PAGES

MISSING

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

FLOW CONDITIONS IN FLUMES*

Observations Made Show That Where Water Flows At High Velocity Investigations Should Be Made Before Final Designs Are Adopted

By JOHN S. LONGWELL

In connection with experimental investigations made on the North Platte project during the irrigation season of 1916, several observations were made of flow conditions at the Congo flume on the Low-Line Canal. These observations were made primarily for the purpose of determining the inlet and outlet losses and the value of Kutter's *n* for the flume. However, studies made of the data submitted revealed an interesting and important condition of flow separate from the original objects of the investigations.

The flume under consideration is of the semi-circular steel type, with smooth interior, known commercially as a Hess No. 204. The inside diameter is 10.823 ft. It is constructed on a tangent and has a total length between head walls of 240 ft. The field observations consisted of: (1) Profile of water surface; (2) profile of sub-grade; (3) elevation of top of flume; (4) measurement of discharge through the flume.

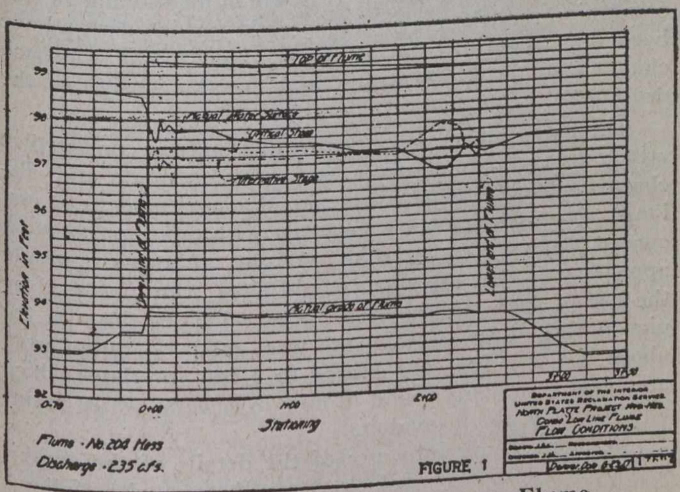


Fig. 1.—Flow Conditions in Congo Flume

The observations made on July 20th, 1916, were taken as representative of flow conditions. Fig. 1 has been prepared on which are shown in full lines the profiles of actual subgrade, actual water surface, and the top of the flume. The discharge through the flume at the time of making the above observations was 235 cu. ft. per second.

An examination of the water-surface profile shows that the flow through the flume is decidedly unstable, especially at the upper and lower ends of the flume. This general unstable condition of flow, together with the decided drop and jump in the water surface at the lower end, was identical in each test made and led to the belief that the flow must be at or near the critical depth. To substantiate the above theory studies have been made of the flow conditions throughout the flume.

*From "Reclamation Record."

With a discharge of 235 second-feet, various depths in the flume were assumed and the resulting area, velocity, and velocity-head for each depth computed. These data were plotted (see Fig. 2) with the depths in the flume as abscissae and the energy required to maintain the flow at these depths as ordinates. The energy required is equal to $D + h_v$ where D represents static head and h_v velocity

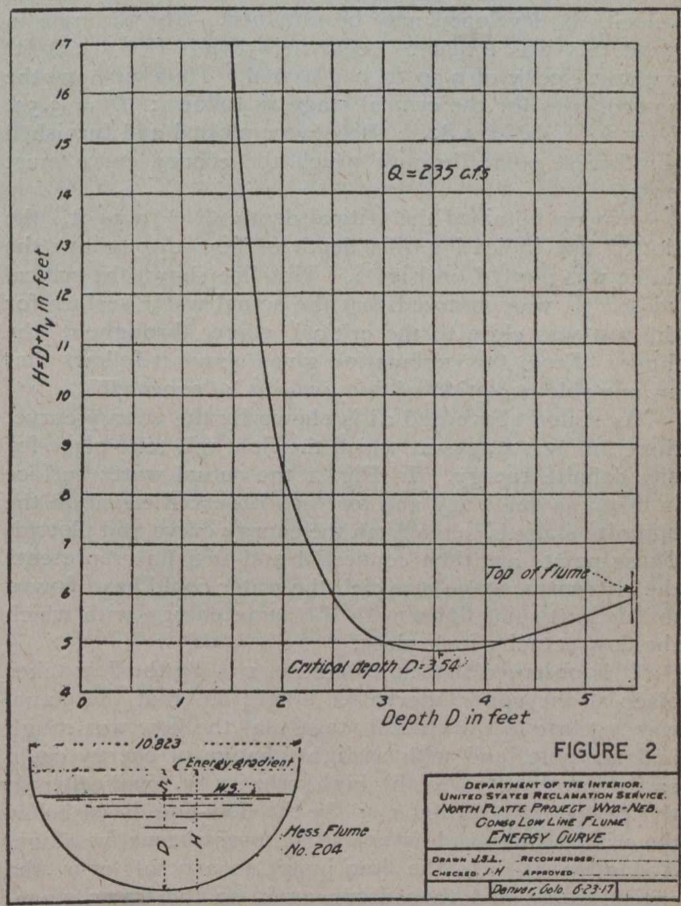


Fig. 2.—Energy Curve

head. The resulting energy curve for a flow of 235 second-feet through the flume was then drawn.

