An ideal preservative is lacking for liquids, like sewage, of changing character. It should be odorless and colorless, and should not affect any of the constituents present or interfere with the analytical determinations.

Suspended Matter.—During the various stages of sewage purification, it is important to observe the physical and quantitative changes in the suspended matter, since the aim to-day is to remove as much as possible at the outset, in order to obtain a fresh effluent. In studying the efficiency of a device, frequent determinations are necessary both for the influent and effluent, extending over a considerable period, before an opinion can justly be formed of the percentage removal of suspended matter.

The settling suspended matter should be clearly distinguished from the non-settling suspended matter, in studying the efficiency of a settling device. Much of the suspended matter in sewage, particularly on large areas, occurs in a finely divided, or colloidal state, not capable of sedimentation even on prolonged storage; hence, when a settling tank is removing perhaps 35% of the total suspended matter, it may actually be taking out 100% of the suspended matter capable of settling. On prolonged storage, however, some of the colloidal matter may coagulate, and material previously in silution will also change to apparent settling matter. This is particularly true for strong sewages. From our analysis of the composition of the settling and non-settling suspended matter, it is evident that the percentage if volatile matter is greater in the non-settling portion. This may have a very important bearing upon the true character of a settled sewage from the standpoint of a prospective nuisance in a stream.

The settled suspended matter is termed sludge. The percentage of volatile and fixed matter depends upon the character of the sludge, a fresh sludge containing more

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* Read before the Chicago Section of the American Chemical Society.

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volatile matter than fixed matter, a septic sludge being higher in mineral constituents. The content of moisture may run from 85% to 95%, depending upon the device.

Since the determination if the settling suspended matter is of importance in the control of a sedimentation plant, the daily variations may be advantageously followed by determining the loss of suspended matter on settling gravimetrically, or else by measuring the number of c.c. of settled matter in a conical-shaped glass holding one liter. Such glasses are used in Germany, and may be of value in dealing with strong sewages containing considerable amounts of settling suspended matter, but in our weak American sewages the control is not as satisfactory, since the 39th Street sewage, for instance, contains, on an average, only 140 p.p.m. of total suspended matter, of which from 40% to 50% is capable of settling. In our case, actual gravimetrical determinations are made of the total volatile and fixed suspended matters by the Gooch crucible method.

Sprinkling filter effluents contain, as a rule, some suspended matter, but of a different character from the original floating or colloidal matter. A sprinkling filter is not built primarily as a means of removing suspended matter, but as a machine to oxidize and mineralize the organic material delivered to it. In the long run, a sprinkling filter should deliver, in its effluent, nearly as much solid as received. At times the effluent may be very clear. Some observers claim that more is delivered. The effluent, however, is greatly improved from the chemical standpoint, and also from the standpoint of putrescibility. The suspended matter, when unloaded, may give rise to putrefaction if stored in considerable quantities, and may become septic, so that shallow secondary settling basins may change a non-putrescible filter effluent into a putrescible final effluent.

Oxygen Consumed.—The time-honored oxygen-consumed test indicates the amount of oxygen absorbed by the oxidizable matter during titration in acid solution with permanganate, and in particular the amount of organic carbonaceous matter present. At present there are so many modifications of the test, that the results from various laboratories cannot be directly compared, without knowledge of the method employed. In our laboratory the 30-minute water bath boiling method is used. For comparative purposes this is a valuable test, although the figures obtained do not represent anything absolute. The result covers only a small percentage of the total carbon. The organic carbonaceous compounds vary in their resistance toward acid permanganate solution. The average of the oxygen consumed in our sewage is about 50 p.p.m.; the average of the effluent of a sedimentation tank is about 40 p.p.m.; and the average in our sprinkling filter is about 25 p.p.m.

It is important to remember that the oxygen-consumed test does not represent the oxygen which the liquid would absorb under natural conditions in a water course. From the practical standpoint, a far superior test is one which indicates quantitatively the rate at which oxygen is absorbed in fresh water. I would style this the biologic oxygen-consumed test in contradistinction to the permanganate oxygen-consumed test. I shall refer to this later.

Nitrogen.—Nitrogen in its various forms represents the never-ending cycle in the conversion of animal into mineral matter, and vice versâ. The organic nitrogen, in decaying, splits off ammonia which, in turn, becomes oxidized to nitrites and then to nitrates not by simple chemical oxidation, but through the activity of various micro-organisms, of which very little is understood. Extensive bacterial research on the problem of nitrification has been made by Winogradsky, Frankland, and others. That the process of nitrification is a bacterial one is not in doubt, since Schlösing and Muntz demonstrated that when solutions containing ammonia were allowed to percolate through the soil, the ammonia was converted mainly into nitrate, but if the living organisms in the soil were paralyzed by chloroform vapor, or other antiseptics, nitrification did not take place. For the activity of these organisms the presence of oxygen is essential, as well as of a base to neutralize the nitrous and nitric acid which is formed. Moderate temperatures are most favorable, but the action may take place even at temperatures as low as 3° or 4° Cent. Species have been isolated which require very little or no organic matter for their subsistence. Such bacteria seed themselves in biological filters, and nitrify or mineralize the material coming to them. In general, the larger the bacterial surface the greater the nitrification will be for a given application of liquid. The size of the material and rates of application have to be varied for the process attained. In an intermittent sand filter, only 100,000 gallons can be applied to an acre in a day, whereas in a coarse grain sprinkling filter from 2,500,000 to 3,000,000 gallons can be applied to an acre in a day. A sand bed 3 ft. deep would give a much higher nitrification than a sprinkling filter bed 5 ft. deep of stone from 1½ to 2 in. in size, at the rates mentioned. Overloading a filter will interfere with nitrification. It is interesting to note how short a period is required to establish nitrification on a large scale. The nitrates represent the last step in the oxidation of the nitrogenous matter, and serve as food for the higher developed living organisms. These organisms, in dying, form the starting point of another nitrogen cycle.

As yet our understanding of the nitrifying organisms, and the processes involved, is very meagre, so that in the future, research will be desirable to learn the exact action taking place. Possibly the nitrification process can be intensified by artificial means.

Denitrification.—It is interesting to note that certain species of bacteria have the power of reducing nitrates to nitrites, free ammonia, and free nitrogen, in contradistinction to the nitrifying group. Grayson and Dupetit made the first observations in 1882, and concluded that denitrification was essentially the result of combustion of organic matter by the oxygen of the nitrates. Frankland and Beyerinck have added to our knowledge. Many organisms have been found which do not bring about denitrification.

Because of the research into the protein molecule, I wish to speak of the nitrogenous intermediate products, which in sewage disposal are frequently productive of disagreeable odors, as for instance indol, with its putrid odor, or ammonia, with its characteristic odor. Free nitrogen, as mentioned, is produced by the denitrifying action.

Significance of Nitrogen Cycle.—The nitrogen cycle offers a good index to the efficiency of a modern sewage filter of any kind. In a settling tank we do not expect much change in the nitrogen, except the elimination of some of the organic nitrogen in the settling suspended matter. In a more extended storage period the free ammonia may increase, and the nitrates and nitrites decrease, provided the sewage originally applied was not septic. In a septic tank the free ammonia ordinarily increases, and the nitrates and nitrites decrease, or become entirely eliminated. The increase in the free ammonia in a septic tank results from the reduction of nitrates and the breaking down of the organic nitrogen. The biologic treatment on sprinkling filters and sand filters is an oxidizing process, and should result in an increase of the nitrates and nitrites. The organic nitrogen is decreased in a filter, on account of the bacterial decomposition and the escape of the volatile nitrogenous products and free nitrogen proper.

Determination of Nitrogen.—The organic nitrogen, as well as the free ammonia, the nitrates and nitrites, are determined as a routine procedure on all our samples from the sewage testing station. The method for the determination of the organic nitrogen is that introduced at the

Columbus testing station, and consists in the digestion of the sample by concentrated sulphuric acid, subsequent neutralization and direct nesslerization. The free ammonia is distilled previous to nesslerization. Very often the sample is nesslerized directly after adding a few drops of potassium hydrate and copper sulphate, the resulting precipitate being allowed to settle. The nitrates are determined by the napthylamine-sulphanilic acid method, and the nitrates by aluminum reduction in alkaline solution.

Formation of Hydrogen Sulphide.—Another interesting topic in the chemistry of sewage is the formation of hydrogen sulphide, the history of the sulphur cycle resembling that of the nitrogen cycle. Its presence in sewage indicates putrefactive changes as a rule, since sulphur is an element of the protein molecule, and as such is always present in small quantities in sewage. Plants absorbing mineral sulphates convert them into organic sulphur. On breaking down, organic sulphur yields hydrogen sulphide which becomes oxidized again to sulphates, either by chemical or biological means. Just as nitrates can be reduced to free ammonia, so are sulphates capable of reduction to hydrogen sulphide. Apparently the sulphur cycle is influenced more by purely chemical reactions than is the nitrogen cycle, but in both cases the changes are largely the result of bacterial activities.

The principal question for further study is the generation of hydrogen sulphide from inorganic sulphates, since hydrogen sulphide is one of the constituents most intimately connected with the development of a nuisance, and may also be responsible for damage to concrete work. Practically all sewage bacteria will form the gas in artificial media containing sufficient organic sulphur. Any sewage containing hydrogen sulphide may form a black sediment typical of septic conditions, the sediment consisting mainly of ferrous sulphide, since iron is almost always present in sewage in varying amounts. Other gases, however, may originate from the destruction of organic sulphur, as for instance, mercaptan. The formation of hydrogen sulphide, however, from sulphates is of more importance perhaps than its formation from organic sulphur, since sulphates are often present in large quantities. The reaction is undoubtedly due to specific types of bacteria, rather than to a wide group. Beyerinck first noted the phenomenon, and stated that the best conditions for the reduction of sulphates were the absence of oxygen, the absence of sugar in the culture media, and the presence of phosphates and other suitable solids. Only small quantities of nitrogen compounds are necessary. The optimum temperature is around 25° Cent. Beyerinck isolated an organism, the spirillum desulphuricans, a strictly anaerobic organism reducing sulphates. Other important work has been carried on by Van Delden, Letts, and recently by Dr. Buchanan.

Significance of Hydrogen Sulphide.—Hydrogen sulphide in sewage may not only be responsible for a local nuisance, since amounts as small as 3 p.p.m. can be noted under outside conditions, but on discharge into a stream it will draw upon the dissolved oxygen present, and often to such an extent that fish life will be seriously interfered with. In addition, hydrogen sulphide by itself is a poison to fish. The reduction of sulphates has been observed in many sewages in the United States and abroad, particularly when the sulphates are high from the introduction of trade wastes. In some cases the disintegration of concrete has been a serious matter, due to the oxidation of hydrogen sulphide to sulphuric acid by the atmospheric oxygen.

One of our settling tanks, a modified Dortmund tank, or, as Professor Phelps calls it, a biolytic tank, affords a typical case of active sulphate reduction. At times as much as 40 p.p.m. of hydrogen sulphide have been observed in the effluent. This can be traced directly to bacterial activity.

Before dismissing this topic, I will mention the classic work of Winogradsky, who made an exhaustive study of the oxidation of free sulphur by higher bacteria, such as beggiatoa. The beggiatoa utilize the sulphur as a source of energy, taking up from two to four times their weight without increasing in growth. Requiring but small quantities of organic matter they flourish in sulphur springs, the decomposing hydrogen sulphide liberating amorphous sulphur. The sulphur in turn is oxidized to sulphates. The effluent of our biolytic tank is quickly oxidized in a sprinkling filter. The effluent of the filter, however, contains abnormally large amounts of sulphate, and the top of the filter is covered by a silk-like growth of sulphur bacteria.

In a sewage-disposal plant there is, as a rule, no occasion to test for hydrogen sulphide as a routine procedure. The sense of smell or a simple lead acetate paper test should suffice, unless some peculiar case requires special investigation.

Chlorine.—The chlorine in a domestic sewage originates largely from the urinary chlorine, and indicates approximately the strength of a sewage. It can be easily determined by direct titration with silver nitrate solution, using potassium chromate as an indicator. Except as an index to the strength of the sewage, the chlorine determination has no further significance. The presence of industrial wastes containing chlorine, or of ground waters or sea water, may prevent us from drawing conclusions. On an average, the sewage of 39th Street contains about 40 p.p.m. of chlorine, indicating a dilute sewage.

Alkalinity.—The alkalinity has little significance in the interpretation of results, since industrial wastes may cause abnormal figures. Sewage ordinarily is slightly alkaline, considerable quantities of acid waste being required in order to turn it acid in the sewer. The average alkalinity of our sewage is 220 p.p.m., calculated as calcium carbonate. We titrate our sample with 1/50 normal sulphuric acid. Methyl orange is used as in indicator.

Fats.—In domestic sewage the fats and fatty bodies result largely from the use of soap in laundries and from household wastes containing grease. On Monday there is a slight increase in the fatty content of our sewage, but the addition is not great, since on our watershed there is a large proportion of apartment houses where washing is spread over several days of the week. No attempt is made to separate the fat from the soaps. On the addition of sulphuric acid, a certain quantity of sewage is evaporated to dryness, and the total fat extracted with ether. The average amount present in our sewage is approximately 25 p.p.m.

Total Solids.—The total solids in sewage are not now determined as a routine procedure, being largely of scientific interest. In our case the amount is about 600 p.p.m., or 0.6 of a gm. per liter. This indicates the extreme dilute character of our sewage.

Dissolved Oxygen and Stability.—Dissolved oxygen and putrescibility will be discussed together, since while both are determined separately, neither is by itself as instructive as when studied in connection with the other. The two determinations not only furnish a key to certain phenomena in biologic sewage disposal, but when their relation is better understood the solution of many problems will be attained. In a popular sense, putrescible matter is material which draws upon the oxygen in solution for its oxidation. However, inorganic compounds sometimes utilize oxygen in solution for their oxidation as well. From the standpoint of sewage disposal by dilution, or in studying the effect upon fish life, it is immaterial how the oxygen is used up. During the colder season, fresh dilute domestic sewages contain, as a rule some oxygen which in a short time becomes exhausted, and anaerobic conditions set in. The liquid then enters a stage where oxygen is quickly absorbed when supplied in any form.

In the control of a sewage-disposal plant, the determination of the putrescibility is more important than the determination of the oxygen, and in comparison with the other constituents, the knowledge of the putrescibility or stability is of the greatest importance. With this test a plant can be controlled to better advantage than by any elaborate chemical analysis. The reason for this is simple. The ultimate aim of any disposal plant is to make the putrescible matter more or less stable. The putrescibility test indicates the degree of oxidation obtained, and the determination of the dissolved oxygen gives a fixed figure of the absolute amount available for further oxidation. Both factors are important in studying a nuisance or fish life. A high oxygen content, in itself, does not indicate stability.

Determination of Dissolved Oxygen.—In our laboratory, the Winkler method has been used to determine the dissolved oxygen in the manner described in the "Standard Methods of Water Analysis" adopted by the American Public Health Association. The sample is collected carefully in order to avoid aeration. Manganous sulphate and an alkaline solution of potassium iodine are then added. The precipitate of manganous hydrate is allowed to settle; sulphuric acid is then added, and the free iodine in the solution titrated with standardized sodium thiosulphate. The equivalent of free iodine is calculated to oxygen. The results are expressed either in p.p.m., or in percentage saturation. In the latter case the temperature must be considered. Normal fresh water which has not undergone temperature changes ought to be 100% saturated, but may be sub-saturated or supersaturated, depending upon conditions, such as the season of the year, the sunlight, the presence of algae, or sudden changes of temperature.

As an alternative method, the American Public Health Association has recently recommended the Levy method for the determination of dissolved oxygen. This consists, briefly, in the conversion of a ferrous salt into a ferric salt by the oxygen in the water. The residual ferrous salt is titrated with the permanganate solution. At present the use of either method is a matter of choice.

Determinations for dissolved oxygen should be made on the spot to avoid a loss of oxygen, particularly in putrescible samples. From a study of this question in our laboratory, we have concluded that only fresh saturated and uncontaminated water like that from Lake Michigan can be kept for a number of hours without showing a reduction in oxygen. Even then the sample should be kept in a cool, dark place. The addition of a small quantity of formaldehyde allows an extension of the storage period, but it is preferable to add the first two reagents in the Winkler method in order to form the precipitate, where the determination cannot be made on the spot.

Determination of Putrescibility.—The putrescibility test has been almost universally adopted by various sewage-purification plants. The one most in favor is the so-called methylene blue test devised by Spitta and Weldert in Germany. A dilute solution of methylene blue is added to a definite quantity of the effluent in a sterile bottle; the mixture is then incubated at 20° Cent. and the number of hours or days noted in which the blue color is discharged. This decolorization takes place only in putrescible samples and depends upon the formation of a leucobase when the oxygen in the sample has been exhausted. Some prefer an incubation temperature of 37° Cent. to obtain quicker results, but this temperature is not desirable because it does not conform to actual conditions as does the temperature of 20°. Furthermore a bacterial flora will flourish at 37°, which would not be favored at the lower temperature. Phelps has put the test on a quantitative working basis by which the putrescibility of a sample can be expressed in terms of relative stability. Such figures indicate the proportion of oxygen present as compared with the total amount required to effect the complete oxidation of a sample in question. The sample should be kept in the incubator for twenty days before being discarded, but from a practical working standpoint this is neither necessary nor desirable. Ten days storage as a maximum is sufficient, and often four days will give results sufficiently accurate for practical purposes. Samples which show signs of decolorization after four days may be held for further observation. The exact hour of decolorization is difficult to fix, but an experienced observer can avoid material mistakes in estimating the end point.

Index of Permissible Dilution.—The putrescibility test outlined is eminently practical and valuable, but is not a quick method. Recently Phelps devised another method to give the desired information in a shorter time. The test in principle is not new, for it has long been known that organic putrescible material will absorb oxygen in solution, and the rate of absorption under certain conditions has rightly been looked upon as a good index to the putrescibility of the sample. Only recently, however, could the permissible dilution be calculated for a sewage effluent under certain assumed conditions. The procedure is to mix a small quantity of sewage carefully with fresh aerated water in definite proportions, and to incubate the mixture at 20° Cent. for a number of hours. To hasten the result, the dilution may be lowered. The dissolved oxygen is determined in the mixture at the start and again after the lapse of several hours. With these two figures in hand, the percentage of sewage permissible in a stream under assumed conditions can be calculated. In the formula are terms for the period of contact and the percentage of dissolved oxygen to be available at the desired point in the flow. With our present knowledge of this test, the same assumptions must be followed from time to time in order to get comparable results, since the formula in its present state is not as perfect as may be, owing to the lack of knowledge of the shape of the curve for this bacterial reaction. The results obtained, however, are very practical and of great value. The method requires more accurate and careful work than the methylene blue test, and at present is open only to a skilled chemist.

Bacteria.—Most of the chemical changes in biologic sewage purification are in reality the result of bacterial activity. The significance of these bacteria in general is of interest largely from the scientific standpoint. The removal of disease-producing bacteria, however, is a question of practical interest. Sewage disposal devices, in themselves, are not built, primarily, as bacterial removers, and cannot be relied upon unless sterilization of the effluent with chloride of lime be added as a sure means for removing bacteria. In a chemical precipitation process, the bacteria may be reduced partly by sedimentation and partly by the germicidal properties of the chemicals employed. In a plain settling tank the reduction of bacteria is due to sedimentation. In a sprinkling filter or in a contact bed the reduction is undoubtedly the result of mechanical detention as well as the action of higher developed organisms. The unfavorable environment may also be an influence. Secondary settling basins will reduce the number of bacteria again by simple sedimentation. The effluent of a filter may contain as low as 5% of the initial number of bacteria present originally. Biologic sewage purification may eliminate the putrescible matter, but if bacterial purification be desired, disinfection only will secure the result.

In our laboratory the method employed to determine the number of bacteria is to place 1 c.c. of the sample, properly diluted, in a litmus lactose agar medium. The temperature of incubation is 37°, and the time of incubation two days for the routine samples. It is well known, however, that no artificial medium—be it an agar or a gelatine medium—will permit the growth of all bacteria ordinarily present. Therefore, the count per 1 c.c. indicates but a portion of the true number. More colonies will develop on gelatine than on agar.

Methods of Sewage Disposal; Dilution, and Sedimentation.—I shall not attempt to discuss here the question of sewage disposal by dilution, other than to point out that such a method is entirely legitimate within the oxidation capacity of the body of water into which the sewage is discharged. I will, therefore, turn to a consideration of the methods of preliminary treatment which may be covered by simple sedimentation, decomposition, either aerobic or anaerobic, and chemical precipitation. In the operation of a sedimentation tank, sludge is removed frequently in the early stages of decomposition. The resultant improvement of the sewage from the standpoint of dilution will, of course, vary with the composition of the sewage and the amount of suspended matter present. We have recently demonstrated the fact that the simple removal of settling suspended matter improves the physical character of the sewage and its relative stability to some extent, but not to as great an extent as might be assumed from the actual physical improvement. In other words, the removal of 50 to 60% of the suspended matter will improve the character of the sewage from the standpoint of dilution from 25 to 30%. This means that the additional removal of the pseudo-colloidal matter will improve the liquid far out of proportion to the quantity of suspended matter thus removed. A device which would remove this fine suspended matter, without resorting to biologic treatment, would undoubtedly furnish an effluent which on a large scale would be intermediate between the preliminary or partial purification effected by settlement, and the more complete purification made by a sprinkling filter. In some cases it might suffice where preliminary purification alone would not.

Septic Tank.—The anaerobic decomposition of sewage finds its widest application at present in the septic tank. This process may also be called a hydrolytic or liquefying process, and is substantially the same as that in the ordinary cesspool. The cellulose decomposes, forming hydrogen and marsh gas. Carbon dioxide and fatty acids are produced as by-products. Nitrogen is formed, probably due to nitrate reduction. Thirty-two degrees Cent. is the optimum temperature for the decomposition of cellulose; therefore a septic tank shows more violent ebullition of gas during the hot season, and frequently unloads large amounts of suspended matter. In our climate not enough gas is produced for any practical purpose, but at Matunga, in India, the gas from a septic tank has been utilized for driving an engine to pump sewage and for lighting and cooking purposes.

The ammoniacal fermentation taking place in sewage is due to the presence of urea. It starts readily and is frequently completed in the sewer itself. In septic-tank treatment the protein substances are the ones responsible for the foul odors, since hydrogen sulphide, mercaptan, indol, skatol, and various amines result from their decomposition. Fats when present in appreciable quantities may give rise to an objectionable rancid odor.

It is still a question whether the decomposition taking place in sewage under anaerobic conditions, as in a septic tank, is an advantage in the further purification. Current practice favors the treatment of a freshly settled sewage. However, treatment of what may be called a "semi-digested" liquid has, apparently, some points in its favor, since compounds which are ultimately formed by these putrefactive processes yield more readily to oxidation than do the higher complex bodies originally present. On the other hand, the anaerobic decomposition products are probably inimical to the aerobic organisms present in the body of the filter.

Biolytic Tank.—In our biolytic tank, a remarkable reduction of the organic nitrogen has taken place, accompanied by the excessive formation of hydrogen sulphide. The pseudo colloidal matter has been completely eliminated, leaving nothing save a slight amount of black sediment and the hydrogen sulphide odor. All this occurs in less than four hours. Without further oxidation the effluent from this tank would be a nuisance, and a detriment from the dilution standpoint.

The chief objection to-day to the use of septic tanks is that they may produce a nuisance, and may discharge sludge in hot weather when the ebullition is a maximum. For these reasons the separate digestion of the settled suspended matter is recommended, particularly in double-deck tanks of the Emscher type.

The septicity of the sewage is a point worthy of comment. If we assume that hydrogen sulphide is the proper index of the increase in septicity, the formation of insoluble ferrous sulphide might be accepted as a measure, provided enough iron were present in solution to combine with all of the hydrogen sulphide. The key to the question probably lies in the bacterial control of the septic tank process, but a far deeper knowledge of the species involved is required than we possess at present.

Sludge.—Whether sludge be fresh or old, its ultimate disposal has been and still is a problem for sewage experts. In order to fully appreciate the difficulties encountered in the commercial utilization of the product, it is necessary to consider its physical as well as its chemical composition. Fresh sludge is a black semi-liquid substance with an odor varying from that of burnt rubber to an acrid putrid stink. The specific gravity varies 0.01 to 1.06. In our case the grit chamber sludge frequently contains considerable quantities of heavier material, and its specific gravity may be as high as 1.35. The average quantity of moisture is from 85 to 95%, the percentage of organic matter 60, and of fixed matter 40 when calculated on a dry basis, in fresh sludge. The nitrogen on a dry basis amounts approximately to 2%, the fat varying from 1% to 5%.

Many schemes have been suggested for the utilization of sludge as fuel, as filling for fertilizer and as material for gas, or even the manufacture of alcohol. Only in isolated cases under peculiar conditions has any process for the recovery of any by-products been successful. For instance in Bradford, England, where the sewage contains a deal of wash water from wool pulleries, fat has been successfully extracted from the sludge. The difficulty of the quick removal of the moisture from the sludge makes its use as a fuel doubtful. For the same reason drying the sludge for fertilizer purposes is uneconomical. Old sludge thoroughly digested contains much less volatile matter than the fresh sludge, the amount decreasing frequently from 60% to 40% of the total dry matter. In Germany and England, sewage sludge has been sold or given away to neighboring farmers, but the general experience has hitherto demonstrated the difficulty of disposing of sludge continuously in any such manner.

Partial purification of sewage can be accomplished under semi-aerobic conditions, as in a Dibdin slate-bed, which is akin to a contact bed. In this device nematode worms, infusoria, and bacteria accumulate and work over the sludge. Experience in this country with the slate beds has not been favorable.

Chemical Precipitation.—The colloidal matter in crude sewage may be eliminated by the use of chemicals as a precipitant. Ferric sulphate, aluminum sulphate, lime and ferrous sulphate have been frequently used in various combinations. The chemical to be employed and its quantity is largely governed by the composition of the sewage, and the cost of obtaining the chemicals. The quantity of sludge resulting is larger than from any other method of clarification. The effluent is low in suspended matter and is susceptible of treatment on filter beds at a high rate. Beyond a certain point, however, the application of chemicals does not reduce the amount of suspended matter appreciably. A concentrated sewage is better adapted to chemical clarification than a weak sewage.

Comparison of Methods.—More complete purification may be accomplished, either on intermediate sand filters, contact beds, percolating or trickling filters. The suspended and colloidal matter is mechanically retained by the filter material to be worked over by the biological life in the filter, which quickly forms in a new bed as a slimy coating on the surface of the particles of the filter material. The chemical change in the liquid is called nitrification or mineralization. When the bed becomes clogged, nitrification gradually ceases. In a sprinkling filter it is favored by the spraying of the liquid, which undoubtedly aids the oxidation process following. As a rule, more nitrates are formed in a sprinkling filter than in a contact bed, but less than in a sand filter.

The deeper the writer progresses into the field of sewage disposal, the more he realizes the amount of work that is still required to make it an exact science or art. The co-operation of biologists, entomologists, chemists, and sanitary engineers is required. The sanitary chemist is mostly concerned with the investigations of the biologic features, a thorough knowledge of which will materially aid in bringing about a better understanding of the facts already accumulated, as well as the solution of new problems. For the industrial chemist, the most fertile field for investigation is the ultimate solution of the sludge question. At present we are able to reduce the quantity of the sludge to a minimum, and to prevent offense, but we realize that certain constituents, even though small in quantity, may some day prove of commercial service. The economies to be obtained, however, will be available only in large plants where careful operation is possible.

PURIFICATION OF WATER BY STORAGE.

In a paper read before the International Congress on Hygiene and Demography, held in Washington, September 24th, Dr. A. C. Houston gave a discussion on the purification of water by storage. He stated that the purification of water by storage is discussed under three main heads: (1) Sedimentation; (2) Equalization; (3) Devitalization. The following comprise the chief conclusions so far arrived at:

(1) Storage reduces: (a) the number of bacteria of all sorts; (b) the number of bacteria capable of growing on agar at blood-heat; (c) the number of bacteria, chiefly excremental bacteria, capable of growing in a bile-salt medium at blood-heat; (d) the number of coli-like microbes; (e) the number of typical B. coli; (f) the amount of suspended matter, color, ammonical nitrogen and oxygen absorbed from permanganate; (g) the hardness.

(2) Storage alters certain initial ratios, for example (h), it reduces the number of typical B. coli to a proportionately greater extent than it does the number of bacteria of all sorts; (i) the color results improve relatively to a greater extent than those yielded by the permanganate test.

(3) Storage, if sufficiently prolonged, devitalizes the microbes of water-borne disease, e.g., the typhoid bacillus and the cholera vibrio.

(4) Storage has a marked "levelling" or "equalizing" effect.

(5) An adequately stored water is to be regarded as a "safe" water, and the "safety change" which has occurred in a stored water can be recognized and demonstrated by appropriate tests.

(6) The use of stored water enables a constant check to be maintained on the safety of a water-supply antecedent to and irrespective of filtration.

(7) The use of stored water goes far to wipe out the gravity of any charge that a water-supply is derived from polluted sources.

(8) The use of adequately stored water renders any accidental breakdown in the filtering arrangements much less serious than might otherwise be the case.

NATURAL GAS BELT IN WESTERN CANADA.

Some important finds of natural gas have recently been made in the Canadian West, within the limits of what seems to be a long, but narrow gas belt, running north and south, in the neighborhood of the 112th meridian. Mr. Aubrey Fullerton, in a recent issue of the "Mining and Engineering World," states that the latest strike was made in June at Tofield, near Edmonton, the capital of Alberta. At that point, after several borings had been made, a flow of gas was struck at a depth of 1,054 ft. The well was at once capped and the flow tested. It has since been gaining in volume, and gives every indication of being permanent, while the quality of the gas, for both lighting and heating purposes, is excellent.

Other towns in the surrounding district are arranging for borings of their own, in the belief that a great gas vein underlies the whole country. Indications of gas have been found at various times during recent years.

A great gas-tapping project is now under way at the southern end of this same belt, where the wells at Bow Island have been piped for a supply to the city of Calgary, 180 miles to the west. The pipe line, which was constructed by Corcoran & Co., of Pittsburg, has just been completed, and when the system is in full working order gas will be sold in Calgary at rates varying from 15 cents per thousand for the larger power consumers, to 35 cents for domestic use. The project represents a $3.000,000 investment.

The Bow Island wells are in the immediate neighborhood of Medicine Hat, whose natural gas system, now in use for some years, has made the town prominent. The town uses natural gas almost entirely for lighting and fuel, and an average householder's bill for both runs at from $20 to $30 a year.

In the northern section of the belt is the biggest gas well. The Athabasca River, for at least a good part of its course, runs through a country that seems to be underlain with gas, and a tract of 100,000 square miles is saturated with petroleum. At Pelican Rapids, at a point on the Athabasca River, 200 miles north of Edmonton, is a gas well that has been burning for fourteen years, and gives no sign of lessening in flow. A photograph taken last winter shows an immense gas jet whose flame is nearly 50 feet high, and of very substantial circumference.

The Pelican well was found in 1898, when the Geological Survey of Canada sent a party of oil-diggers into the north to see if the reported existence of petroleum was a fact. They got their outfit in over the wilderness trail, and set to work. When the drill reached a depth of 820 feet it struck gas. The flow was so great that it drove back the drill, and the noise of the escaping gas could be heard two or three miles away. After the survey party went away some one came along and lighted the jet, and it has been burning more or less continuously ever since.

The report to the Geological Survey in regard to the Pelican well recommended that a new bore at the depth of 820 feet, where the first large gas vein was encountered, "should be at least 10 inches in diameter; then it would be possible to reduce the casing four or five times, giving that many different lines of pipe to be used in getting by these gas veins." Meanwhile the search for oil was of necessity abandoned, and until the railroads get into the country there is little chance of this great natural resource being developed. The big gas jet is still blazing high and fiercely, but wastefully, and a great coal area further north is similarly on fire, and has been for many years, burning slowly from within. The whole region is a vast depository of natural fuel. Oil oozes out along the shores of Great Slave Lake and the Mackenzie River, and tar drips all summer long from the banks of the Lower Athabasca and Great Slave Rivers.

FIELD SURVEYS FOR ROAD CONSTRUCTION.

At the American Road Congress at Atlantic City, Mr. E. L. Griggs, Associate Professor of Civil Engineering in the University of Georgia, presented a paper, which is reprinted below practically in full, in which he describes the methods of making the actual field surveys necessarily precedent to the proper construction of highways.

Before a survey of a road is made it should be known how the construction of it is to be carried out as that determines in a large measure how much engineering work should be done.

If the road is to be constructed by contract, and especially if the consideration is based on a price per yard of material handled, then justice to both parties to the contract demands a full and most accurate survey and determination of volumes.

While to take the other extreme, if a county is building its roads with its own labor, convict for example, much less engineering work may be done. The question of exact cost in this case is not so important and the determination of volumes is for construction purposes only.

Preliminary to the final decision of the location of a new road or, what is nearly equivalent, a radical relocation of an old road, a thorough study of all the feasible routes is essential. For this purpose a most useful instrument is the Plane Table or Traverse Table. We use the simplest form for this purpose which is 14 or 15 ins. square and weighs only a few pounds. With its aid all the probable lines are gone over and plotted, the distances being obtained with sufficient accuracy by pacing, while any determining features such as residences, roads, streams, etc., are triangulated in. Property lines crossed are also noted as bearing on the question of rights of way over the individual properties. A useful adjunct to the plane table in this preliminary study is a good hand level, with which comparative elevations of ridges, etc., passed over are very conveniently estimated and then noted on the map.

This work requires only one man for its execution and equipped with only these light instruments he can cover considerable ground in a day. If he is careful to make copious notes on the map it will show when completed not only the lengths and directions of the lines but also the character of the country over which the road would pass and the number of homesteads served. This latter is, of course, one of the really governing features of the final selection. This map also furnishes facts that will aid the engineer in answering the questions of the too persistent patron who has personal ends to serve.

After this preliminary work is completed and the final selection of the location is made then we are ready to actually stake out the road. If the road is to be constructed by contract then the regular work of a railroad survey should be done. The line should be carefully measured and staked, levels run and profiles made, cross-sections taken, slope stakes set and volumes accurately determined. All these operations are essential to a just settlement of the contract but they entail heavy engineering expenses.

In the State of Georgia, as in some of the other States, most of the roads are built by convict labor and here such reasons for great accuracy do not exist and quicker and more economical engineering methods may be used. For it is of far greater importance that a road should have easy grades, perfect protection from water and a good surface than that its curves, for example, should be theoretically correct. If a road is so located and graded that the material taken from the cuts will just make the fills why should we bother about the exact number of yards of material handled? Short sharp curves and quick reverse curves are both disagreeable and dangerous with rapid automobile traffic and are to be avoided.

In making our road surveys the road is staked out by a transit party in the usual manner of staking out a railroad location. The stakes are set every 100 ft. but on one side instead of the centre of the road so that they will not be disturbed in construction. Long curves are laid out in the usual method of deflection angles. Short curves, however, can be put in much more economically in point of time by setting the stakes over on offsets from the tangents. For instance, for a two-station curve the previous tangent is prolonged straight 100 ft. to the vertex, the angle with the forward tangent measured and the degree of curve decided upon. The stake at the vertex is then moved over on the curve. The distance the stake is moved over is equal to 1.75 ft. for every degree of deflection or 2 deg. of curve. For example, if the angle between the tangents is 16 deg., then the curve will be 8 deg., and the stake at the vertex will be moved over four times 1.75 ft., or 7 ft. The effect of this is to put the stake almost exactly on the curve, but the forward tangent will be found 0.6 ft. from the position it would have occupied if it had been laid out in the regular way, the curve shortened between 1 and 2 ft. from the recorded length, and the degree of curve slightly changed.

If, however, the central angle was larger and four stations of an 8 deg. curve decided upon, then the stakes at stations one and three would be set over 7 ft., while the stake at the vertex would be set over four times seven, or 28 ft., since the offset varies directly as the squares of the distance in 100-ft. lengths. That is, at station two the distance set over would be four times that at station one, and at station three, in a six-station curve, it would be nine times that at station one. Very little time, however, is saved in using this method for curves over 400 ft. long.