From the shape of the curve it follows that there are two depths at which the flow will take place with the same energy. These two depths are known as the lower alternative stage (stage of high velocity) and the upper alternative stage (stage of low velocity). The curve also demonstrates that there is one depth at which the two stages merge, this being the lowest point on the curve and hence the depth of flow requiring the least energy. This depth is known as the critical depth.

As the depth becomes less than the critical, the flow is taking place at the high velocity of the lower alternative stage, and if obstructed will jump and flow under the condition of the upper stage of low velocity. With the flow taking place at or near the critical depth, as shown by the flatness of the curve at this point, any slight change in energy will cause a decided change in the depth. It is thus to be expected that in such a case the water surface will be rough and the depth will shift back and forth along the curve. A jump may be expected if the flow is at all restrained.

The velocity at which the water will flow at the critical stage is termed the critical velocity and may be shown to be equal to $V = \sqrt{g\frac{A}{T}}$, the corresponding velocity being $h_v = \frac{A}{2T}$, in which

V = critical velocity,
g = acceleration due to gravity,
A = cross-sectional area of flume,
T = width of water surface.

From this formula the depth at which the critical velocity is developed may be obtained. For the case in hand this was found to occur at a depth $D = 3.54$ ft. with a velocity of 9.09 ft. per second. Thus we have the co-ordinates for the critical stage as follows: $D = 3.54$, $D + h_v = H = 4.82$. These were plotted and furnished the lowest point through which the energy curve must pass.

Having obtained the critical depth, $D = 3.54$ ft., the dotted line indicating this depth of flow throughout the flume was plotted on Fig. 2. This line shows the critical stage. It was observed that the actual water surface for the test was close to the critical stage throughout the flume. From the explanation given above it follows that an unstable condition of flow was to be expected.

As stated above and as is shown by the energy curve, there are two stages at which the flow will take place for any definite energy. In Fig. 1 the actual water surface is taken as one stage and for each observed elevation the opposite stage is taken from the energy curve and plotted. These points are then connected and this line represents the alternative stage at which the water could have flowed in this particular flume with the same energy with which the flow actually took place.

It is observed that up to station 1 + 83 the flow takes place at the upper alternative stage, but that the actual was so close to the critical stage that the flow was rough and unstable, and with a slight change of energy could easily have shifted to the high velocity or lower alternative stage. At station 1 + 83 the flow-line drops below the critical stage and assumes the lower alternative stage. At station 2 + 30 the flow jumps to a point near the critical stage and then drops again to the lower stage. This rise at station 2 + 30 was probably caused by the rise in the subgrade. Had this rise in subgrade been a little more pronounced the flow-line would have taken approximately the elevation 97.78 as shown for the alternative stage.

The above data show the unstable conditions of flow which may be expected to take place in a flume with the water flowing at or near the critical stage. The necessity for consideration of the above principles in connection with flume design is apparent. It is believed that for all flumes in which the water is flowing at a high velocity, similar investigation should be made before final designs are prepared. In case of flow at or near the critical stage, additional freeboard should be provided.

INTAKE AND OUTFLOW VELOCITIES

BULLETIN No. 96 of the Engineering Experiment Station of the University of Illinois contains a description of and conclusions from experiments on the effect of attaching mouth pieces to the intake and outflow ends of a short pipe, so far as these affect the head lost at entrance and exit and the velocity of flow through the pipe. The problem investigated might appear to be one of very little practical value, but in certain classes of work having to do with water (including sewage) the solutions of it are by no means unimportant. Concerning this, the investigator (Fred B. Seely, Associate in Theoretical and Applied Mechanics) cites a number of instances where it is of considerable importance to know how to reduce this lost head. For example, the passages through a large valve or through locomotive water columns, the draft tube to a turbine, the connection from a centrifugal pump to a main, sluice ways through dams, slat screens at head gates, culverts and short tunnels, suction and discharge pipes of dredges, and the guide vanes and runner of a turbine. The efficiency of a pump working under low head may be increased by an entrance mouthpiece on the suction pipe because it would allow the pump to receive the water in smoother condition of flow. It is well known that a turbine must receive the water from the guide vanes without shock if, in the subsequent flow through the runner, the energy of the water is to be absorbed efficiently by the turbine. The loss of head through a Venturi meter may be considerably increased if the meter is placed too short a distance downstream from a valve, elbow, or other obstruction or cause of disturbance in the pipe. It is worth mentioning in this connection that the recent advances in turbine design have been due largely to the attention given to the approach channels to the guide vanes and to the design of the draft tube.