In the case of the four-station 8 deg. curve mentioned above the near half of the curve is almost exactly located while the forward tangent is again found away from its theoretical position, about 5 ft. in this case, and the whole curve shortened about 10 ft. from its recorded length. This difference of about 2½ ft. in one hundred will not affect the grade and it is also to be remembered that it is not cumulative but rather balancing. For if the curve is staked out on the outside of the curve and a centre line afterwards measured it will be found that the centre line to the point of tangency is still shorter than the curve as staked out. This will tend to balance when the curve is staked on the inside

Another very convenient method of laying out a curve and especially if one happens to be without his instrument, is one derived from the method given by Searles in his Field Engineering. At the point of curvature the previous tangent is prolonged 100 ft. further and perpendicular to it at its end in the direction of the proposed curve is laid off a distance equal to 1.75 ft. times one-half the proposed degree of curve for the first station of the curve. For the second station, and all succeeding stations, the line through the two preceding stakes is prolonged 100 ft. and perpendicular to it is laid off a distance equal to twice that for the first station or 1.75 ft. for every degree of curve. In order to get on the tangent at the end of the curve the line of the last two stakes is prolonged 100 ft. and the perpendicular laid off is equal to the one laid off at station one. For example, if we propose to use an 8 deg. curve the perpendicular laid off for the first station of the curve after leaving the tangent and for the first station on the forward tangent would be 1.75 ft. times one-half of eight, or 7 ft., and for all other stations it would be 1.75 ft. times eight, or 14 ft.

The transit party also determines accurately the location of the property lines crossed, so that the exact area of the right-of-way on each separate piece of property may be found.

After the line has been staked out the level party goes over it and stakes levels, the rod being held on the ground by the stake. Levels are also taken at the opposite side of the road, the width of the road being measured by pacing. Profiles are made of each side of the road approximately paralleling each other on the same piece of profile paper. This will give sufficient information to very closely approximate the balancing of the cuts and fills without the necessity of cross-sectioning. No slope stakes are set, as the cuts are usually light. The road bed is graded down to its proper depth and the banks afterwards shaped up.

We have sometimes carried out the whole operation of surveying a road with a party of only three men: an instrument man carrying a transit equipped with level tube and stadia hairs, a rodman carrying a self-reading level rod and a stakeman.

The instrument man, after he has set up his instrument and gotten his alignment, signals the rodman forward or backward until he is the proper distance away as shown by the stadia, then lines the rod in for the exact position of the stake. After this is driven he determines the elevation of the station by using his instrument as a level. As the distances are usually in hundreds of feet and the telescope horizontal no stadia notes will have to be kept or reduced. If the ground is practically level transversely no further levels need be taken, but if not the rodman must return, after going as far as the rod can be read, and hold his rod on the opposite side of the road. This method is very laborious and subject to errors by the instrument man overlooking some of his manifold operations and is suggested only for short pieces of work or when assistants cannot be had.

The stakes are of course numbered when set and if the foreman of construction is an experienced man he is simply furnished with a profile with the cuts and fills for each station written on it, or merely a list of the stations with the amounts of the cuts and fills. If he is not so experienced he will require considerable more supervision by the engineer.

Some may infer from what has been said that since certain approximations in the surveys are to be used, the services of the engineer may be dispensed with as unnecessary and the road located by the eye alone. Such, however, is very undesirable. The knowledge, judgment and experience of an engineer are always needed for the proper location of a road, and the responsibility should be his for grading the road and so balancing the cuts and fills, yet keeping within the limits of allowed grade, that the minimum amount of earth will be handled, and for placing proper culverts that the storm water may be at all times taken care of.

Experience has shown that the cost of construction is often very materially increased by not having proper grade stakes set beforehand. As an example, on one occasion in grading a hill, 6 ins. seemed enough to take off. So it was plowed to this depth and the dirt hauled to the next fill and the road shaped up. The grade still did not look right and it was plowed 6 ins. more, the dirt hauled down and the road shaped up. If grade stakes had been set at the beginning this plowing would have been done at one time and the road shaped but once, thus saving the cost of the whole construction force for some time. Again, in a piece of side hill work, the road authorities, without consulting an engineer, decided that the road should be built at a certain elevation. They thought that a shallow cut there and a slight fill at the bottom of the hill would give them an easy grade. The final result was a very deep cut, a very steep grade and greatly increased cost, when all their expectations might have been gained if the road had been located a little further down hill in the beginning.

Even in the flat sections the eye is often deceived and where there seems sufficient grade for drainage there often develop low places in the road which hold water after rains.

TEMPERATURE EQUIVALENTS OF WIND VELOCITIES.*

By W. H. Whitten.

A comparison of records taken at the group of buildings of the Harvard Medical School on the total heat expended and average temperatures and average wind velocities showed that one mile of wind movement per hour required substantially the same amount of heat supply as one degree change in temperature. A further study of similar records, however, has shown that there is a greater proportion of loss due to wind movement as the temperature drops.

This led the author to make investigations as to the impact effect of wind of the same velocity at different temperatures. It was found that there is a regular rate of increase in effective pressure as the temperature drops, although the wind velocity remains constant. This regular rate of increase of pressure is maintained only while the barometer readings are normal. A barometrical change caused changes in the impact pressure. The exact rate of this change was not determined, but the fact of such change was detected, the tendency being for an increase in pressure as the barometer rose and for a decrease as it fell.

It was estimated that, with the barometer and the wind constant, the increase in pressure is 0.4 per cent. per degree drop in temperature. It was also found that the non-pressure or suction on leeward sides of buildings increased in about the same proportion. The point at which heat loss from one mile of wind movement per hour and temperature were equal seemed to be between 36 and 39 degrees above zero. Above this temperature, the effect of wind became less important than the temperature changes, and below it, correspondingly more important.

For example: If, at 37 deg. plus, one mile of wind movement per hour is equal to one degree drop in temperature, at zero one mile of wind movement per hour will equal

$$1 + (37 \times 0.004) = 1.148 \text{ deg.}$$

If the temperature increases to 50 deg. plus, then one mile of wind movement equals

$$1 - (13 \times 0.004) = 0.948 \text{ deg.}$$

As a rule for personal guidance, the author has adopted the following: From 40 to 15 deg. plus, one mile of wind movement per hour is equal to one degree drop in temperature; from 15 degrees plus to 20 degrees minus, one mile of wind movement per hour is equal to 1.15 degrees drop in temperature. This is for buildings constructed in the ordinary manner, that is, without protected windows. Applied strictly to the glass surface, with leakage standardized, the loss from wind movement may be calculated as only three-sevenths of the loss under usual and ordinary conditions. This not only applies to the sides having the so-called greatest exposure, but, owing to the suction or non-pressure existing on the sheltered sides, should be applied to all sides of the building.

* Abstract of paper read before the American Society of Heating and Ventilating Engineers, at Detroit.

The Canadian Pacific Railway Company is acquiring several independent lines in Ontario, Quebec and Alberta, which now act as Canadian Pacific Railway feeders. Notice is given of the application to the railway commission next month, for a recommendation to the governor in council to sanction the lease by the Canadian Pacific Railway of the following lines: The Alberta Central Railway, the Campbellford, Lake Ontario and Western Railway, the St. Mary's and Western Ontario Railway, the Kingston and Pembroke Railway, and the Cap de la Madeline Railway.

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CONTENTS OF THIS ISSUE.

SEWAGE DISPOSAL AND WATER POLLUTION.

This question was discussed at the meetings of the Great Lakes International Pure Water Association and the National Association for the Prevention of Pollution of Rivers and Harbors, which have just closed in Cleveland, Ohio. At these meetings Dr. Allan J. MacLaughlin repeated his opinions as recently given before the International Joint Commission at Ottawa, to the effect that to compel cities along the Great Lakes so to treat their sewage that it would not contaminate the lakes into which it is dumped, would place upon these cities an unnecessary and unjustifiable expense, which would bankrupt the cities in most cases.

Dr MacLaughlin's evidence as given before these bodies does not agree very well with some of his statements as they appear in a report known as Bulletin No. 83 of the United States Hygienic Laboratory, entitled "Sewage Pollution of Interstate and International Waters." There he states that "unfortunately, the Detroit River is so grossly polluted that the city of Wyandotte has suffered terribly from typhoid fever. Undoubtedly, Wyandotte and Munroe also should filter their water supplies and protect themselves, but they should not be required to treat a raw water, which puts an unreasonable strain and responsibility on their filter plant." Many other statements similar to the above might be quoted which make it rather hard to appreciate Dr. MacLaughlin's stand in his evidence before the International Joint Commission.

It is interesting to follow the reasoning used in the above mentioned bulletin. He states that with the present rate of discharge of the St. Lawrence River Lake Ontario would require over six years to empty itself if all inflow were stopped, and then he adds that this means that the water in Lake Ontario is capable of purifying an enormous amount of organic matter, and that with the existing pollution the water should be pure outside of the zones of polluted water which surround the water-front of cities and towns and the mouths of large rivers.

The zone of pollution is a most uncertain one, as has been well demonstrated in the vicinity of Toronto. Prevailing winds may force the area of sewage-polluted water many miles from its ordinary boundary. Thus, the benefits of six years' storage of water in Lake Ontario are rather minimized. Dr. MacLaughlin states that the pollution by the Niagara River, including the sewage of Buffalo, the Tonawandas and Niagara Falls (together with the Canadian towns) is subjected to natural purifying agencies in its passage over the Falls and through the river. The results of bacteriological examinations show that the pollution at Niagara-on-the-Lake is a great deal higher than at Buffalo or Lake Erie. The effect of the Niagara River as a purifying agency is practically negligible, for it is only a matter in time of about twelve hours for water to pass from Lake Erie to Lake Ontario.

While it is true that the danger of sewage pollution of Lake Ontario is minimized by the depth of the lake and its enormous capacity for storage, at the same time it must be recognized that Lake Ontario is becoming constantly more infected. In the very near future, some experts say immediately, means must be taken to treat the sewage of the cities on the Great Lakes and the rivers flowing into them. Therefore, since this is true, the sooner the control of pollution of the Great Lakes is placed in the hands of the International Joint Commission the better it will be, in the ultimate, for both countries.

MATHEMATICS AND THE ENGINEER.

Theory and practice, in the minds of most engineers, have not a proper relationship. It is too commonly accepted by the profession to-day that a distinct line must be drawn between the purely theoretical man and the practical designer and constructor. We often hear the statement made that theory is all right, but practice and experience are the safest in the long run. As a matter of fact, there is no line to be drawn between theory and practice.

It is true that it is hard to analyze the strength of any engineering structure by means of mathematics without a practical knowledge. At the same time, it will be readily admitted that the progress made in engineering design and construction during the past few years has been due to the application of mathematics in the analysis of the stresses in their component parts.

In an address delivered by Sir William H. White, at the recent International Mathematics Congress held at Cambridge, another view of the utility of mathematics to the engineer is given. No one knows, he pointed out, any method by which the strength of a ship can be settled à priori, by deduction from the results of laboratory experiments on the physical constants of the materials used in its construction. All that is possible in getting out the scantlings of a ship, of larger size than ordinary, is to take as a model a ship which experience has proved to be of satisfactory strength. This is treated as a girder loaded in a hypothetical and purely arbitrary fashion. The stress which would result from this load is calculated, and a similar hypothetical load is then applied to the proposed vessel. Should the calculation show that this calculated, but wholly hypothetical, stress is not greater than in the model, the scantlings are considered satisfactory. The whole process, in fact, amounts to little more than an application of the rule of three, and experience shows that in this instance the procedure is legitimate. In fact, in a great number of cases we can find by mathematical methods the relative strength of two structures; but mathematical methods afford us generally no data as to the absolute strength of either. Indeed in certain cases, they fail even to indicate fairly the relative strength of similar members of different materials. Some years ago, for instance, the purchaser of a large testing-machine had considerable difficulty in persuading the builders of a well-known type to supply him with one having a steel beam. They wished to supply cast-iron, and submitted calculations which represented the latter to be not only stronger than the proposed plate-steel substitute, but stiffer. In the end, however, they gave way, but supplied their cast-iron model to another customer, with the result that it broke in seven pieces some eighteen months after being put into service. Taking a narrow view as to the field occupied by theory, it would be permissible to maintain that there was here a serious discrepancy between theory and practice; but, although it is not possible to express in mathematical form the difference in the reliability of a tough and of a brittle material, the difference cannot be neglected in any theory that claims to be in any way complete.

Mathematics to a great extent has been responsible for the benefits of our present day civilization, and it will always be the basis for engineering design. Mistakes have been made, and will continue to be made, not through the use of mathematics, but through the use of wrong assumptions on which the mathematics are based.

MONTREAL HARBOR COMMISSION

The announcement of the resignation of Major George Washington Stephens from the position of chairman of the Board of Harbor Commissioners of the port of Montreal brings to its end a Commission which has appeared to shipping and commercial circles of Montreal almost ideal. The resignation of Major G. W. Stephens came shortly after those of his two fellow-commissioners, and to some extent was no doubt occasioned thereby. Mr. Stephens makes that fairly clear in his letter of resignation, in which he refers to the manner in which the three Commissioners always worked in harmony, and expresses the view that harmony of that character is essential to the effectiveness of a commission. He considers, therefore, that it is best to retire and give the government an opportunity of electing an entirely new commission.

Part of the success of the commissioners and the cleanliness of their administration was no doubt due in large part to the fact that none of them were in financial need of the appointment. The chairman is a millionaire, and the financial remuneration attached to his position was of little consequence to him, and would be largely exceeded by the cost of maintaining the position. Messrs. Ballantyne and Geoffrion are wealthy men, and would also make more money attending to their own businesses.

The post of chairman of the Commission is one which demands the highest type of executive ability and imaginative power.

The government can only be praised for the appointments made to the chairmanships of the Transcontinental Railway Commission in Mr. R. W. Leonard, and to the International Joint Commission in Mr. C. A. McGrath. The action of the government in the selection of a new Commission will be awaited with much interest. It is to be hoped the choice of a chairman will fall on a man of engineering training and of the requisite administrative capacity.

TRINIDAD ASPHALT MINING.

The consumption of Trinidad asphalt, mainly for street construction and in a minor degree for chemical and other purposes, increases from year to year. The bulk of it is recovered from the pitch or asphalt lake on the island situated on elevated ground about fifteen miles from the sea shore. Smaller quantities are recovered by open pit mining in the close vicinity of the lake, where various deposits have accumulated from overflows in prehistoric times. The lake covers about 40 hectares, and is very deep; its surface is solid and hard enough to carry people. The asphalt is cut off with large hoes; the pieces so recovered are carried by hand into trucks attached to cable trams, and removed to the sea shore for export. A comparatively small portion of the output is, previous to being exported, freed from its water contents in a refinery on the island. The crude asphalt represents a brownish-black mass with a peculiar smell; it contains about 30 per cent. water, 30 per cent. mineral substances, and the rest is bitumen. The bitumen averages 82 per cent. C, 10.5 per cent. H, 6 per cent. S, and 1 per cent. N. The yearly export has now reached about 180,000 tons. Of late a liquid asphalt, or rather a highly asphaltic mineral oil, has been recovered on the island and exported, after the elimination from it of the liquid oils. It is particularly suitable for softening the hard Trinidad asphalt. The natural generating and hardening processes, which have ultimately resulted in the production of the asphalt, are of a very complicated nature; sulphur seems to have played a conspicuous part in them in conjunction with oxydation and polymerisation processes.

COST OF WATER SOFTENING BY LIME.

The members of the Metropolitan Water Board, London, England, have recently issued a pamphlet under the title of "Eighth Report on Research Work," by Dr. A. C. Houston,

(10,000 gallons=100,000 lbs.)

Temporary hardness of water as carbonate of lime, or its equivalent in soap destroying power, parts (or lbs.) per 100,000 parts (or lbs.) = lbs. per 10,000 gallons (100,000 lbs).	Cost of quicklime (10 lbs. = 2c.) and the amount to be added to soften the water.					
	Theoretically, that is 1 lb. of carbonate of lime requires ·56 lb. quicklime.		Practically, that is assuming that from ·75 to 1·0 may actually be required (owing to free CO_2 inert lime, &c.)			
			BASIS 1. 1 lb carbonate of lime requires ·75 lb. quicklime.		BASIS 2. 1 lb. carbonate of lime requires 1 lb. quicklime.	
	lbs. lime.	cents.	lbs. lime.	cents.	lbs. lime.	cents.
1	·56	·112	·75	·15	1	·2
2	1·12	·224	1·50	·3	2	·4
3	1·68	·336	2·25	·45	3	·6
4	2·24	·448	3·00	·6	4	·8
5	2·80	·560	3·75	·75	5	1·0
6	3·36	·672	4·50	·9	6	1·2
7	3·92	·784	5·25	1·05	7	1·4
8	4·48	·896	6·00	1·2	8	1·6
9	5·04	1·008	6·75	1·35	9	1·8
10	5·60	1·120	7·50	1·5	10	2·0
11	6·16	1·232	8·25	1·65	11	2·2
12	6·72	1·344	9·00	1·8	12	2·4
13	7·28	1·456	9·75	1·95	13	2·6
14	7·84	1·568	10·50	1·1	14	2·8
15	8·40	1·680	11·25	1·25	15	3·

and a perusal of its contents would leave an impression that this board had spent considerable time since the issue of the seventh report on the financial economics of softening and sterilization of water and of the effects of time on bacteriological and pathogenic organisms when treated with germicidical agents of varying strengths.

The method of softening water with lime may be explained by the following equation:—

Bicarbonate of lime.		Quick lime.		Carbonate of lime.		Water.
$CaO, CO_2 H_2O, CO_2$	+	CaO	+	$2 CaO, CO_2$	+	H_2O
100 62	+	56	=	218	+	18

Fifty-six parts of quicklime (CaO) are required to combine with 62 parts of hydrated carbonic acid (H_2O, CO_2), holding the 100 parts of carbonate of lime in solution. As the hardness of a water, however, is expressed in terms of carbonate of lime, 0.56 part of quicklime is required to precipitate 1 part of carbonate of lime.

In practice considerably more quicklime is required, because the free as well as the combined carbonic acid in the water has to be acted upon and, in addition, part of the quicklime (CaO) may have become hydrated (CaO, H_2O), and therefore less active weight for weight, and part may be inert (carbonate or impurities), and, further, the mixing operations may be imperfect.

The free carbonic acid, of course, is a constant factor, for all degrees of hardness, which it is sought to remove.

The accompanying table shows the working cost of softening 10,000 gallons of water with quicklime, irrespective of interest on capital expenditure, depreciation, labor, etc., and is based on a price of $4.80 for a ton of lime. Lime in this country is somewhat higher, so that this must be allowed for.

The cost remains the same whether quicklime or slaked lime is used, but the above weights of quicklime must be multiplied by 1.32 to obtain the comparative effective weights of slaked lime.

The above results are expressed as parts (or lbs.) per 100,000 parts (or lbs.), which is the same as lbs. per 10,000 gallons. To convert into grains per gallon and "degrees" of hardness, multiply by 7 and divide by 10. No account is here taken of permanent hardness, which requires a different kind of treatment for its removal.

The wastage of lime due to free carbonic acid being a constant factor, the figures in the last two columns are only approximately correct—thus the wastage at 1 and 15 (due to CO_2) being the same, it is proportionately cheaper to soften to 15.

To take an example:—A water has a total hardness of 21, the permanent hardness being 7 and the temporary hardness 14. It is required to soften 10,000 gallons from 21 down to 11 (i.e., 10 parts). The amount of quicklime required would be, theoretically, 5.6 lbs. (costing 1.12 cents), but practically about 7.5 (costing 1.5 cents) to 10 lbs. (costing 2 cents) would be needed. Erring somewhat on the side of exaggerating the cost, it may be said that 10 lbs. of quicklime, costing 2 cents, would be needed to reduce the total hardness from 21 down to 11 (10 parts) for every 10,000 gallons of water treated.

A NEW BRONZE.

The great strength necessary for bronze used in the construction of machinery, the keen competition existing between manufacturers, and the wide fluctuations in the price of tin, have induced metallurgists to study the question of substituting for the rather expensive tin bronze some special brass compositions (so-called zinc-bronzes) which not only have the advantage of being cheaper, but also surpass the tin bronze, so far as the breaking strength and elongation quality are concerned, at the same time offering the same resistance to attacks by acids.

The fact that despite the aforementioned advantages claimed for zinc bronzes, tin bronze still obstinately keeps its ground in most of the large foundries and in nearly all the minor ones, is unquestionably due to rather serious drawbacks, which even the best zinc bronzes, so far known, present along with their above-mentioned advantages.

The principal drawbacks may briefly be summarized as follows:

These zinc-bronzes generally have a very complex composition, mostly containing addition of metals not easily fusible and which unite only with great difficulty. On account of these two features the preparation of the alloy can only be carried out in a very complicated and expensive way, often even necessitating the separate preparation of distinct compositions, so-called "preparatory alloys."

The zinc-bronzes have a strong tendency toward separating when cooling down in the mould: the so-called "sweating" (liquation) takes place, which destroys the homogeneity of the smelted metal, the splitting tendency of which increases, whereas its chemical stability greatly suffers.

It is obvious that metal additions, which have to be forcibly dissolved, either by resorting to preparatory alloys or to incessant mixing before casting, take advantage of the first opportunity to separate, which opportunity presents itself during the solidification of the metal in the mould, or, in other words, during the period when a regular development of the process is of utmost importance.

scale for several years in the manufacture of any kind of machinery parts exposed to heavy and sudden stresses, such as wedges, bearings bushes, valves, stuffing boxes, screws, screw heads, wings of screw propellers, runners for turbines and turbo-pumps, etc.

Particularly in the construction of turbo-pumps for raising impure water or acids, the employment of "Universal

	Limit of proportionality in lbs. per sq. inch	Ultimate tensile strength, lbs. per sq. inch	Elongation %	Contraction %	Deformation limit under compressive stress in lbs. per sq. inch.	Coefficients of hardness (deduced from Brinell) in lbs. per sq. inch	Resistance to shocks in lbs. per sq. inch under the test for flexure of notched bars. (Resilence)*
Universal Bronze "S," moulded in sand	28600	71000	24.2	25	47000	190000	116
Universal Bronze "W," do.	25600	67700	33.0	36	.....	......	...
Universal Bronze "H," do.	40000	77000	14.0	20	.....	215000	126
Universal Bronze "S," wrought when hot	44000	76300	23.0	36	.....	......	...
Universal Bronze "S," wrought when hot; hammered when cold	65500	82700	11.0	36	.....	......	...
Universal Bronze "WW," 1¼" bars compressed when hot	19000	65500	39.0	47	.....	167000	224
The same bar stretched when cold at 30 m/m	59000	83000	20.0	51	.....	238000	155
Universal Bronze "WW" rolled in flat plate when cold, annealed; thickness 3/32"	30600	74800	26.5	46	.....	......	...
The same plate rolled half-hardened at 2 m/m	48500	82500	26.0	38	.....	......	...
The same plate rolled when hardened at 1 m/m 45 ..	65500	96000	13.0	35	.....	285000	...
Universal Bronze "WW" in plate 23/10 m/m; rolled when hardened at 18/10 m/m	74000	84600	14.0	33	.....	......	...
The same plate tested at 300°	60000	61000	15.0	36	.....	......	...
The same plate tested at 350°	not taken	56500	20.1	not taken	.....	......	...
Universal Bronze "WW" stretched in hammer; hardened wire of 4 m/m thickness	not taken	96000	6.6	54	.....	......	...

*In accordance with the requirements as adopted by the fifth International Congress for the testing of manufacturers products and materials, the said congress held at Copenhagen in 1909.

Furthermore, all zinc-bronzes contain iron, manganese or aluminum, and most of the time the compound of these three metals. These additions cause the formation of an oxide scale on the surface of the smelted metal; this scale or pellicle is indestructible and is continually being formed anew even if every precaution is taken in cleaning off the surface. This pellicle may also be carried in the mould, where it is constantly formed afresh; it often gives rise to troubles by intruding into the casting in the form of slag incrustation or superficial impurities.

Another and perhaps the most important drawback attached to the best zinc bronzes known to date is the fact that they shrink considerably when cooling down, bringing about a tendency to form blows (blow-holes) in the castings.

As the result of numerous series of systematically conducted researches, the foundry laboratory of the engineering works of Escher Wyss and Company, Zurich, Switzerland, has succeeded in producing a zinc bronze, which, besides being one of the most simple compositions imaginable, possesses a remarkably great breaking strength and tenacity, without presenting the disadvantages outlined above.

This bronze can be prepared in the most simple way by means of simultaneous fusion of its differents components; it has no tendency whatever to sweating or liquating, and only a slight tendency toward shrinking. The surface of the new bronze can be kept perfectly clean before being cast, without having to fear the formation of a prejudicial pellicle of oxides, and owing to this fact first-class castings are obtained without the slightest difficulty.

At the engineering works of Escher Wyss and Co., at Zurich, Switzerland, and at Ravensburg (Wurtemberg), this new bronze, "Universal Bronze," has been used on a large

Bronze" has been a success. This bronze has proved to resist the wear and tear of these liquids in a way so far unknown. "Universal Bronze" may also be forged, rolled, stretched and bent in cold condition, whereby its qualities of resistance are being considerably increased (see table). The low price should particularly be noted as same is considerably cheaper than ordinary tin bronze (4c. per lb.)

A few co-efficients of resistance obtained at tests made with "Universal Bronze" are stated in the attached table. As to the resistance to stresses produced by shock by testing the flexure on a notched bar (the results obtained are stated in the table in the last column), it should be noted that these tests have been carried out in accordance with conditions agreed upon by the fifth congress for testing materials held at Copenhagen in 1909. The figures obtained in the annexed table, therefore, cannot be compared with those based upon testing methods by Charpy, Fremont or Guillery.

INDUSTRIAL ACCIDENTS.

According to the record of industrial accidents maintained by the Department of Labor, that for the month of September shows there to have been 89 workmen killed and 419 injured, a total of 508. Compared with the record for August, this is an increase of one fatal and 114 non-fatal. The trades and industries in which the greatest number of accidents occurred were: Steam railway service, in which there were 28 fatal and 123 non-fatal; metal trades, with 3 killed and 72 injured; mining, with 10 killed and 42 injured; and the building trades, with 10 killed and 33 injured.

WINTER TROUBLES ON ELECTRIC RAILWAYS.*

By Charles J. Jones.

The operation of electric railways in sections of the country where there is little or no snowfall, differs but little from the regular performance at other seasons. Where the winter is a rainy season of a few months the problem becomes one of railway construction, requiring waterways of sufficient number and capacity and properly located so as to avoid breaks in the roadbed due to washouts. In our northern districts, where the snowfall is of some importance, the question of maintaining the schedule in winter becomes at times a difficult one and a source of anxiety. Snow, sleet, ice and frost are the trouble makers, and the manager who contends successfully against them is the one who has made full preparation before the winter had made its appearance.

The maintenance-of-way department should see to its waterways and bridges. Where pile bridges are maintained over streams, such tools and explosives as may be necessary to protect the supports from ice should be on hand and ready for use. Heaving of track by frost is a menace to the safe operation of trains, and is a frequent cause of delay to the service. It seems almost impossible to obviate this trouble entirely, but as it is usually the result of poor drainage, it is important that all ditches in the cuts should be cleaned before the frost comes. Certain cuts cannot be drained properly by the ordinary ditch, and it then becomes necessary to lay drain tile a few feet below the ditch in order to draw away the moisture from the subsoil.

Sleet and ice coupled with high winds are serious factors to be considered in the proper maintenance of transmission lines and the assurance of a continuous supply of power. Poles and cross-arms should be carefully inspected and strengthened where necessary; new insulators should replace doubtful ones, and all wires (telephone, trolley and transmission) should be looked over and the weak places made strong. On lines where the third rail takes the place of the trolley wire, the same careful inspection should be made and proper attention given to the insulators, underground cables (with the necessary drainage thereof) and the cable terminals. The loss of power for a short time during the progress of a winter storm may mean the loss of train service for many hours.

The handling of snow may be considered under two heads: 1, Methods of preventing snow from accumulating; 2, Methods of removing snow.

Methods of the first class as applied to interurban lines include the widening of cuts and the use of snow fences. Where trouble from snow drifts occurs annually, a permanent board fence may be erected in place of the usual right-of-way wire fence. Frequently we use boards nailed to the regular fence, supporting them by nailing to the fence wire and to an intermediate post. Portable snow fences may be set out in the fall and removed in the spring. These are usually made in panels about 16 ft. long and 6 ft. high, and should be set from 50 to 100 ft. from the track.

As a rule, landowners do not object to allowing these fences on their land, but in some cases compensation is demanded. A wise forethought while securing right-of-way, has in some instances provided for the right to use portable snow fences on the adjoining property, and where possible this should always be done. These fences cost about 25c. per lin. ft., and when properly placed are extremely valuable in preventing the snow from drifting into the cuts. As the snow piles up around them, these fences can be raised on the drifts or set farther back as occasion warrants.

* Abstract of a paper read before the Illinois Electric Railways Association.

There seems to be no reason why the usual wire right-of-way fence should not be replaced in places subject to snow drifts by hedges of osage orange, honey locust, Japan privet, tartarian honeysuckle, or other hardy growth, which could be kept trimmed to fence height. In addition to acting as a partial protection against drifting snow they would make a permanent right-of-way fence, neat in appearance and effective in preventing cattle from passing through.

Methods of the second class, referred to as the "removal of snow" are various. They include many devices, from the man with the shovel to the light rail scraper and the powerful mechanical plow. The man with the shovel is not to be disregarded, as he is an essential factor in any snow-fighting equipment. His limitations, however, are apparent to anyone who has attempted to clean snow from track with a hundred and more men in the face of a gale of wind, the air dense with drifting snow and the temperature about zero. He no doubt has felt not only the effect of exposure to the storm, but also that of discouragement when, upon looking back, he has found that the section just cleared from snow was again full.

On city lines it is usual to equip the cars with scrapers, which are under the control of the motorman and so arranged that the blades are held on the rail under pressure. On all unpaved streets and highways it is important that the mud and dirt should be scraped aside and leveled down before it becomes frozen. If this is not done, the scraper will not be able to reach the rail and the motor and gear casings will be dragging on the high places.

The rotary broom sweeper is used especially on city lines and, being very effective, should be included in the snow-fighting equipment of all companies operating cars on streets and highways. These sweepers may also be equipped with wings which push the snow beyond the range of the brooms. As the sweeper throws a cloud of snow it is important that it should be operated by men of good judgment, as the flying snow is very likely to frighten horses. The electrical equipment to operate these sweepers varies according to the ideas of the purchaser, but the mistake of having slow-speed motors to drive the brooms should be avoided.

On lines operating on private right-of-way in the open country the high-V-shaped nose plow and centre-share plow prove to be highly efficient. These plows also are equipped with adjustable side wings to push the snow farther aside. These types of plows practically force their way through the snow and the secret of their success is weight of car and high speed. They should have the speed of the fastest passenger car on the system, in order to be able to run ahead of the regular cars and keep clear of them, and also for the purpose of clearing a large track mileage. The writer has passed through snow drifts varying from 2 to 10 ft. deep and 2,000 ft. long with a snow plow of the centre-nose type built on a flat car 34 ft. long (50 ft. over points of plows), with wings open to clear a width of 11 ft. It was weighted down with rails and old iron; equipped with four 125-h.p. motors, and geared to a speed of 72 miles per hour.

Passenger, freight and express cars are frequently equipped temporarily with a small nose-plow attachment, and are able to cut their way through snow that otherwise would stop them. In sections where the snow conditions are severe, the rotary snow plow is much to be desired. This type of plow has a large pan or hood in front, with spreading wings to collect the snow as the car is driven forward. Within the hood is a revolving wheel fitted with blades which cut the snow and carry it upward, throwing it a considerable distance to the side.

The movement of cars through snow soon forms a crust which becomes harder as the motor casings continue to drag on it. This hard centre not only checks the speed of the cars, but causes a loss of power in proportion to the extent to which the casings ride on it. This condition becomes at once apparent if a car having smaller wheels than the others is run over the line. When such a car comes to the hard centres it soon stops, and efforts to move it brings only spinning wheels. Upon examination it is found that the motor casings are riding on the crust of snow and raising the wheels from the rails, destroy the traction effort. To remove this hard centre we have the scraper and flanger, which is usually lowered and raised by compressed air. In some cases a device with steel points arranged in the form of a tooth harrow is used successfully to break down the hard centre. In congested terminals and streets where the snow can no longer be pushed aside by the wings of snow plows, etc., it becomes necessary to load it on wagons or cars and haul it to the most convenient place for unloading.

Snow storms vary in intensity and in kind, and it is hardly possible to depend upon a single type of snow plow or sweeper to overcome them all. Certain types of plows are better adapted to control certain storms. To have at command any or all of the above mentioned snow-fighting devices is not alone sufficient; there must be organization for the work. The organization should be carefully planned in advance and the men included therein fully instructed and trained, so as to avoid confusion or misunderstanding when the emergency arises. Men trained to a particular work of this kind should be kept there, if possible, as experience is a valuable asset. The men should be instructed to report for duty immediately upon the first snowfall and be ready to take charge of the work allotted to them. The superintendent or officer in charge should be where reports of progress or difficulty can reach him promptly, so that he can act in accordance therewith with precision. The work must be started with the appearance of the storm, without waiting until reports come in of the cars being stopped.

Having an organization and equipment, it is also important that the equipment be thoroughly overhauled and put in condition for immediate service at the beginning of winter. When the threatened danger has made its appearance, there is no time for repairs or the purchase of shovels and brooms or plows. A contest against the storms of winter is war, so let us follow the adage "In time of peace, prepare for war."

SURFACE OILING AND CONSTRUCTING OIL MACADAM.

The city of Oakland, Cal., has been employing heavy asphaltic road oil on its macadam construction so as to make it suitable for light traffic under modern conditions. A description of the methods employed in this work and the results obtained were given by Mr. Wm. J. Baccus, commissioner of streets, of Oakland, in a paper presented at the 15th annual convention of the League of California Municipalities, held at Berkeley, Cal., September 23 to 28. Mr. Baccus' paper, in abstract, follows:

Surface Oiling Methods.—Our methods of surface oiling may be outlined as follows: The street is first cleaned by scraping and sweeping the dust and mud from the surface, including the gutters, sufficiently at least to show whether any patching must be done to secure a uniform surface. All holes and depressions are filled with suitable rock, watered and rolled. The street should then be allowed to stand long enough to enable the traffic to compact the patches to a density uniform with the rest of the street. When this uniformity is secured, or before, if time presses, the necessary screenings are placed in the gutter and the street again swept to remove the last particles of dust. Oil is then spread upon the street at a rate varying from ½ gal. to the square yard to a full gallon, depending on the compactness of the street surface. Ordinarily on a street that has been in use for two or more years, ½ gal. per square yard gives the best results. This oil is then covered with fine, clean screenings already at hand in the gutters, sufficient to prevent the oil from running into the gutters or adhering to passing vehicles. The street is then rolled with the steam roller and thrown open to traffic. It has been the custom in the past to allow the oil to stand for one or two days before screening, with the thought that the irregularities in the application will disappear, but this has several objections, and it is no longer necessary since we have adopted the use of the pressure oiler. The method described is applicable only to streets in fairly good repair. If so badly worn that half of the street must be covered with rock to produce a uniform surface, it is doubtful if the results will justify the expenditure. In such cases it is now our practice to scarify the street, harrow, reroll and reconstruct as oil-macadam, the oil having a penetration of two or three inches.

Surface Oiling Cost.—Our costs have varied between 5 and 12 cts. per square yard for ordinary surface oiling on different streets. Assuming that the street is in fair condition, and eliminating the cost of patching ruts and holes, which is not properly chargeable to oiling, a cost of 6 cts. per square yard should not often be exceeded. This does not include office expenses or general supervision. This assumes about ½ gal. of oil per square yard. More oil adds to the cost directly by the cost thereof, and indirectly by increasing the amount of screenings that must be used.

Following is a statement in detail of oiling several streets recently in Oakland, aggregating about .7 mile and having an area of 11,738 sq. yds. These streets were hard and smooth and in a hill section of the city:

	Total.	Per sq. yd.
6,000 gals. oil at 4.38 cts. (delivered)..	$263.12	$0.0224
160 yds. screenings at $1.75 (delivered)	280.00	.0238
3 days steam roller at $15.00..........	45.00	.0038
Oiling—		
District deputy 2 days at $5.00.....	10.00	.0009
Sub-foreman 5 days at $3.00......	15.00	.0012
Labor, 25 days at $2.50............	62.50	.0053
Cleaning Street—		
Deputy, ⅔ day at $5.00..........	3.33	.0003
Sub-foreman, 2 days at $3.00......	6.00	.0006
Labor, 10 days at $2.50............	25.00	.0021
Cart and driver, 2 days at $4.00 per day	8.00	.0007
Total	$717.95	$0.0611

Or about 6 1/10 cts. per sq. yd.