The experiments described in this bulletin consisted in attaching conical mouthpieces to the entrance and discharge ends of a pipe 6 ins. in diameter and 22½ ins. long. No experiments were made with mouthpieces with curved elements rather than straight, although it would appear to us that the effect would have been increased by the use of such mouthpieces. The velocities through the pipe during these experiments were made to range from about 0.6 of a foot per second to 5 feet, or those which are most commonly found in flow in sewers, water mains and other forms of conduits.

Without going into any of the details of the experiments, the author's conclusions may be quoted as follow:

"The preceding discussion has shown that the losses accompanying the flow of water depend largely upon the state of its motion, which in turn is influenced by many factors, the effects of which in many cases can be but roughly estimated. While the results of these experiments tend to define the range of such effects for certain conditions of flow, additional experiments would be necessary to establish all the inferences which have been suggested. The following conclusions, however, seem justified:

"(*a*) As applying to conditions likely to be met in engineering practice, the value for the head lost at the entrance to an inward-projecting pipe (i.e., without entrance mouthpiece and not flush with the wall of the reservoir) is 0.62 of the velocity head in the pipe ($0.62\frac{v^2}{2g}$), instead of $0.93\frac{v^2}{2g}$, as usually assumed. To put it in another form, the coefficient of discharge for a submerged short pipe with an inward-projecting entrance is 0.785, instead of 0.72, as given in nearly all books on hydraulics. Further, the lost head at the entrance to a pipe having a flush or square entrance is 0.56 of the velocity head in the pipe ($0.56\frac{v^2}{2g}$), instead of $0.40\frac{v^2}{2g}$, as usually assumed. In other words, the coefficient of discharge for a submerged short pipe with a flush entrance is 0.80, instead of 0.82, as given by nearly all authorities.

"(*b*) The loss of head resulting from the flow of water through a submerged short pipe when a conical mouthpiece is attached to the entrance, may be as low as 0.165 of the velocity head in the pipe ($0.165\frac{v^2}{2g}$) if the mouthpiece has a total angle of convergence between 30 and 60 degrees and an area of ratio of end sections between 1 to 2 and 1 to 4 or somewhat greater. In other words, the coefficient of discharge for a submerged short pipe with an entrance mouthpiece as specified above is 0.915.

"(*c*) The loss of head which occurs when water flows through a submerged short pipe having an entrance mouthpiece varies but little with the angle of the mouthpiece if the total angle of convergence is between 20 and 90 degrees and if the area ratio is between 1 to 2 and 1 to 4 or somewhat more. The loss of head for any mouthpiece within this range would be approximately 0.20 of the velocity head in the pipe ($0.20\frac{v^2}{2g}$). There is, therefore, little advantage to be gained by making an entrance mouthpiece longer than that corresponding to an area ratio of 1 to 2. Thus, an entrance mouthpiece with a total angle of convergence of 90 degrees and the length of which is only 0.2 of the diameter of the pipe gives approximately $0.20\frac{v^2}{2g}$ for the loss of head.

"(*d*) The amount of velocity head recovered by a conical mouthpiece when attached to the discharge end of a submerged short pipe depends largely upon the angle of divergence of the mouthpiece. This is true for lengths greater than that corresponding to an area ratio of 1 to 2 and for total angles of divergence of 10 degrees or more. The amount of velocity head recovered decreases rather rapidly as the angle of divergence increases from a total angle of 10 to 40 degrees. At or near 40 degrees the amount of velocity head recovered falls rather abruptly to approximately zero.

"(*e*) A conical discharge mouthpiece having a total angle of divergence of 10 degrees and an area ratio of 1 to 2, when attached to a submerged short pipe, will recover 0.435 of the velocity head in the pipe, which is 58 per cent. of the theoretical amount possible of recovery.

"(*f*) The amount of velocity head recovered by a diverging or discharge mouthpiece when attached to a submerged short pipe is considerably more when a converging or entrance mouthpiece is also attached than it is when the entrance end of the short pipe is simply inward-projecting (no mouthpiece attached). This excess in the velocity head recovered diminishes rather rapidly as the angle of the discharge mouthpiece increases, and it becomes zero for a discharge mouthpiece having a total angle of divergence of approximately 40 degrees. This increase in the velocity head recovered is probably due to the effect of smooth flow in the pipe as the water approaches the discharge mouthpiece. The smooth flow allows the mouthpiece to recover more of the velocity head in the pipe than when a more turbulent flow exists; this increase amounts to as much as 33 per cent. in the case of the discharge mouthpiece having a total angle of divergence of 10 degrees and an area ratio of 1 to 2.