Results From Surface Oiling.—To make clearer the significance of these figures, apply them to a certain group of streets, comprising one sprinkler route in another part of the city. This route is also in a hill section and comprises 4.26 miles, besides a number of blocks not sprinkled because already oiled. The average daily cost for sprinkling is $3.68 for water and $5 for driver, horses and carts, a total of $8.68 per day. Allowing 250 days per year, the annual cost for sprinkling is $2,170. The estimated cost of cleaning the streets twice per year, together with special cleaning of culverts and gutters during and after storms, is $810, of which it is estimated that $426 would be saved if the streets were oiled. The total saving, on these two items alone, of sprinkling and cleaning, would be $2,170, plus $426, or about $2,600, excluding office expense and general supervision. The estimated cost of oiling being about 72,240 sq. yds. at 6.1 cts., is $4,407. Therefore, if the oil surface lasts on the average one year eight months over the district, the expense of oiling this sprinkler route is justified by the saving in these two items. Other routes, on more level ground where sprinkling costs less, would not show results quite so favorable to the oiling; while others would show even more favorably.

Patching is done intermittently on macadam streets, at such intervals that we have no satisfactory figures on cost per mile per year. Patching on oiled streets must be done systematically and more frequently, because the public demands a smoother surface on an oiled street. Therefore, until more definite figures are obtainable, we must assume that there will be no decrease in the cost per mile per year for patching as a result of surface oiling, but that the same amount of money, or a small increase, will give better service. The saving will appear in lessened wear and tear on vehicles and greater convenience to the public.

Oil Macadam: Methods.—Our method of constructing oil macadam, summarizing briefly from our specifications, is as follows:

After the roadway has been brought to the proper sub-grade . . ., and after the curbs and gutters have been constructed, a layer of broken stone, having a depth varying regularly from 8 ins. at the centre of the roadway to 6 ins. at the gutters, measured before rolling, shall be spread on said sub-grade. . . . The aforesaid layer of broken stone shall then be covered with a layer of screenings of sufficient depth to fill the voids in said layers of broken stone, and then thoroughly rolled with a 10-ton roller until the screenings have worked down into the broken stone and the roadway presents a uniform surface. All depressions occuring in said roadway during the rolling shall be brought to the required grade with broken stone and screenings of the same size and quality as is used in the aforesaid layers.

The aforesaid broken stone and screenings, after being thoroughly rolled and before the rolled surface has been disturbed, shall then be sprayed uniformly with oil at the rate of 1 gal. to the square yard of roadway surface covered, and allowed to remain in this condition for a period of not less than 48 nor more than 72 hours. A light layer of screenings shall then be spread over this oiled surface, after which the roadway shall be sprinkled with water and thoroughly rolled with a 10-ton roller.

The roadway, prepared as hereinbefore specified, shall then be allowed to become thoroughly dry, after which oil is to be sprayed uniformly over the surface at the rate of ½ gal. to the square yard of street surface covered. Screenings, to the extent of preventing the oil surface from adhering to vehicles shall then be dusted over said oiled surface and thoroughly rolled.

Oil shall be applied to the pavement under pressure of at least 30 lbs. per square inch. . . .

All of the above-mentioned oiling shall be done only while the atmospheric temperature is above 65° Fahr., and even then only during such periods as the sun is shining. No oiling will be permitted when the layer of broken stone or the screenings are in any way wet.

The oil is a residuum of an asphaltic oil and contains 85 per cent. of asphalt, having a penetration of 80. The temperature, volatility and allowable impurities are specified in detail.

Good workmanship and materials are necessary to secure results. In general, it may be said that the same precautions must be observed as for plain macadam, with several that are special to this work. Dirt, and dust in quantities, must be excluded. The greatest difficulty, and one that requiries experience and judgment to overcome, is in securing that amount of penetration that will use all of the oil (that is, take the surplus from the surface) and yet allow enough near the surface to produce finally an asphaltic appearance. The kind of rock and screenings used, the amount of screenings, the amount of rolling, the moisture present, and the weather are all conditions that must be considered. In general, it may be said that the voids should be well filled and the stone compacted before the first oil is brought on the work, but the surface should be quite porous, even open. After the first oiling should come the greater part of the rolling. In fact, before the second oiling the street should be as thoroughly compacted as can be done with a roller weighing at least 250 lbs. per lineal inch of tread. In some cases there has been a tendency to reduce the amount of rolling below the requirements of plain macadam. This should not be permitted. Oil macadam requires fully as much rolling as plain macadam.

In some places we have used and are planning to use more extensively in the future, a better class of oil macadam. This is constructed in two courses. The first consists of 4 or 5 ins. of ordinary macadam sized rock, screened, rolled and practically completed as for plain macadam. Then we spread 3 ins. of rock, not exceeding 2 ins. in size, and proceed much as already described in detail. We try to confine the penetration of the oil to the second course.

With neither type of oil macadam, nor in fact, with surface oiling, do we try to secure a uniform asphaltic appearance immediately upon completion. If we should, the material would adhere to passing vehicles and we would find it necessary to spread more screenings. It requires several weeks or months, and in some cases a year, for the surface to assume its final appearance.

Oil Macadam: Cost.—We have no figures showing the additional cost of constructing oil macadam over and above the cost of constructing plain or water-bound macadam, except such as can be deduced from our experience in surface oiling and from a comparison of contractors' bids. Roughly we figure that oil macadam, constructed as already described, costs from 1½ to 2 cts. per square foot more than plain macadam. Perhaps it would be fair to say that comparison of bidding prices shows an average increase of about 15 cts. per square yard. For oil macadam complete, as described, we are paying this season from 8¼ cts. per square foot to 9¾ cts. per square foot, or from 74 to 88 cts. per square yard. These prices, of course, include the contractors' profits, cost of collection and all overhead expenses. Where the pavement is constructed in two layers, the cost is increased again about 12 or 15 cts. per square yard. Two-layer work being better in all classes of macadam, this further increase, of course, is not chargeable to the use of oil.

Before closing this paper, it might be well to explain our reason for using oil macadam on new construction and on reconstruction instead of the cheaper process of surface oiling. As already indicated, the results are more permanent. If it be necessary to restore the asphaltic coating of oil macadam after the lapse of several years, it can be done with even less expense than original surface oiling on plain macadam. A mere surface of oil is removed within a period varying from two to five years by the action of traffic and storm water, but these agents seem to have little effect on oil macadam except at the surface. Furthermore, it is claimed, on proof of experience, that surface oiling frequently encourages raveling by preventing the renewal of the moisture that is so necessary to preserve macadam. Theoretically this should be particularly true of streets oiled soon after construction before traffic has secured final compaction. This difficulty should not be observed where the upper half or more is bound with oil. Furthermore, we have found it extremely difficult to secure a surface of oil that will adhere to the macadam and that will not "roll" or "wave." Every precaution must be observed to have the street clean and to adjust the quantity of oil to the requirements of the street. With oil macadam, however, we have more latitude within reasonable limits, for if the street finally shows a deficiency of oil at the surface, the fault can always be corrected by a light third application.

In conclusion, it may be said that it is our policy to permit the use of standard asphalt pavement on light traffic streets, but not to urge such construction excepting near the business district; to use oil macadam on all new construction in the residence districts; to surface oil, as rapidly as funds permit, all plain macadam streets that are in condition to be treated economically; and to reconstruct with oil macadam all plain macadam streets whenever such streets become worn out, unless conditions require a better pavement.

AMERICAN ROAD BUILDERS' ASSOCIATION.

Arrangements for the American Good Roads Congress and ninth annual convention of the American Road Builders' Association at Cincinnati, O., December 3rd, 4th, 5th and 6th, have been practically completed. The plan adopted last year of considering certain specified subjects each day will be adhered to this year, although a somewhat greater subdivision of the main topics has been made. The first session, on Tuesday, December 3rd, will be devoted to the usual addresses of welcome and responses, and a presidential address by Nelson P. Lewis, Chief Engineer of the Board of Estimate and Apportionment of New York city, and president of the American Road Builders' Association. Six of the seven remaining sessions will be devoted to the presentation of technical papers and their discussion, and one session will be used for the annual business meeting of the Association.

The tentative programme of the technical sessions includes three papers on the organization of highway departments of States, large cities and small cites, respectively. The first will be presented by Major W. W. Crosby, Consulting Engineer of the Maryland State Roads Commission; the second by Wm. H. Connell, Chief Engineer of the Bureau of Highways, Philadelphia, Pa., and the third by a speaker yet to be announced. The development of a plan for a State or county road system will be treated in a paper by an authority yet to be announced, as will also the construction of stone and brick pavements. The building of earth and gravel roads will be treated in a paper by Robert C. Terrell, State Commissioner of Public Roads of Kentucky. The subject of bituminous pavements for cities will be presented in a paper by George W. Tillson, Consulting Engineer of the Borough of Brooklyn, New York city, and Ellis R. Dutton, Assistant City Engineer of Minneapolis, Minn., will describe the construction of wood block pavements by the day labor plan now in force in that city. Three papers on questions of importance to all engaged in either road or street work will be presented by Col. Wm. D. Sohier, chairman of the Massachusetts Highway Commission, who will speak on the importance of the traffic census as a preliminary to the planning of road improvements; Clifford Richardson, Consulting Engineer, New York city, who will discuss the economics of road and paving construction, and Arthur S. Lewis, Secretary and Superintendent, Lincoln Park Commission, Chicago, Ill., who will discuss the value and importance of cost data. Contractors will hear the matters with which they are especially concerned discussed by Hugh Murphy, a well-known public works contractor of Omaha, Neb., who will present a paper on the general subject of the problems of a road contractor, and by F. E. Ellis, manager of the Essex Trap Rock and Construction Co., and a prominent road contractor of Peabody, Mass., whose subject will be plant equipment. It is probable that the technical programme will also include two or three other papers dealing with specific work of interest to road builders and with general questions with which they are concerned.

In addition to the day sessions, at least one evening session will probably be held, at which illustrated addresses will be made. This, together with other features incidental to the convention, will be announced later.

OPERATING RESULTS OF IMHOFF SEWAGE TANK.

The Imhoff sewage tank at Winters, California, has now been in operation for over four months and the operating results were described by Mr. Fred H. Tibbetts, designing engineer, in a recent paper before the League of California Municipalities. The design of the tank is similar to other Imhoff tanks previously described in this journal, especially those at Chambersburg, Pa., and Winchester, Ky. A brief description of the structural features of the tank at Winters is here given, however, to aid in the interpretation of the operating results later described. The information is abstracted from Mr. Tibbetts' paper.

Features of Design.—The sewage disposal works at Winters were designed to accommodate a population of 3,000, which is twice the present number, so that no enlargement of the work will be necessary in the near future. The estimated daily sewage flow is 75 gals. per capita, 225,000 gals. for the assumed population of 3,000. There are two tank units with sludge digesting chambers capable of storing six months' sludge production. The chambers are 20 ft. in diameter and have an effective depth for storing sludge of 6.5 ft.; the sludge capacity amounts to 1,950 cu. ft. for each tank or a total of 3,900 cu. ft. Estimating the amount of sludge at 0.007 cu. ft. per capita per day, the amount from 3,000 persons, therefore, would be about 3,780 cu. ft. in six months.

Communication between the upper and lower chamber of each tank unit is afforded by 10-in. slots. The trough bottoms slope toward the slots at an angle of 45 deg., which is assumed to be steep enough to allow the solids which settle on them to slide down and pass into the sludge chamber. The sewage as it enters the sedimentation tank passes under two scum boards set 1 ft. apart, with their lower edges 18 ins. below the water surface. These intercept floating matter and if the scum forms back of or between the boards it may be removed by raising the planks which cover this space. The arrangement at the outlet end of the tanks is identical with the inlet and provision is made for reversing the direction of flow periodically so as not to get a greater accumulation of sludge in one tank than in the other. The bottom of the sludge digesting chamber is an inverted cone with a height of 5 ft. and a diameter of 20 ft. The depth of sewage will be such that the sludge at the bottom will be under 19 ft. of water.

When the sludge is being removed water may be discharged into it from five points to stir it up and make it slide down to the intake of the sludge pipe. Around the base of the vertical walls of the beginning of the bottom slope is a 2-in. water pipe for flushing. There are four 1-in. openings spaced around the tank at 90 deg. intervals and a branch running to the lowest point of the tank.

Sludge is removed from each tank by an 8-in. outlet pipe of cast iron coated with coal tar to protect it from the action of the sewage. The intake end of this pipe is at the lowest point of the sludge chamber and the discharge end is in a square concrete manhole 5 ft. below the sewage level of the tank and is fitted with a shear gate. When this gate is opened the sludge will be forced into the manhole from the bottom of the sludge chamber by a 5-ft. head of water and from here will flow by gravity to the sludge drying bed.

The tanks are covered by a reinforced concrete roof 6 ins. thick, high enough above the sewage surface to allow the formation of a sludge mat. Manholes 18 x 36 ins. at the side and 24 x 36 ins. at the centre of each tank are provided for removing this mat if it becomes necessary to do so. All parts of the roof of the sludge chamber slope toward one of these three manholes, so that the gas bubbles from the working sludge will have free passage to the vents.

A 10-in. galvanized iron pipe connects with each of the three gas chambers and extends 10 ft. above the roof.

To give complete control of operation a 2-ft. concrete channel to carry the sewage runs entirely around the tank and is provided with stop planks, so that the sewage may run through both tanks in reverse direction, through the first tank only or by-pass both tanks. The major part of the sedimentation takes place in the first tank and it is proposed to reverse the flow through the system every week or so in order to equalize the accumulation of sludge. If it should prove that one tank is sufficient for the present population to be served, the second tank may be by-passed and held in reserve until needed. The tanks are located near the site of a proposed public park; for this reason it was considered advisable to cover them.

Operating Results at Winters.—The Imhoff tanks at Winters have not been in operation long enough to give very definite ideas of what may be expected of them, as they were first put into service about four months ago. The operation has been under the supervision of Mr. Luke Gregory, who, although without experience in sewage disposal, has given unusually careful and intelligent supervision. Three progress reports have been obtained from assistant engineers since that time, but no analyses have been attempted. The last inspection was made on September 20, by the writer, in company with Mr. Gregory. The system is completed, but all the houses have not yet been connected and the amount of domestic sewage delivered is much less than that for which the tanks were designed. The effluent from the tanks has been quite clear and comparatively free from solids, except at times some finely divided black humus matter. At first, while the flow was very small, a slight odor might be detected, but this appears to be hardly perceptible at present. During the greater part of the period of operation, only one tank has been in use. Lately a part of the sewage has been diverted so as to enter the outer end of each unit, being taken off at the centre opening. This makes the tanks operate in parallel rather than in series, as was intended.

Bacterial action is decidedly active, as evidenced by the continual rising of large quantities of gas bubbles. Most of these bubbles rise in the centre manhole, which collects gas from the largest portion of the sludge wells. Although gas was escaping in large quantities no odor of hydrogen sulphide could be detected, even close to the open manholes. The heaviest mat was found in the centre manhole of the first tank. This was about 6 ins. thick, the manhole being 3 x 4 ft. All of the other floating solids would probably be not more than six more cubic feet, making in all about 12 cu. ft. of floating solid material in the entire tank. This is a very small quantity compared to the amount of material usually found in the floating mat of a septic tank, and indicates that a large proportion of the solids do not hold enough gas to keep them continually floating.

The mat was similar to that usually found on a septic tank, and when judged by the odors given off was not nearly so offensive. Some of the material from the lower part of this mat was taken out and examined. It consisted of a black homogeneous mass containing very little fibrous material and having little odor other than that suggestive of tar or crude oil. The mat on the side manhole of the first tank was but about 2 ins. thick, similar in appearance to that in the centre. Bubbles were rising here also, but in not nearly such large quantities as appeared in the centre. This was due also in part to the fact that most of the solids fall nearer the centre of the tank, after passing through the slots from the sedimentation chamber.

The sludge deposited in the bottom of the tank has been measured by Mr. Gregory, who found it to be about 2 ft. thick. No sludge has yet been drawn out. Since the capacity of the sludge well permits of an accumulation of something over 6 ft. before this will become necessary, no observations on the character of the sludge from the bottom have yet been made.

It was found that a slight mat had formed on the sedimentation chamber longest in use. This mat was very thin, probably not over ½ in., and its origin has not been definitely ascertained. The slope of the partitions between the sedimentation chamber and the sludge wells is 45 deg., or 1 on 1. It may be that some finely divided solids have remained on this surface for a period long enough for putrification to set in and have bubbles form, causing them to float. Or it may be that, as was observed in the Philadelphia experimental tanks, some solids are contained in the sewage, which are light enough to float of themselves. Gas and scum is so small compared to the amount of sewage passing through that it cannot be a serious defect. Later designs of Imhoff tanks call for slopes of 1 on 1½ for these surfaces, and perhaps with such steeper slopes there would be less tendency for scum to form in the sedimentation chambers.

As will be noted from the description, a cover was placed on the tanks. This was done in spite of the fact that both Dr. Imhoff and Dr. Rudolph Hering of New York considered it unnecessary. In general, a cover is, undoubtedly, not required. The writer, however, believes it better to cover any sewage disposal works operated in close proximity to residences, as there is undoubtedly less odor in any type of works which is covered. At Winters, the pipes arranged for conduction of the gas from the tanks have been brought together and extended so that the point of discharge is now about 30 ft. above the ground. The operator states that previous to this there were, on quiet mornings, objectionable odors in the immediate vicinity of the tanks. This condition was relieved upon the extension of the pipes. The effluent has been concentrated in a closed iron pipe and taken down to the creek bed, where it flows through a channel in the gravel for a distance of about 100 ft. to the main stream of the creek, which is very low at this season of the year. The only odors noticeable about the entire plant were in the 100-ft. channel through the gravel. This could be readily eliminated by diverting the flow of the creek so that the point of discharge of the tank would be under water.