"While these conclusions are drawn from experiments on the flow of water through a particular short pipe having various entrance and discharge conditions, it is felt that the results of the experiments are applicable in a general way to a large variety of cases in engineering practice where the contraction and expansion of a stream of water occurs. A number of such cases are suggested in the introduction."

PRODUCTION AND DISTRIBUTION OF ELECTRICAL ENERGY IN ONTARIO UNDER JURISDICTION OF POWER CONTROLLER

Sir Henry L. Drayton, chairman of the Dominion Railway Board, has been appointed "controller of the production and distribution of electrical energy by companies generating or distributing electrical energy in the province of Ontario." His duties as defined in the order-in-council will be "to determine preferences and priorities in the supply of such electrical energy to the end that a sufficient supply shall be furnished to factories and users engaged, directly or indirectly, in munition work or work for any of the Allied governments, and also for municipal and public utility requirements." He will also restrict the disposal of electrical energy to users other than those before mentioned until such preferences and priorities have been first met. In the event of a dispute between a power company and a customer coming within the preferred class, the controller will fix the price at which electricity is to be supplied.

Under the order-in-council, generating and distributing companies are required "to the fullest capacity of their plant and equipment to supply such energy to users thereof, entitled to preferences and priorities hereunder in the quantities as when from time to time directed by the controller." Any company neglecting or refusing to comply with an order of the controller will be liable to a penalty not exceeding $5,000. Any manager of a company or any other person violating any order of the controller will be liable to a fine of $5,000, or imprisonment for a term not exceeding five years.

Sir Henry Drayton's appointment follows his investigation of a serious power shortage in Ontario disclosed to the government by the Hydro-Electric Power Commission. His report was considered by a sub-committee of the Cabinet and was discussed at a conference between the committee and Sir Adam Beck and representatives of the power companies. At the conference the basis of an order-in-council was agreed upon. That order recognized the desirability of maintaining the supply of electricity for munition plants on both sides of the international boundary, some of which were complaining of shortages of motive power. It also recognized the necessity of providing for the demand from municipal utilities.

Mr. John Murphy, who for ten years past has been hydro-electric engineer for the Railway Commission and the Department of Railways and Canals, is acting as assistant to Sir Henry Drayton in connection with this work.

The Queenstown Government Railways are the latest to be the subject of an investigation. Messrs. M. Kirwan and Arthur Cooper have been appointed a commission for the purpose of inquiring into and reporting on the administration.

SAND-HAY-TAR EXPERIMENTAL ROAD

By John S. Crandell, B.S., C.E.
General Tarvia Department, Barrett Company.

NOTE.—[Sandy roads are more or less common throughout Canada. The following account of experiments recently carried out by the Wisconsin Highway Commission will, therefore, be of interest to many readers.—EDITOR.]

IN the counties of Wisconsin, near the town of Portage, the soil is sandy. Practically no stone is to be found, and gravel does not occur. What stone there is, is of inferior quality and useless for road building. Traffic cuts deep ruts in the sandy roads, cuts so deeply that a motorist who is not a "sand driver" hopelessly stalls his car in them. The roads do not gain by being dragged or shaped up with a scraper, for within 24 hours after such treatment, they are worse than ever.

The sand is of such grade that it is difficult to make it stable with any usual treatment. After a heavy rain much of it acts like quicksand. The farmers living along these roads have occasionally strewn hay over the sand. This forms a mat which lasts for a season and makes the roads passable. But the hay eventually grinds up and leaves the road nearly as bad as it was before.

Mr. A. R. Hirst, Wisconsin's highway engineer, after careful study of conditions, hit upon the plan of giving

Spreading the Hay

the hay a treatment of tar which would preserve the hay, and aid materially in forming the mat surface. To import broken stone or gravel would be too expensive and if this simple expedient of tarred hay works, it means a passable road at slight cost.

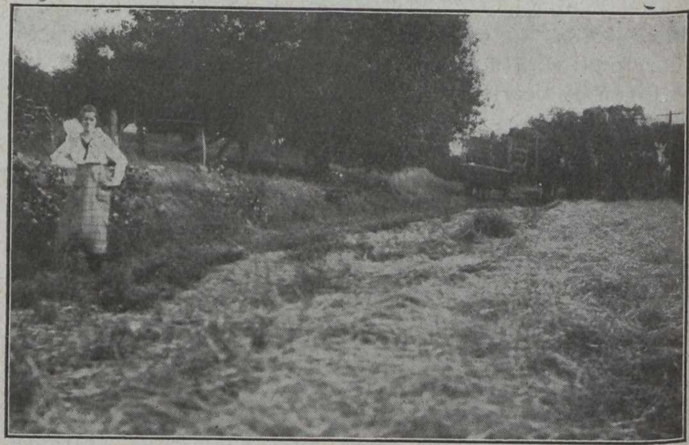
On August 23rd, the writer accompanied Mr. H. J. Kuelling, assistant highway engineer of Wisconsin, to Rio, where an experiment was made.

A road machine shaped the road up in the form of a trough to hold the hay. The machine passed over the road twice, cutting to the shape as shown. Hay was placed loosely over the road for a depth of 5 to 6 inches.

Next, a half gallon of Tarvia "B" was spread uniformly over the hay. An examination of the hay showed that the tar only lay on the top surface of the hay and did not at first find its way down through the mat. This was unexpected and caused doubt as to the preservative value of the tar, which doubt however was dissipated as will be described later.

Another layer of hay was next applied about the same thickness as before. This was given a half gallon of tar and then the road was lightly sanded. Traffic was admitted immediately and did not become bespattered with tar.

The day was a very cool one, and a high wind was blowing. The work went forward rapidly and no trouble was had with the hay blowing away, despite the wind.



Straw Spread Ready for Application of Tar

The experiment was laid out as follows: "A" 450 ft. of marsh hay treated as described above; "B" 350 ft. of rye straw treated as described above; "C" 200 ft. of marsh hay untreated; "D" 200 ft. of rye straw untreated. The untreated sections were for comparative purposes. Later, a short stretch with a one-coat tar treatment was built.

On September 29th, five weeks later, the writer examined the road. The untreated sections presented a yielding, springy surface. That section built of straw showed the straw to be broken up into small bits that the wind could scatter. The hay section was very much better, for this marsh hay is tough and wiry. The treated section of straw was only fair, but the treated section of hay was in excellent condition. A thorough examination showed that the tar had penetrated to the sand base, completely covering it and entering into the top one-half inch. The hay was entirely coated with tar and was uniformly black, as though it had been dipped in a tar barrel. Traffic had matted the hay into a mattress about one inch thick, and both auto traffic and horse-drawn vehicles found a satisfactory surface over which to travel.

Applying Tar to Straw; First Application

The residents along the road seemed well satisfied with the results.

The mat, a portion of which was cut out for examination, was tough and compact. With more traffic, it is probable a nearly waterproof surface will be formed.

The one-treatment section spoken of above was not in as good condition as the whole-treatment section, nor was the hay so thoroughly covered with and preserved by the tar. The second coat of tar seemed to be necessary.

The method of construction is so simple and the apparatus needed so slight that any community with like conditions can readily construct their own roads.

There is every indication that with subsequent yearly treatments a good road for light traffic can be maintained at a trifling cost.

CONCRETE IN SEA WATER

Messrs. R. L. Wigg and L. R. Ferguson have carried out some very interesting experiments bearing upon the effect of sea water on concrete. They have found, among other things, that the character of the workmanship has an important bearing on the ability of concrete to resist the action of sea water. Only contractors of experience, employing competent men, should undertake important work in sea water. The difficulties usually encountered cannot be overcome by any but the best of organizations thoroughly equipped with the necessary tools and machinery.

Tight Forms are Absolutely Essential

The methods to be followed in sea-water concrete work depend in certain details upon the location of the structure, as this governs the rigor of the climatic and sea action, and also upon the particular design employed, this, too, being governed considerably by the conditions to which the structure will be subjected. Certain general principles can be followed, however.

The forms should always be made tight, so that leakage of the concrete will be prevented. For work below the low-water line this is just as true as for that above. The best under-water work is secured by erecting a cofferdam and building in the dry, but this is expensive and at times impossible. When the bottom of the work is at a depth below water which prevents its being seen from the surface, the services of a diver are essential, for the forms must be carefully examined to insure their tightness. Leakage is most likely to occur around the bottom edge of the forms where they rest on the ground. In such cases the washing of the tide carries away the mortar from the concrete, leaving honeycombed sections which are readily cut away as soon as the forms are removed. This undermines the supporting parts of the structure, and settlement and cracking result. A very simple and effective method of preventing the trouble is to plug the crevices around the bottom edge of the forms with bags filled with sand, or better still, bags of concrete.