The cover has been found efficient in preventing the use of the tanks as a breeding place for mosquitoes, and the operator has found it desirable to make all openings as nearly tight as possible except for the gas pipes and effluent pipes.

During the summer months a large amount of cannery waste, estimated by the operator as high as 150,000 gals. in 10 hours, was discharged into the sewers, and found its way to the tanks. This material is strongly alkaline from the use of lye in the fruit canning process. It is stated by the operator that upon its arrival at the tanks, sludge decomposition as evidenced by the formation of gas bubbles, ceased. Also that the velocity of flow through the tanks was too high to admit of thorough sedimentation, and that at such times objectionable odors were given off and the effluent was dark and contained considerable suspended solids. Normal action was quickly resumed, however, when the cannery wastes were diverted from the disposal works.

TO UTILIZE LUMBER REFUSE.

Vancouver sawmill owners propose to utilize lumber refuse now being consumed in huge burners at the mills to make electrical power and steam heat, and to offer the same for sale. Application is made to the civic authorities for the necessary permission to lay wires and pipes for transmission purposes. The movers in the scheme say they can offer electricity to the city at ¾ of a cent or one cent per kilowatt.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

BOOK REVIEWS.

Artistic Bridge Design.—A Systematic Treatise on the Design of Modern Bridges according to Aesthetic Principles. By Henry Grattan Tyrrell, C.E., Bridge and Structural Engineer. Chicago: The Myron C. Clark Publishing Co. Cloth; 6 x 9 in.; 294 pages; 242 figures (about 80 full-page half-tones). Price, $3.00 net.

Reviewed by C. R. Young, B.A.Sc., Consulting Engineer.

Although several comprehensive discussions of bridge æsthetics have appeared in the transactions of the great engineering societies and as chapters in general treatises on bridge design, Mr. Tyrrell's book is the first one in English, as far as the reviewer is aware, to be given over entirely to the consideration of this subject.

The author's purpose, as disclosed in the sub-title, is a commendable one, and, broadly judged, he has treated the subject well. Such criticisms as a careful reader may make are largely those of detail, and cannot be said to challenge the value of the book as a whole.

After a splendidly-written introduction by Mr. Thomas Hastings, of Carrère & Hastings, the well-known architectural firm, of New York, the author justifies his choice of subject by showing the importance of bridges, their effect on civilization and progress, and the necessity for artistic bridge construction. He then proceeds to establish "Standards of Art in Bridges," stating and discussing the following five:—

1. Conformity with environment.
2. Economic use of material.
3. Exhibition of purpose and construction.
4. Pleasing outline and proportions.
5. Appropriate but limited use of ornament.

In the fourth chapter, which, it would seem, in the interests of logical arrangement, should have preceded the one just mentioned, the author effectively sets forth the "Causes for Lack of Art" in bridges. Chapter V., entitled "Special Features of Bridges," is given to the consideration of bridges carrying buildings, memorial arches, towers, etc., but rather curiously, it has been made to include also the very **general** subjects of the kinds of bridges from the standpoint of the material employed and the selection of the bridge type. Eight "Principles of Design" are elaborated in Chapter VI., which if followed would, it is inferred, satisfy the "Standards of Art" established in Chapter III. In Chapters VII. to XI., inclusive, are discussed the various æsthetic points which come up for consideration in designing "Ordinary Steel Structures." "Cantilever Bridges," "Metal Arches," "Suspension Bridges" and "Masonry Bridges." Then, constituting Chapter XII., but not so indicated in the text, is a series of some 83 fine half-tone illustrations, most of which occupy a full page each. On the page facing each illustration is a brief description of the bridge shown, but, strangely enough, the descriptions concern structural features, dimensions, costs and history, and very little in the way of æsthetic comment is offered in this part of the book, where it would be most effective.

Some of the artistic judgments of the author will undoubtedly be questioned by bridge engineers who have given thought to the question of æsthetics. His dictum (p. 45) that "there is no greater jar to æsthetic feeling than to see a bridge in which this principle (symmetry) is violated with large spans at one end and smaller spans at the other, or with the principal span noticeably out of centre" is scarcely supported by reference to an elevation of the Walnut Lane bride at Philadelphia. Lack of symmetry is, of itself, not a source of disappointment if the reason for it is **distinctly** apparent and does not arise from sub-aqueous conditions. Nor is disappointment occasioned if a part of the bridge is obscured from view, or if the bridge is so large that the whole structure cannot be seen in elevation at any one time. Again, the alleged necessity of indicating in some way on the surface the absence of spandrel filling where spandrel curtain walls are used (p. 22) is not defensible if the arch ring is accentuated in proportions consistent with a spandrel-filled arch. It might further be pointed out that the three designs for girder bridges by the author, shown on pages 51 and 52, are not wholly free from the defects which commonly mar such structures. In two of them the abutments lack face batter, thus giving an impression of instability; in all of them an even, rather than an odd, number of fascia panels are employed; and in one the turned balusters are large enough to effectually dwarf the girder itself.

There is a certain looseness of expression in portions of the book, indicating undue haste in writing. For example, the author speaks of certain buildings being "adorned with art" and stone bridges displaying "an amount of art . . ." Trusses are said to resist bending "by the counteracting moments in the upper and lower chords."

One regrettable feature of the book is the paucity of references to the work of those who have done most to shape and define the aesthetic principles which the author is able to re-state, possibly in improved form. Of the fourteen foot-notes, twelve refer to the work of the author and two other sources of information. The critical reader will scarcely believe that the division of honors in the references bears a proper relation to the division of labor in the development of the subject.

Apart from these and certain other criticisms which might be made, the value of the book is unquestionable and everyone who is responsible for the design of bridges should own, or have access to, a copy.

The Metallography of Iron and Steel.—By Albert Sauveur. Published by Sauveur & Boylston, Cambridge, Mass. 450 pages; size, 7½ x 10½; fully illustrated. Price, $6.00, post-paid.

Reviewed by T. R. Loudon, B.A.Sc., Metallurgical Engineer.

Metallography has in the past few years received a great deal of attention in the literature of the day. One would not be far astray in saying that more attention has been devoted to the metallography of iron and steel than to any of the other metals, and, indeed, it is only to be expected that this would be so when the complexity of the composition of iron and steel is taken into account, together with the commercial importance of iron and steel. It is readily seen, however, that the very fact that a great deal has been written on the subject constitutes the main difficulty that is encountered by the student or the engineer who wishes to get authoritative opinion along these lines, and who, not being a specialist on the subject, has not very definite ideas where to look for information. The need for an up-to-date treatise on the metallography of iron and steel has long been felt.

In view of the above mentioned state of affairs, it is not surprising that such an authority as Professor Sauveur should undertake to compile a work on the metallography of iron and steel.

Professor Sauveur's book is divided into twenty-four lessons, a list of which is given at the end of this review; a chapter on the apparatus of the metallographic laboratory, and two appendices on the manipulation of apparatus and the nomenclature of microscopic constituents. The illustrations throughout are very clear; this being particularly true of the microphotographs of the various specimens. To anyone at all familiar with the photographing of metallographic specimens this will be keenly appreciated. Only too often is good subject matter spoiled by blurred microphotographs that convey no real idea of actual conditions.

It might be pointed out that the system of dividing the book up into Lessons instead of Chapters rather detracts than adds to the value of the book. There is, perhaps, rather too much of the academic suggested, whereas really the book is written with a good, practical style. Then, also, the numbering of the pages by the Lesson, i.e., beginning anew at each Lesson instead of consecutively from the beginning of the book with an ordinary index, is certainly not a time-saver.

In Lesson No. I. on Pure Metals, the author very clearly points out the difference between crystalline growth and the formation of grains. The term crystalline grains as applied to grains resulting from crystallization is a good one.

In Lesson No. 5, page 12, under the heading Micro Test for the determination of carbon in steel, the statements made are perhaps a trifle misleading. It is said that, "after a little experience and by taking the necessary precautions it will be found that, in the case of decidedly hypoeutectoid steels at least (steels containing, say, less than .6 per cent. carbon) results are obtained fully as accurate as those of the colorimetric method, and on the whole more reliable, since the possibility of serious errors is practically eliminated." Undoubtedly the author refers to steels that are supposed to be homogenous in composition. Even admitting the value of the microscope in determining carbon content, the great trouble is that such a determination merely holds for the surface examined—the steel one-eighth of an inch below this surface may be, and often is, of a different carbon content. By chemical means, however, drilling being taken, a better average is obtained. Of course, one must admit that serious errors do often occur in colorimetric determinations, but these are mainly due to lack of skill. The same applies to the microscope. One cannot agree with the author that "after a little experience" carbon contents can be estimated. It requires a good deal of experience. As a check the microscope is invaluable, but should be used very guardedly in making determinations of carbon content.

In the investigation of the effects of mechanical and heat treatment on steels, the practical value of metallography is at once seen. This is undoubtedly the great field for metallography. In Lessons XI. to XIV., on the mechanical treatment, annealing and hardening of steel, Professor Sauveur has given a very thorough presentation of the subjects. The illustrations show very clearly the effects of the treatment to which the specimens have been subjected. These portions of the book form a valuable practical piece of scientific literature.

Lessons that should be at the end and not the beginning of the book seem a trifle strange. One can make very little real progress in the metallography of iron and steel before understanding the equilibrium diagram of iron and carbon. Be this as it may, it is pleasing to note that Professor Sauveur takes the stand that in iron carbon alloys above about 1.7 per cent. carbon, the eutectic formed is that of austenite and cementite, and that any graphite that may be found subsequently, results by the breaking up of the cementite into ferrite and graphite. This is surely the more practical way of treating the subject. The explanations of the iron-carbon diagrams are very clear, the points of historical interest being very neatly worked into the subject.

The entire book is a valuable addition to scientific literature. The book can be said to contain everything pertaining to the metallography of iron and steel written from an ardent metallographer's point of view.

The following is a detailed list of the Lessons in the book: Pure Metals, Pure Iron, Wrought Iron, Low Carbon Steel, Medium High and High Carbon Steel, Impurities in Steel, The Thermal Critical Points of Iron and Steel, Their Occurrences, Causes and Effects (three Lessons), Cast-Steel, Mechanical Treatment of Steel, The Annealing of Steel, The Hardening of Steel, The Tempering of Hardened Steel, Theories of Hardening of Steel, Cementation and Case-hardening of Steel, Special Steels (two Lessons), Cast-Iron, Impurities in Cast-Iron, Malleable Cast-Iron, Constitution of Metallic Alloys, Equilibrium Diagram of Iron-Carbon Alloys, The Phase Rule, and two Appendices mentioned before.

Theory of Structures.—By R. W. Angus, B.A.Sc., Professor of Mechanical Engineering, University of Toronto. Published by the Engineering Society, University of Toronto. Cloth; size, 6¼ x 9¼ in.; 232 pages, 147 figures. Price, $3.00.

The full title of this volume is the "Theory of Machines, Including the Principles of Mechanism and Elementary Mechanics of Machinery." The book is intended as a textbook for students in engineering in the University of Toronto. The subjects treated in the chapters are: The Nature of the Machine, Motion in Machines, Velocity Diagrams, The Motion Diagram, Toothed Gearing, Bevel and Spiral Gearing, Trains of Gearing, Cams, Forces Acting in Machines, Crank Effort and Turning Movement Diagrams, The Efficiency of Machines, Governors, Speed Fluctuations in Machinery, Proper Weight of Flywheels, Accelerations in Machinery. The method of determining the velocities of parts of machines, used in the volume, is called the phorograph method, and is here published for the first time. This gives a convenient graphical method for determining accelerations, kinetic energies of links, etc. The whole matter covered in the treatise is presented in readable form, and is very clearly written. To the student or engineer interested in the study of the theory of machines the book will be of considerable assistance.

Modern Organization.—By Charles DeLano Hine. Published by The Engineering Magazine Company, N.Y. Cloth; size, 5 x 7½ in.; 110 pages. Price, $2.00.

This volume is the latest addition to the Works Management Library, issued by The Engineering Magazine Company, and is the first complete statement of Major Hine's theory and practice of "unit organization" that has been put forth. The unit system applied on the Harriman lines has been remarkably successful in promoting efficiency without causing trouble. It is peculiarly interesting, because it seems to involve so little physical change and to depend so completely upon the apparently subtle, but after all, very direct internal improvement that is brought about when the official is given a new viewpoint of his work and its relation to co-ordinate departments. The system establishes a third mode of bringing line direction and staff guidance into co-operation, a mode essentially different from either Emerson's efficiency staff or Taylor's functional management

The chapters assembled in this volume appeared originally in The Engineering Magazine as a series of articles, which ran from January to July, 1912. The volume forms a comprehensive definition of this philosophy of management, and forms a valuable addition to Efficiency Management textbooks.

Energy and Velocity Diagrams of Large Gas Engines.—By Paul L. Joslyn. Published by the Gas Engine Publishing Co., Cincinnati, O. Cloth; size, 6 x 9 in.; 70 pages, 62 diagrams. Price, $2.00.

The designer of large gas engines has to consider many things which on small engines are often left to be worked out after the engines has been built in its first form. With small engines it is not so expensive or so difficult to change some points, and it frequently happens that very radical changes in construction are so effected. But with the engine of several thousand horse-power it is impossible to do this. So far as can be done, everything must be worked out in advance. Castings and machine work run into a large amount of money on engines working on blast furnace gas, and to scrap a cylinder or a bed casting because some change is found necessary may amount to several thousand of dollars in initial expense, manufacturing cost, delays, etc. In this book, the author gives the methods of laying out energy and velocity diagrams for large engines operating on blast furnace, producer or natural gas, with instructions as to their use, etc. The data given is the result of actual designing of this character on some of the largest engines built in American and Europe, and will be found of inestimable advantage to the designer working on engines of this character.

Central Station Heating.—By Byron T. Gifford. Published by Heating and Ventilating Magazine Co., New York. Leather; size, 5½ x 9 in.; 208 pages.

Central Station Heating during the last three or four years has received a great impetus, and a new era in this branch of engineering is rapidly dawning. With the increased attention and interest it has become desirable that the engineers interested in this department of engineering design should have the existing data on the subject presented in concrete form. Central station heating in its broader sense is properly classed as a public utility, and will eventually be controlled by the different utility commissions. As the development of these plants increase the field for them will become larger. Many of the elementary principles of the science of heating have been omitted, but the possibilities and the limitations of these plants are clearly outlined. The volume includes chapters on Pipe Line Losses, Pipe Line Design in General, Rates in General, The Heating Station, Operation and Maintenance, Management, Franchises, Building Equipment in General, and miscellaneous data. The book affords a most valuable addition to the literature of the subject, which is exceedingly small, and will be welcomed by all engineers interested in this particular branch of engineering.

The Materials Used in Sizing.—By W. F. A. Ermen. Published by Constable & Co., London. Cloth; size, 5 x 7½ in.; 119 pages. Price, $1.40.

This little volume was compiled from a course of lectures delivered at the Manchester School of Technology, and deals with the chemical and physical properties of the materials used in sizing, giving simple methods for their technical analysis and valuation. Chapters are included on The Starches, Weighting Materials, Softening Ingredients, Antiseptics, Analysis of Size, Warps and Cloth, The Preparation of Normal Volumetric Solutions and Tables.

Handbook for Highway Engineers.—By Wilson G. Harger and E. A. Bonney. Published by McGraw-Hill Book Co., 239 West 39th Street, New York. Size, 4 x 7 in.; 500 pages. Price, $3.00.

This admirable publication is divided into two parts:—

Part I. Theory of Design.

Part II. Practice of Design and Construction.

The authors are men actually engaged on roadwork, and are, therefore, in a position to state clearly and well the subject matter of the text.

The publication contains the information ordinarily used in the design and construction of roads warranting an expenditure of from $5,000 to $30,000 per mile.

The information is presented in a compact and convenient form, and in addition to a table of contents there is a complete index.

It is a book valuable to experienced and inexperienced road-builders alike.

The cost data furnished is a valuable contribution to the literature on road-making, but the table and lists of quantities is if anything more useful.

The following questions are dealt with in logical sequence: Grades and Alignment, Pavements, Surveyors, Estimating, Construction, Specifications, and in addition the book contains sixty-seven tables.—E.A.J.

Concrete Highways.—Published by the Association of American Portland Cement Manufacturers, Land Title Building, Philadelphia, Pa. Paper; size, 6 x 9 in.; 95 pages. Profusely illustrated; free.

Every person interested in the good roads movement is aware of the latest development in this important work through the use of concrete. This new type of road is now the subject of extended experiments by the United States Government. It has met with such pronounced success in Wayne county, Michigan, as to give that locality national celebrity. The Association of American Portland Cement Manufacturers has published for free distribution a comprehensive book, entitled "Concrete Highways," which will interest road supervisors, contractors and taxpayers in every section of the country. The book, which is handsomely and profusely illustrated, contains nearly a hundred pages. It was prepared by expert road engineers, and goes into every detail of construction, concluding with a tabular digest of concrete pavements in all sections of the country. The various chapters include discussion of bituminous compound wearing surfaces, grouted pavements, reinforced concrete pavements and specifications for the one and two-course types. In fact, the book covers the entire subject in the most reliable and authentic way. Road supervisors especially will find it of inestimable value, and the taxpayer will be extremely interested in the economical results obtained by the introduction of these durable concrete highways.

Tunneling: A Practical Treatise.—By Charles Prelini, C.E., author of "Earth and Rock Excavation," "Dredges and Dredging," "Earth Slopes, Retaining Walls and Dams"; Professor of Civil Engineering, Manhattan College, New York. Sixth edition, revised and enlarged. New York: D. Van Nostrand Co. Cloth; size, 6 x 9¼ in.; pp. xix. + 340; 167 text illustrations. Price, $3.00 net.

This standard treatise on tunneling needs little comment, for it is now in the sixth edition, and is recognized as an authoritative exposition of the subject. During the few years that have elapsed since the publication of the first edition of this work, the art of tunneling through different soils, and especially under large bodies of water, has made considerable progress. During the last ten years no less than eight sub-aqueous tunnels, involving the construction of sixteen tubes, have been constructed for the service of the city of New York alone.

This edition has been revised, so that the entirely new methods which have been introduced by professional men are here presented in due prominence.