A popular form of construction where limnoria and teredo are not found is that of wood piles cut off at or near the low-water line and supporting a wood platform on which rests a gravity-section concrete wall. Where this type of structure has been used it is not unusual to find the lower outside edge disintegrated. This is due largely to the fact that the joint between the face form and the platform on which the wall rested was not made tight. The bottom layer of concrete is deposited when the tide drops to the lowest point. This, however, is frequently but little below the platform, and so the water rises to that elevation shortly after the concrete has been placed. If there is any leakage along the bottom edge of the front form the fresh, soft concrete is very likely to have the mortar washed from it along this section. This results in a porous mass which is readily attacked.

The bottom joint, however, is not the only one which should be tight. They should all be tight. It is advisable to use lumber surfaced on the edges and inside face; and in some instances where the wash of water is severe, tongued and grooved material should be used. Smoothness of the exposed face of the concrete assists materially in resisting sea-water attack, and this cannot be secured unless forms are carefully made of surfaced lumber.

If the forms are oiled, and this is preferable, a mineral oil should be used. Practically any kind of mineral oil is suitable, and cylinder oil has been much employed. Two or three applications of kerosene serve better than cylinder oil in preventing the sticking of concrete, and this has the added advantage of not staining.

Correct Proportions and Thorough Mixing Essential

After the materials are selected the concrete must be proportioned to secure the maximum density. Density and strength are closely related and generally the concrete with the greatest density will possess the most strength—that is, when made from given ingredients.

The amount of water used in mixing is of even greater importance, perhaps, than the proportioning of the concrete. This is particularly true for sea-water work. If too little water is used the concrete is porous and the surface lacks smoothness and density; if too much is used the concrete is also porous and the surface chalky and weak. The proper consistency is one just dry enough to permit of light tamping but not so dry as to require any effort to bring water to the surface.

The amount of water used in mixing concrete exposed to sea water action has a most important bearing upon the durability of the structure. Either too dry or too wet a consistency will cause failure. A medium consistency must be used if permanency is to be secured under severe exposure conditions.

The effect of thoroughness of mixing upon the quality of the concrete warrants more consideration. Up to a certain point there is a rapid and consistent increase in the strength of concrete with the thoroughness of mixing. The amount required to give the best results is dependent upon the conditions, such as type of mixer, proportions, consistency and character of materials.

A better quality of concrete at less cost can be secured by omitting a considerable part of the cement and increasing the thoroughness of mixing.

Concrete Must Be Properly Placed

After the concrete is mixed comes the placing it in the forms. In this, especially, more difficulties are encountered in sea-water work than in land structures, and yet only the best quality of work will be permanent.

Unless a cofferdam is built and the concrete placed in the dry, either a tremie or a bottom-dump bucket is used. Both methods have proved successful, although the tremie is preferable if correctly operated. This, however, is far from a simple thing to do. Contrary to the supposition of many contractors, the concrete cannot be forced up above the bottom edge of the tremie for more than a few inches, even when the pipe is long and kept full. In order to start the flow the bottom of the tremie must be raised slightly so that the lateral movement of the concrete restrained by friction is permitted. As soon as the concrete starts to move it tends to discharge rapidly, owing to the combined hydrostatic and velocity head, and this frequently results in the loss of the charge—for a very nice balance must be maintained in order to control the rapidity with which the concrete leaves the pipe.

Of course, a tremie should always be plugged when first charged; otherwise a layer of separated stone, sand and cement mixed with laitance will be deposited in the bottom of the forms, or a seam of such material made in the structure.

The bottom-dump bucket method possesses the disadvantage of permitting at least a slight settlement of the concrete through water and the precipitation of a small amount of magnesia on the surface of each batch. This will cause some laitance to permeate the mass, and may also cause some segregation. As with the tremie, successful results can be obtained only by the exercise of extreme care.

If the work below the low-water line is carried on intermittently trouble may occur unless particular precautions are observed thoroughly to clean the surface of the concrete previously deposited before the placing of concrete is resumed.

Construction Seams Must Be Prevented

For the work above the low-water line every precaution should be taken to prevent the formation of construction seams of laitance. If the tide rises and covers the section before completion of the work the surface of the concrete should be thoroughly cleaned by scrubbing with a stiff broom and washing with a hose before resumption of concreting.

The simplest way to prevent disintegration at construction seams is to not have any such seams. If the work is done in short sections bulkheaded between the forms the concrete can be brought up faster than the tide rises.

BREAKS IN WATER MAINS*

By S. E. Killam
Superintendent, Pipe Lines and Reservoirs, Metropolitan Waterworks, Boston, Mass.

BREAKS in water mains, their causes, and means of preventing same, is a subject which is growing in interest to waterworks officials, especially officials responsible for the supplies to thickly populated districts. The fact that it is always unknown when one of these breaks will occur is acknowledged by all engineers and superintendents having responsible charge of the water supplies as the most trying part of the maintenance of the waterworks system.