Space has also been given to important tunnels recently built. This material illustrates the various methods discussed in the text, and brings out more clearly the characteristics of the different methods of tunnel excavation. The volume now forms an admirable treatise on the subject, and will, no doubt, meet the present requirements of both engineers and students.

Design of Steel Mill Buildings.—By Milo S. Ketchum, C.E., Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado. Published by McGraw-Hill Book Co., New York. Third edition; cloth; size, 6½ x 9 in.; 562 pages; 66 tables and 270 illustrations. Price, $4.00 net.

In this third edition Professor Ketchum has brought this treatise on the design of mill buildings and the calculation of stresses in frame structures to date.

In the preface to the first edition he states that the book is intended to provide a short course in the calculation of stresses in frame structures and to give a brief discussion of mill building construction. The original edition admirably filled the place allotted to it by the author. The book has received a well-merited appreciation since it was first published. In this edition the chapters on Stresses in Frame Structures and Stresses in Bridge Structures have been re-written and enlarged; the "Specifications for Steel Frame Buildings" have been revised and re-written and many changes have been made in the text. The additions to the book include two Problems in Graphic Statics, and Appendix III., "Structural Drawings, Estimates and Designs."

A Textbook of Physics.—Contributors: A. Wilmer Duff, E. Percival Lewis, Charles E. Mendenhall, Albert P. Carman, R. K. McClung and William Hallock. Edited by A. Wilmer Duff, D.Sc., Professor of Physics, Worcester Polytechnic Institute, Worcester, Mass. Third edition, revised. P. Blackiston's Son & Co., Philadelphia. Cloth; size, 5½ x 8½ in.; 686 pages; 595 text illustrations.

This textbook of Physics has now reached its third edition, the first edition being published in 1908. As noted, it is the combined work of seven experienced teachers of College Physics. For this edition, entirely new parts on Heat, and Electricity and Magnetism have been prepared. and extensive changes have been made in other parts. To facilitate reference a list of tables of constants has been given, and the indexes have been somewhat increased.

Machine Design.—By H. D. Hess, M.E., Professor of Machine Design, Sibley College, Cornell University. Published by J. Lippincott Co., Philadelphia. Cloth; size, 6 x 9½ in.; 368 pages; 18 plates; 318 figures. Price, $5.00 net.

The book deals specifically with machine design as applied to hoists, derricks and cranes. While the book is written with special reference to the student, it will be well received by the practising engineer, particularly those who are directly engaged in the design of this particular field.

A determination of the stresses in frames and machinery is developed by the use of elementary theoretical principles. While empirical formulas are used throughout the book where the conditions call for such use, the theoretic development is used where possible. Many examples are shown throughout the text, and these are practically all drawn from present-day practice.

The book is divided into twelve parts under the following headings: Introduction, Frames and Girders, Brakes and Clutches, Winches and Hoists, Pillar Cranes, Jib Cranes, Under-braced Jib Crane, Inverted Post Crane, Wall Crane, Overhead Electric Travelling Cranes, Hoisting Engine, Locomotive Cranes.

The Introduction includes a discussion of the properties of materials and fibres used in this class of machine design, and a few pages are given to an exposition of the elements of graphic statics, followed by a discussion of rolling and sliding friction crane blocks and block efficiencies for chain and wire rope. The other parts of the book are devoted to a presentation of the theory of columns and beams, methods of determining stresses in different frames, the various forms of brakes and clutches, and the remaining portion of the book takes up under the several headings the design of different types of cranes.

The treatise will be a most valuable one as a book of reference for the practising engineer and as a textbook for the student.

PUBLICATIONS RECEIVED.

Annual Report City Engineer, City of Ottawa. For the year 1911. City Engineer, Newton J. Ker, Ottawa.

Outline of the Smoke Investigation. Bulletin No. 1 of Department of Industrial Research, University of Pittsburg.

The Specific Heat of Wood. By Frederick Dunlap. Bulletin 110 of the Forest Service, U.S. Department of Agriculture.

Tests of Structural Timber. By McGarvey Cline and A. L. Hein. Being Bulletin No. 108 of the Forest Service, U.S. Department of Agriculture.

Department of Agriculture. Seventh Annual Report for the Province of Saskatchewan, 1911. W. R. Motherwell, Minister of Agriculture, Regina, Sask.

A Great Industrial Plant and Its Owner. Being booklet No. 1, Water Supply Educational Series, issued by the Bureau of Water, City Hall, Philadelphia.

The Simmen System of Railway Signalling and Despatching. By Paul J. Simmen. Reprint from *The Canadian Engineer*, September 12th, 1912. Copies may be secured from Northey-Plummer, Limited, Toronto.

Forest Products of Canada, 1911. Tight and Slack Cooperage, compiled by R. G. Lewis. Bulletin No. 31, Forestry Branch, Department of the Interior, Ottawa.

Report of the Chief Engineer of the Board of Estimate and Apportionment of the City of New York for the Year 1911. Office of the Chief Engineer, 277 Broadway, New York.

Summary Report of the Geological Survey Branch of the Department of Mines, for the year 1911. R. W. Brock, director, Geological Surveys Branch, Department of Mines, Ottawa.

Sewage Pollution of Interstate and International Waters. By Allan McLaughlin. Being Bulletin No. 83, Hygienic Laboratory, Public Health and Marine Hospital Service of the United States.

Provincial Board of Health of Ontario. The thirteenth annual report for the year 1911. Copies may be obtained from Dr. J. W. S. McCullough, Chief Officer of Health, Parliament Buildings, Toronto.

Association of the Ontario Land Surveyors. Annual report of the association and proceedings of the twentieth annual meeting held at Toronto, February 27, 28, 29, 1912. Secretary, L. V. Rorke, Toronto.

Plans for Concrete Houses. Being plans for small houses of poured concrete, as submitted in a competition for prizes given by the Blaw Steel Construction Company, Westinghouse Building, Pittsburg, Pa.

The Hetch-Hetchey Water Supply for San Francisco, 1912. Being a report by John R. Freeman, Consulting Engineer to the city of San Francisco. Board of Supervisors, San Francisco, Cal. Price, $3.50.

Steam Boiler Explosions. By Wm. H. Boehm. Being an illustrated lecture delivered at Cornell University May 3rd, 1912. Copies may be secured from the Fidelity and Casualty Company, 92 Liberty Street, New York City.

Canada's Canal Problem and Its Solution. Being a reply to the Toronto Board of Trade. Issued by the Canadian Federated Boards of Trade and Municipalities. Secretary, A. J. Forward, Castle Building, Ottawa, Ont.

Icebergs and Their Location in Navigation. By Prof. H. T. Barnes. Being a reprint of lecture delivered before the Royal Institution of Great Britain. Copies may be secured from the author, McGill University, Montreal.

Electrolytic Purification of Sewage. By F. C. Caldwell, Professor of Electrical Engineering, Ohio State University, Columbus, Ohio; Honorary Member of Ohio Electric Light Association. Paper; 6¼ x 9¼ in.; pp. 7. Address the author.

The-Lakes-to-the-Gulf Deep Waterway. By Wm. A. Shelton. Being a study of the proposed channel, terminals, watercraft freight movement, and rail and boat rates. Paper, 75c.; cloth, $1.00. The author, 6146 Greenwood Avenue, Chicago.

Engineering Index Annual, 1911. 530 pages; cloth; edited and published by The Engineering Magazine, 140-142 Nassau Street, New York. Price $2.00. With this volume (the tenth) a continuous index to the engineering and technical literature of the past twenty-seven years is available.

Utilization of Peat Fuel for the Production of Power. A report by B. F. Haanel, B.Sc., chief of fuel testing division, Mines Branch, Department of Mines; being a record of experiments conducted at the fuel station at Ottawa, 1910-11. Eugene Haanel, director, Mines Branch, Department of Mines, Ottawa.

CATALOGUES RECEIVED.

Cranes, Etc. Herbert Morris, Limited, Empress Works, Canadian office 79 Peter Street, Toronto, forward very complete catalogue covering all the different types of lifting machinery made by them. Catalogue is bound in cloth; 472 pages, and is printed on a heavy mounted paper.

Stump-Pulling Machinery. A pamphlet forwarded by the Clyde Iron Works, Duluth, Minn., entitled "Cutting the Cost of Clearing Logged-off Lands." This is a catalogue of stump-pulling and land-clearing machinery placed on the market by this company. The pamphlet is most artistically printed and illustrated.

Tool Holders, Drills, Etc. Armstrong Brothers' Tool Company, 339-357 North Francisco Avenue, Chicago, Ill., who are manufacturers of tool holders, ratchet drills, drop forged wrenches, etc., forward their catalogue A-12, illustrating different types of their tools, together with a price list.

Suction Gas Plant. The British-Canadian Engineering and Supply Company, Limited, 122 Phœnix Block, Winnipeg, forward pamphlet entitled "No Power on Earth is Cheaper," being a description of the Ruston patent suction gas plant.

Tar Macadam Highways. The Barrett Manufacturing Company, of New York, Canadian agents, the Paterson Company, Limited, forward reprinted article entitled "Rhode Island's Tar Macadam Highways."

Hammer Drills. The McKiernan-Terry Drill Co., 115 Broadway, New York, forward illustrated catalogue of different types of their "Busy Bee" hammer drills.

Universal Packing. The H. W. Johns-Manville Company forward folder descriptive of their universal packing for use on rods, plungers and pistons.

Turn-Down Lamp. The Canadian General Electric Co., Limited, Toronto, forward folder illustrating a few of the many applications of the "Economical" turn-down lamp.

Modern Welded Pipe. The National Tube Company, of Pittsburg, Pa., have recently issued a book which gives a short history of the industry and considerable information relative to modern tubular products.

Sewer Flushing and Its Cost. A book on sewer flushing and a discussion of the cost of flushing at intervals; includes a discussion on the design of flush tanks. Issued by the Hydraulics Department, Merritt & Company, Camden, N.J.

Freight and Package Handling Machinery. Being Bulletin No. 74, illustrating the different types of freight and package handling machinery manufactured by the Jeffrey Manufacturing Co., Columbus, Ohio.

Motor Locomotives. A pamphlet issued by Ironside, Son & Dyckerhoff, 40 Mincing Lane, London, E.C., illustrating their "New Century" motor locomotives for surface haulages, also railway and passenger services.

Filters. Royles, Limited, Irlam, near Manchester, England, forward a complete set of their catalogues illustrating gravel filters, air heaters, calorifiers, steam traps, valves, etc.

Hydraulic Accumulators. Catalogue No. 84. just issued by the Watson-Stillman Co., and illustrating, tabulating and fully explaining the seven principal types of accumulators which they manufacture. A few pages are devoted also to accumulator accessories and to special hydraulic testing apparatus, reservoirs, etc. 56 pages; 6 in. by 9 in. A copy may be obtained by addressing the Watson-Stillman Co., 50 Church Street, New York.

The Pedestal Pile. The MacArthur Concrete Pile & Foundation Co., of 11 Pine Street, New York City, has recently published a new edition of their book, "The Pedestal Pile." The general layout of the book is the same as that of the first edition, but it contains a number of illustrations and descriptions of work recently completed and also other additions to the text. As the book contains much valuable data on the bearing power of soils, frictional resistance, etc., besides a complete description of the Pedestal Pile and how it is constructed, it should prove of interest to every engineer and architect.

Concrete Bridges. The Universal Portland Cement Company, Chicago, has published an attractive little booklet showing illustrations of a number of different highway bridges and giving a brief description of each. This booklet is entitled "Concrete Highway Bridges."

Appliances for Burning Fuel Oil. The Tate, Jones & Company, Inc., Pittsburg, has published a booklet entitled "Appliances for Burning Fuel Oil," which discusses oil as a fuel and illustrates and describes its various types of oil burners. Pumping systems for pumping, heating and regulating the oil flow to burners are also described.

COAST TO COAST.

Ottawa, Ont.—A sub-committee of the Dominion cabinet council has been appointed to consider the recommendation of the Royal Society of Canada for the establishment of a system of research stations throughout the country.

Vancouver, B.C.—By a vote of 37 to 24 the Vancouver Board of Trade rejected the report of the special committee which recommended that the Canadian Northern Railway be required to pay the city at least $2,000,000 for its terminals at False Creek.

London, Ont.—Scarcity of labor is proving a serious handicap to the extension work now being carried on by the Street Railway Company and they have notified the civic officials that they will be unable to complete their agreement by December 1st.

Saskatoon, Sask.—The Roberts filtration plant recently installed in Saskatoon is giving satisfactory results. The water is not only pure, but the bacterial contents are reduced to an infinitesimal point, with the result that the water is practically sterile.

Province of British Columbia.—The pay-roll of the Canadian Northern Railway for the month of September on account of construction work carried out in this province amounted to $1,454,000. The previous record for abnormal pay-rolls came to $1,100,000.

London, Ont.—Hon. Adam Beck is reported to have said that a friendly suit will be started against the Dominion Government in an endeavor to secure for the Hydro-Electric Commission control of all rivers in the province and of surplus water in the canals.

Athabasca Landing, Alta.—What is reported to be the heaviest flow of natural gas in the Peace River District has been located at this point. A pressure of 600 pounds to the square inch has been recorded so far and great precaution is taken to guard against accidental ignition.

Portage la Prairie, Man.—Mr. Hobbs, a civil engineer of Winnipeg, has arrived here to begin the work of locating a route for the proposed boat canal between here and Lake Manitoba. Some of the deep creeks extending into the prairie from the lake towards this place will be utilized in connection with the scheme.

Fort William, Ont.—The new million-dollar dock of the Canadian Pacific Railway has been placed in commission and the first freighter, laden with coal, will steam up the well-dredged McKellar River. A freighter laden with ten thousand tons of coal can be completely unloaded in ten hours at this new dock.

Outlook, Sask.—The bridge of the Canadian Pacific Railway across the Saskatchewan River at this point was sufficiently completed a day or two ago to allow trains on the main line between Edmonton and Minneapolis to pass. This bridge is a little over three thousand feet long and 156 feet high.

Sydney, C.B., N.S.—The "Duke of Connaught," the large drydock for Montreal, has been safely brought to this port. The trip across the Atlantic was made with difficulty, the towing cables parting five times. On one break the huge dock drifted thirty-five miles before it could be again secured to the tugs.

Quebec, Que.—Word has been received that Mr. Gauthier and Mr. Tremblay, of St. Jerome, Lake St. John, and Mr. Bedard, of Cape Bouge, three members of the expedition sent from Quebec in July by the government to survey the proposed James Bay route, were drowned in the Nottawa River during their journey.

Regina, Sask.—The commissioner of public health of Saskatchewan has strongly recommended the city of Regina to install a chlorinization plant for the purpose of treating the city water. This treatment of water by chloride of lime destroys typhoid bacteria without in any way injuriously affecting the water. While the source of Regina's water supply remains unprotected, it is the duty of the city to thus treat its water supply, thereby making it perfectly safe to drink. The water has been found by the city health officer to be polluted. He has recommended that it be boiled, but this is not always practicable. A chlorinization plant is very inexpensive to install and easy to operate.

Montreal, Que.—Judgment has been handed down by the Public Utilities Commission giving a general approval to the plans submitted by the Montreal Electrical Commission for the placing of the wires on St. Catherine Street, from Guy to Mance, underground. This approval is not, however, final, as certain modifications may be found necessary later, and the Electrical Commission can submit further recommendations and suggestions on which the Utilities Commission may act on its own responsibility without another inquiry. Work will be started next spring, and all the wires on this section of St. Catherine Street are expected to be safely stowed away in the conduit by the end of 1913. The conduits will be under the sidewalk at both sides of the street, ready access being given by large manholes at street intersections, and service manholes for making connections at various points. Sufficient space for all the wires will be provided, the conduits being 26 inches wide and 26 inches high. When the work is finished the appearance of Montreal's great shopping thoroughfare will be completely changed.

Regina, Sask.—Under an amendment to the Public Works Act of Saskatchewan, the Minister of Public Works was given power to make regulations governing townsites and subdivisions, and in accordance with this amendment regulations were brought into force on July 19, 1911. These regulations have undoubtedly accomplished a large amount of good in stopping undesirable subdivisions from going on the market and the selling of lots entirely unsuited for building purposes. The government sees that if a lot is sold a house can be built upon it, that there is proper access to it, and that the land is dry. A school site of at least one acre in every subdivision is insisted upon, and other provisions safeguarding the public interest are inserted in the regulations. The government, however, does not try to force any particular theory of town planning upon those laying out annexes. During the twelve months prior to February 29, 1912, there were 562 plans of subdivisions registered in the survey branch, as against 272 for the previous year. The fees to cover inspection and other services rendered by the department are about $4 per acre, and have resulted in the addition of about $60,000 to the revenue during the past year.