The purpose of this paper is to give an account of the breaks which have occurred in connection with the supply of water to Boston, Mass., and the surrounding towns, known as the Metropolitan Water District, since the works were put in operation, January 1, 1898.

The area of the Metropolitan Water District is 174.8 square miles, and the population as supplied, July 1st, 1916, is estimated as 1,190,220.

Water is distributed to the several cities and towns through 122.22 miles of pipes from 60 ins. to 10 ins. in diameter. Connected with these mains there are 516 valves for controlling the flow of the water, and 59 Venturi meters of sizes varying from 6 ins. to 48 ins., by means of which a continuous record is kept of the quantity of water used in each of the eighteen municipalities supplied with water.

*Abstract of paper read before the New England Water Works Association.

With the exception of a 30-in. wrought-iron cement-lined pipe line, 11,200 ft. long, a 10-in. calomine pipe line 3,140 ft. long, and a few short lengths of steel pipe, all the distributing pipes belonging to the Metropolitan Works are made of cast iron.

The distribution system in the several cities and towns which are supplied with water from the Metropolitan works contain 1,732.85 miles of pipe, 176,236 services, and 16,928 fire hydrants.

Every precaution was taken in the construction of the works to see that the pipes were properly inspected as to quality of material, workmanship, and coating at the foundry. The pipes were again inspected as they were delivered at the various pipe yards for imperfections and cracks. The pipe lines were laid under the direction of engineers and inspectors especially qualified for this work. Instructions were given to see that the trench was properly excavated, especially in a rock cut, where there is great danger of breaks occurring if all projecting points of the rock are not removed to a sufficient depth to allow a slight settlement of the pipe after it has been laid.

Of the twenty-five breaks that have occurred on the Metropolitan Waterworks system since January 1st, 1898, seven have been on pipes of existing works that were taken as part of the system.. Thirteen of these breaks were due to settlement of the pipe on to a rigid support which supported the pipe at only one point. Five breaks were due to cracked pipe, two to blasting, one to a water hammer caused by a pressure regulator, one to a spud of a dredge being dropped on to the pipe, one to a dredge pulling a pipe apart, one to a blow-out in a cement line, and one, cause unknown.

Examination shows that thirteen of the breaks have been probably due to a slight settlement of the cast-iron pipe on to something solid, which emphasizes the fact that it is necessary to see that the rock is excavated to a sufficient depth to allow a slight settlement of the pipe after it has been laid. It also emphasizes the fact that great care must be taken in maintaining a line to prevent other structures being erected under the main so that there will be sufficient clearance to allow a slight settlement. The writer has always found public service corporations willing to use due care when the situation was fully explained to them, but has always insisted that all work, where any structure was to pass under the Metropolitan mains, should be inspected while the work was in progress.

The Canadian Monthly Building Review says: "New building holds up well in eastern Canada. During the first nine months of 1917 the returns from 19 cities in Ontario increased $571,827 over the corresponding period last year. In Quebec the gain in five cities totalled $464,597, and in three cities in the Maritime Provinces $124,580."

The reconstruction of the Yokohama pier, which has been in progress for the past six years, has been completed. The pier is now 1,200 ft. long and 138 ft. wide, and the depth, alongside, which was formerly only 26 ft. at low water spring tides, has been increased to 35 ft., providing adequate accommodation for the largest steamers engaged in the Pacific passenger trade. Two large double-storied sheds have been provided.

Chrome ore or chromite production in the United States in 1916 exceeded all previous records. More than 47,000 tons was mined and sold, against only 255 tons in 1915, according to the United States Geological Survey. In the Pacific Coast states, particularly California, the increased output has been remarkable. In Oregon the production was more than 3,000 tons last year, while in California it was nearly 44,000 tons. It is evident that for some time to come California will furnish the chief domestic supply with the output from some deposits expected to exceed this year that of 1916.

MODERN PRACTICE IN WOOD-STAVE PIPE DESIGN AND SUGGESTIONS FOR STANDARD SPECIFICATIONS

IN the Proceedings of the American Society of Civil Engineers for August, 1917, a paper on this subject, by J. F. Partridge, Jun.Am.Soc.C.E., was printed. The following discussion of Mr. Partridge's paper, by O. P. M. Goss, Assoc.M.Am.Soc.C.E., and W. H. R. Nimmo, Assoc.M.Am.Soc.C.E., published in Proceedings of the American Society of Civil Engineers, September, 1917, will doubtless interest many readers.

O. P. M. Goss: The writer has read this paper with considerable interest. It contains some very interesting suggestions, and is believed to be a step in the right direction, at least in so far as it suggests the standardizing of specifications covering the design and construction of wood-stave pipe. This subject, however, is very important and should receive thorough consideration before any definite specification is approved.