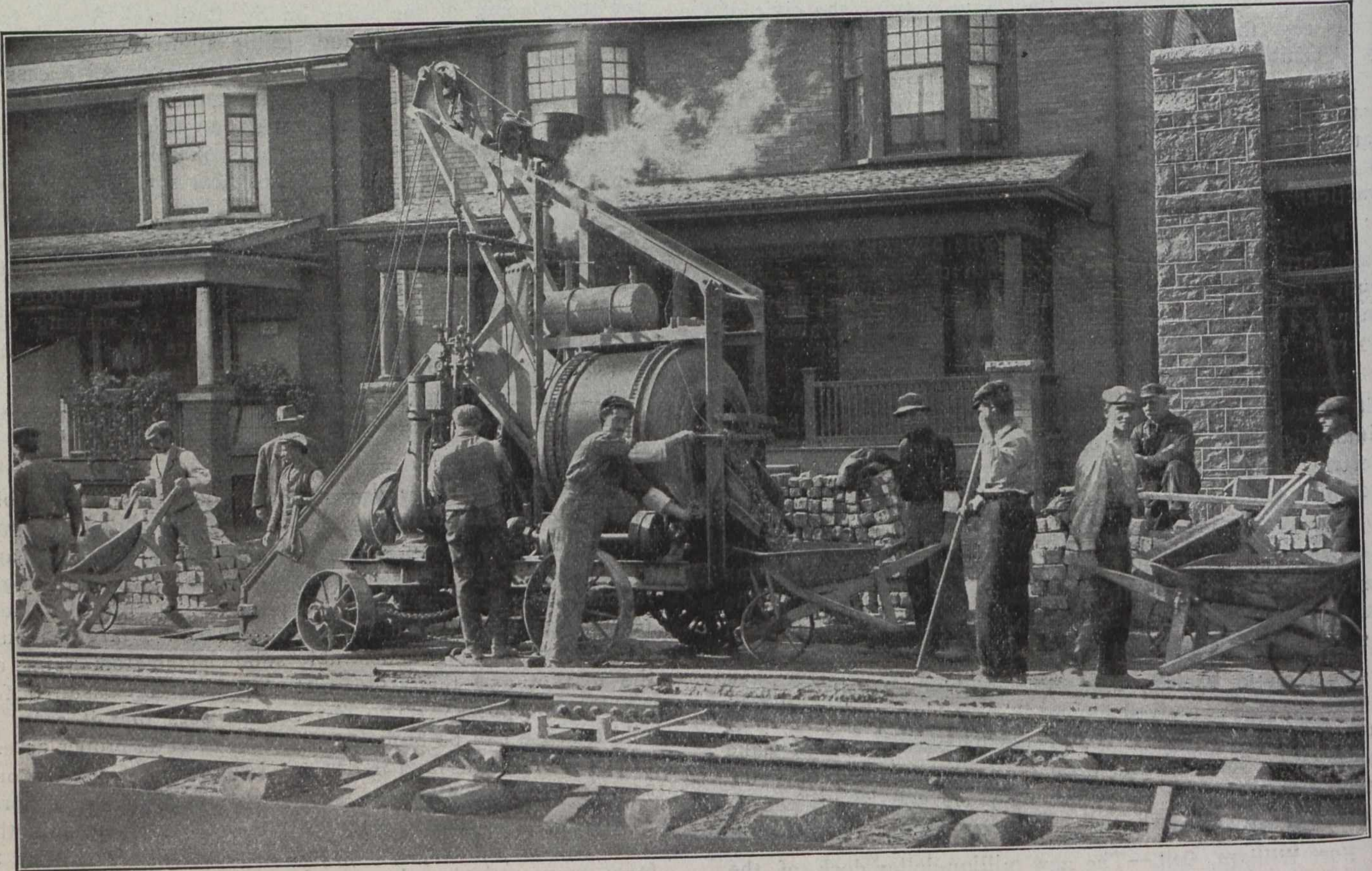
MEETINGS.

UNIVERSITY OF MANITOBA.

Research work was the main theme in an address given by Dr. A. H. R. Buller at the opening session of the University of Manitoba. No university, he stated, could live to itself alone. It would indeed be shameful for the University of Manitoba to acquire all its knowledge from without and to contribute nothing. Besides this, there remained the consideration that the best teaching is always done in an atmosphere of research. To encourage research, professors should be free from lectures for at least half of every day. The question might be asked, what is the practical value of research work? Dr. Buller's reply was that the dollar was not the only form of wealth, and that intellectual wealth is the most valuable possession of any people.

A RECORD IN CONCRETE MIXING.

The rapidity with which concrete work can be done by an experienced gang and efficient machinery is exemplified by the following record recently made by workmen employed by the city of Toronto on Dundas Street, Toronto, using a Koehring No. 14 street mixer, made by the Canada Foundry Company, Limited. Seven hundred bags of cement, each weighing over 87 pounds, were put through the concrete mixer. It was also fed four cars of broken stone. Approximately 235 tons of concrete came out of the other end, and were laid in the roadway. This all happened in a working day of 540 minutes, so that about a ton of concrete was made, handled, and put in place every two and a third minutes. The 235 tons of concrete measured 175 cubic yards. In other words, it would have formed a pillar five feet square and 189 feet high—far higher than the Lumsden building.



Placing Concrete on Foundation for Civic Car Lines, Toronto.

GENERAL REQUIREMENTS OF WOOD-PRESERVING OILS.

The value of any creosote as a preservative against decay is fundamentally dependent upon its ability to prevent the development of wood-destroying fungi. This prevention may be accomplished in either of the following ways:

1. By introducing a material sufficiently poisonous to wood-destroying fungi to prevent their development.

2. By introducing a material which will sufficiently exclude moisture or air to reduce the amount of either below that required by the fungi for their development.

In the past the creosotes which have been successful have generally possessed, at least to some extent, both of these properties; but the first is generally considered the more essential. In recent years, however, there has been some tendency to use materials not markedly antiseptic, but primarily intended to exclude moisture. As yet, however, it has not been completely demonstrated, nor generally accepted, that a product can be obtained to fulfil entirely the second requirement.

Aside from these considerations, it is of course essential that the creosote be of such a nature as to remain in the wood for the desired period of protection. In this connection its relative solubility in water and its volatility are important. However efficient it may be in poisoning the food supply or preventing the absorption of moisture, if it will not remain in the wood with a considerable degree of permanence, its ultimate value will be small. Where the treated wood is to be placed in wet situations or under water, as in the case of piling, a soluble preservative is inefficient; and a volatile preservative is especially unsuited for timbers exposed to the air in warm climates.

The relative ease with which a preservative can be injected is of much importance in wood-preserving operations; for this reason a product which is not sufficiently fluid at temperatures which can be conveniently used at commercial treating plants is undesirable. The presence of free carbon is known to decrease the penetrance of creosote and for this reason is objectionable.

AMERICAN MINING CONGRESS.

As a result of the determined campaign for reduced rates to the fifteenth annual convention of the American Mining Congress, which will be held in Spokane, Wash., November 25-29, the transcontinental railroads have announced the following rates: From Missouri River points to Spokane and return, $52.50; from Chicago and return, $68.80. Tickets on sale November 9, 10, 11, 21, 22 and 23, with final return limit December 31. A rate of one and one-third fares, on the certificate plan, has been granted from local points.

DRAINAGE SCHEMES IN SASKATCHEWAN.

In a country such as the province of Saskatchewan, where the cultivated area is so small a percentage of the total acreage, it might at first sight seem superfluous for the people to spend much money and energy upon reclamation schemes, but the comparatively low cost per acre of such reclamation work, and the great fertility of what would otherwise be waste land, render such schemes very attractive.

Prior to the passage of the Drainage Act of 1909, the only drainage schemes in the province were built directly by the government out of the general revenue funds. The Act is now becoming more widely known amongst the agricultural community, and as a result there are several propositions under way at the present time. The following is a brief epitome of the working of the Act.

A petition to the government is prepared, which must be signed by resident owners representing at least one-half of the lands of resident owners. Upon receipt of the petition an engineer is appointed to prepare plans, estimates, and a report upon the feasibility of the scheme. When the report has been received and the plans examined, the whole must be submitted to the Lieutenant-Governor-in-Council for his approval. If approved, the next step is to advertise that it is the intention of the government to proceed with the work under the Drainage Act. The cost of the ditch is assessed against all the lands benefited. The signers of the petition have the privilege of withdrawing for any sufficient reason, such as, for instance, that the scheme is to cost more than they anticipated. After these withdrawals, if half the land of resident owners is not still represented, then no action takes place and the scheme falls through, otherwise the government proceeds to issue debentures, running for a term of from 20 to 35 years, to be retired by the assessments which are collected by the municipality.

There is no doubt that in course of time the Act will be more and more widely taken advantage of. The adoption of the Act not only gives a legal right to enter upon land and construct a drain, but renders possible very valuable reclamation work which would probably be beyond the means of a municipality or of any private company of settlers.

The drainage schemes mentioned here are all of them under way, and on some of them a large amount of construction work has already been done. There is the Egg Lake drain in township 20 range 15 west of the second meridian; a very large scheme near Invermay; one at Rama, and another near Shellbrook. The largest scheme of all is the reclamation of flooded lands southwest of Rouleau. It is estimated that this proposition will cost in the neighborhood of $40,000, but if carried out in its entirety will result in the reclamation of from thirty to forty thousand acres of land.

MODULI OF ELASTICITY.

In a paper recently read before the Society of Engineers, Professor F. H. Hummel gives values of Young's modulus for a number of materials, as the result of experiments made on the flexure of thin strips:

Material.	E. Lb. per Sq. In.
Celluloid (1)	347,500
Celluloid (2)	547,000
Drawing-paper (in direction of rolling)	394,000
Drawing-paper (across direction of rolling)	581,500
Thick stiff paper	852,000
Box-wood	174,000
Whalebone	503,000
Copper	15,900,000
Brass	11,600,000
Aluminum-nickel alloy	10,000,000

PERSONAL.

MR. C. DURBAN, of the main drainage department, city of Toronto, has been appointed assistant city engineer of London.

MR. REGINALD A. DALY, formerly of Napanee, Ont., has been appointed head of the Geological Department of Harvard University, Cambridge, Mass., U.S.A.

LIEUT.-COL. GEORGE W. STEPHENS, chairman of the Montreal Harbor Board, in a letter to the Hon. G. D. Hazen, Minister of Marine and Fisheries, announces his resignation from the board.

MR. HARRY ANGUS, B.A.Sc., consulting engineer, Confederation Life Building, Toronto, has given up his practice and gone in with the Canadian Domestic Engineering Company, at their Toronto office.

MR. R. W. BROCK, director of the Canadian Geological Survey, visited Rossland, B.C., on his way east from Victoria, where he had been attending the British Columbia meeting of the Canadian Mining Institute.

MR. C. C. KRONK is in collaboration with Mr. Wynne-Roberts upon the question of development of electrical power for the province of Saskatchewan, and is making investigations into the possibility of economical transmission of such power.

MR. R. E. CHADWICK, who has been recently appointed as eastern manager in charge of the Montreal office of the Foundation Company, Limited, and who succeeded Mr. Alexander Allaire in that position, was born in Toronto. He is an honor graduate of the University of Toronto in mechanical engineering in the class of 1906. Mr. Chadwick was bridge engineer for the city of Toronto during 1909-10. He joined the Foundation Company, of New York in the first part of January, 1911, as superintendent on the Woolworth Building. In May, 1911, he joined the Foundation Company, Limited, of Montreal, Canada.

Mr. R. E. C. Chadwick.

DR. W. W. ANDREWS has been engaged in determining how the gumbo soil, found in some parts of the province of Saskatchewan, can be best treated to render it fit for road traffic. The work is being done under the Board of Highway Commissioners of the Province.

MR. M. J. BUTLER, general manager of the Dominion Steel and Coal Company, has resigned his position. Mr. Butler, as is well known, was deputy minister and chief engineer of the Department of Railways and Canals from 1905 to 1907 at Ottawa, when he was appointed to the general managership of the Dominion Steel Corporation. It is not known what he has in mind, although it is reported that he will become connected with another large undertaking.

MR. L. O. BEAM has resigned the position of inspector of public works of the province of Saskatchewan and has joined the staff of the R. J. Lecky Company. Mr. Beam was a bridge foreman under the old Territorial Government, whose outside staff he joined in 1889. He was afterwards in charge of ferry construction, and was appointed inspector of public works on the inauguration of the province in 1905. As a thoroughly practical man, with a thorough knowledge of all kinds of steel construction work, Mr. Beam's loss is a serious one. No successor has as yet been appointed.

MR. R. O. WYNNE-ROBERTS has been investigating since July 1st the lignite coal fields of Saskatchewan, in order to ascertain the feasibility of the generation of power and the distribution of it throughout the southern part of the province. Mr. Wynne-Roberts was city engineer of Cape Town during the Boer war, and was a consulting engineer in London, England, for some years. Since coming to Canada he made an inquiry into the water supply of the city of Regina.

COMING MEETINGS.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Monthly Meeting will be held in the Rooms of the Society, 413 Dorchester Street West, Montreal. November 7th. Chairman, Henry Holgate.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Annual Convention to be held at Dallas, Texas, November 12th to 15th, 1912. Secretary, A. P. Folwell, 50 Union Square, New York.

NATIONAL ASSOCIATION OF CEMENT USERS.—December 12th to 18th. Annual Convention, Pittsburgh, Pa. President, R. L. Humphrey, Harrison Building, Philadelphia, Pa.

AMERICAN CIVIC ASSOCIATION.—Annual Convention will be held at Baltimore, Md., November 19th to 22nd. Secretary, Richard B. Watrour, Union Trust Building, Washington, D.C.

AMERICAN RAILWAY ASSOCIATION.—Nov. 20th. Annual Meeting at Chicago, Ill. Secretary, W. F. Allen, 75 Church St., New York.

THE INTERNATIONAL ROADS CONGRESS.—The Third International Roads Congress will be held in London, England, in June, 1913. Secretary, W. Rees Jeffreys, Queen Anne's Chambers, Broadway, Westminster, London, S.W.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Ninth Annual Convention will be held in Cincinnati, December 3, 4, 5 and 6, 1912. Secretary, E. L. Power, 150 Nassau St., New York.

THE INTERNATIONAL GEOLOGICAL CONGRESS.—Twelfth Annual Meeting to be held in Canada during the summer of 1913. Secretary, W. S. Lecky, Victoria Memoriam Museum, Ottawa.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, W. F. TYE; Secretary, Professor C. H. McLeod.

KINGSTON BRANCH—Chairman, A. K. Kirkpatrick; Secretary, L. W Gill; Headquarters: School of Mines, Kingston.

OTTAWA BRANCH—
177 Sparks St. Ottawa. Chairman, R. F. Uniacke, Ottawa; Secretary, H. Victor Brayley, N.T. Ry., Cory Bldg. Meetings at which papers are read, 1st and 3rd Wednesdays of fall and winter months; on other Wednesday nights in month there are informal or business meetings.

QUEBEC BRANCH—Chairman, W. D. Baillairge; Secretary, A. Amos; meetings held twice a month at room 40, City Hall.

TORONTO BRANCH—96 King Street West, Toronto. Chairman, T. C. Irving; Secretary, T. R. Loudon, University of Toronto. Meets last Thursday of the month at Engineers' Club.

VANCOUVER BRANCH—Chairman, C. E. Cartwright; Secretary, Mr. Hugh B. Fergusson, 911 Rogers Building, Vancouver, B.C. Headquarters: McGill University College, Vancouver.

VICTORIA BRANCH—Chairman, F. C. Gamble; Secretary, R. W. MacIntyre; Address P.O. Box 1290.

WINNIPEG BRANCH—Chairman, J. A. Hesketh; Secretary, E. E. Brydone-Jack; Meets every first and third Friday of each month, October to April, in University of Manitoba, Winnipeg.

MUNICIPAL ASSOCIATIONS

ONTARIO MUNICIPAL ASSOCIATION—President, Mayor Lees, Hamilton. Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ontario.

SASKATCHEWAN ASSOCIATION OF RURAL MUNICIPALITIES.—President, George Thompson, Indian Head, Sask.; Secy-Treasurer, E. Hingley, Radisson, Sask.

THE ALBERTA L. I. D. ASSOCIATION.—President, Wm. Mason, Bon Accord, Alta. Secy-Treasurer, James McNicol, Blackfalds, Alta.

THE UNION OF CANADIAN MUNICIPALTIES.—President, Chase. Hopewell, Mayor of Ottawa; Hon. Secretary-Treasurer, W. D. Lighthall, K.C. Ex-Mayor of Westmount.

THE UNION OF NEW BRUNSWICK MUNICIPALITIES.—President, Councillor Siddall, Port Elgin; Hon. Secretary-Treasurer J. W. McCready, City Clerk, Fredericton.

UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. S. MacMillan, Warden, Antigonish, N.S.; Secretary, A. Roberts, Bridgewater, N.S.

UNION OF SASKATCHEWAN MUNICIPALITIES.—President, Mayor Bee, Lemberg; Secy-Treasurer, W. F. Heal, Moose Jaw.

UNION OF BRITISH COLUMBIA MUNICIPALITIES.—President, Mayor Planta, Nanaimo, B.C.; Hon. Secretary-Treasurer, Mr. H. Bose, Surrey Centre, B.C.

UNION OF ALBERTA MUNICIPALITIES.—President, Mayor Mitchell, Calgary; Secretary-Treasurer, G. J. Kinneard, Edmonton, Alta.

UNION OF MANITOBA MUNICIPALITIES.—President, Reeve Forke, Pipestone, Man.; Secy-Treasurer, Reeve Cardale, Oak River, Man.

CANADIAN TECHNICAL SOCIETIES

ALBERTA ASSOCIATION OF ARCHITECTS.—President, G. M. Lang Secretary, L. M. Gotch, Calgary, Alta.

ASSOCIATION OF SASKATCHEWAN LAND SURVEYORS.—President, J. L. R. Parsons, Regina; Secretary-Treasurer, M. B. Weeks, Regina.

ASTRONOMICAL SOCIETY OF SASKATCHEWAN.—President, N. McMurchy; Secretary, Mr. McClung, Regina.

BRITISH COLUMBIA LAND SURVEYORS' ASSOCIATION.—President, W. S. Drewry, Nelson, B.C.; Secretary-Treasurer, S. A. Roberts, Victoria, B.C.

BRITISH COLUMBIA SOCIETY OF ARCHITECTS.—President, Hoult Horton; Secretary, John Wilson, Victoria, B.C.

BUILDERS' CANADIAN NATIONAL ASSOCIATION.—President, E. T. Nesbitt; Secretary-Treasurer, J. H. Lauer, Montreal, Que.

CANADIAN ASSOCIATION OF STATIONARY ENGINEERS.—President, Wm. Norris, Chatham, Ont.; Secretary, W. A. Crockett, Mount Hamilton, Ont.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.—President, Peter Gillespie, Toronto, Ont.; Secretary-Treasurer, Wm. Snaith, 57 Adelaide Street, Toronto, Ont.

CANADIAN CLAY PRODUCTS' MANUFACTURERS' ASSOCIATION.—President, W. McCredie; Secretary-Treasurer, D. O. McKinnon, Toronto

CANADIAN ELECTRICAL ASSOCIATION.—President, A. A. Dion, Ottawa Secretary, T. S. Young, 220 King Street W., Toronto.

CANADIAN FORESTRY ASSOCIATION.—President, John Hendry, Vancouver. Secretary, James Lawler Canadian Building, Ottawa.

CANADIAN GAS ASSOCIATION.—President, Arthur Hewitt, General Manager Consumers' Gas Company, Toronto; John Kelilor, Secretary-Treasurer, Hamilton, Ont.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—President, W. Doan, M.D., Harrietsville, Ont.; Secretary-Treasurer, Francis Dagger, 21 Richmond Street West, Toronto.

THE CANADIAN INSTITUTE.—198 College Street, Toronto. President J. B. Tyrrell; Secretary, Mr. J. Patterson.

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