There are, for example, certain statements in the paper which are not based on the natural laws underlying the most approved use of wood. In offering the following comments for consideration, the writer has endeavored to set forth certain facts which cannot be ignored in the general discussion of wood-stave pipe.

On page 565 of the April, 1917, Proceedings of the American Society of Civil Engineers the author states:

"Fir and pine are pitchy woods, and it is impossible to obtain commercial run lumber without sap, pitch, pitch seams, pitch pockets, and knots. Under conditions of partial saturation, this lumber will not last, and, even with saturation, the pitch and sap will be the cause of deterioration. Most failures are attributable to this fact. There are conditions under which fir or pine will have a long life and give perfect satisfaction."

Pitch does not in any way cause the deterioration of timber. Tests of recent date, made at the U.S. Forest Service Laboratory, indicate that wood containing resin deteriorates a little less rapidly, on the average, than that which is free from this substance. The following quotation is taken from a recent report issued from the U.S. Forest Products Laboratory, at Madison, Wis.:

"Relation of Resin to Strength and Durability.—Data on the effect of resin on durability were worked up for 105 samples of long leaf pine. The results, when considered as averages for four durability classes, indicate that increasing amounts of resin tend to be directly correlated with increased durability. Individual blocks do not necessarily bear out this relation, showing that there are other factors involved."

The following quotation is from page 567 of the paper:

"The cases of redwood pipe already cited illustrate its adaptability, whether laid on the surface of the ground, partly or completely buried, or run through salt marshes or tropical swamps in direct contact with the soil humus. Direct exposure to the rays of the desert sun, and alternate wetting and drying when the pipe is used intermittently in irrigation systems, do not lessen its efficiency."

The writer cannot see how any one can make such a broad statement, and particularly that "Alternate wetting and drying when the pipe is used intermittently in irrigation systems" does not lessen its efficiency. Again, tests made recently at the U.S. Forest Products Laboratory indicate that all woods are subject to decay under adverse conditions. It could only be considered good engineering when conditions are prevented which would tend to make any wood less durable. Heartwood from the California big trees, at the end of a 12-month test, showed a loss in weight of 35.1 per cent., due to deterioration. This wood is not the same as redwood, but is similar, and is used here in the absence of similar data for redwood. Western red cedar, an unusually durable wood, under similar conditions, showed a loss of 21.3 per cent., but it is reported that the samples were too wet to give a fair test, which indicates that 21.3 per cent. loss is lower than a fair test would have shown. Port Orford cedar, readily conceded to be one of the most durable woods, showed a loss of 22.6 per cent., which, again, is lower than the value would have been had the specimens been less saturated. Douglas fir showed a loss of 28.1 per cent., according to these tests. Deterioration, in this case, also, was somewhat retarded by an excess of moisture. These results show that the most durable woods are likely to decay if subjected to adverse conditions. Due to this fact, no wood pipe, regardless of the species from which the staves are made, should be laid under unfavorable conditions without taking practical precautions against decay of the wood fibre.

On page 570 the author (Mr. Partridge) states:

"Fir and pine, being hard woods compared with redwood, and being coarse-grained, having wide rings of hard and soft wood, enter the classification of woods giving excessive percolation, with slow and incomplete penetration. This is caused by the water passing rapidly through the soft summer wood, appearing in drops on the outer surface of the pipe, and of penetrating but slowly, and often through only a fraction of a stave, along the hard winter rings. The result is a stave showing percolation and incomplete penetration at alternate points throughout its cross-section."

Douglas fir, as a matter of fact, is one of the most difficult woods to penetrate with a liquid, and, in this respect, might about as well be classed with metal as with pine. In creosoting timber, throughout the United States, there has seldom if ever been found a wood which has required so much scientific study to secure thoroughly satisfactory impregnation as has been the case with Douglas fir. In the treatment of ties of this wood, it is highly desirable to perforate the sides of each tie with fine holes, uniformly spaced, in order to get an effective injection of creosote oil.

It is usually specified that pipe staves of Douglas fir shall be practically free from all defects, which means that this stock must not be cut from the centre of the log, which usually contains most of the knots and other defects. Due to this fact, the staves are cut from the fine-grained material found on the outer portion of the large fir logs, and not from the coarse-grained material, which is almost always confined to the centre portions of the tree.

In the selection of pipe staves, care is taken to eliminate coarse-grained material. No difficulty whatever is experienced in eliminating practically all the sap wood, and, in pipe properly manufactured, the sap is never allowed to occur on the outer portion of the stave. Sap is not considered a defect on the inner portion, in a line which is in continuous service, because of the fact that, under this condition, it is always thoroughly saturated.

In Douglas fir staves of medium and fine growth, the summer and spring wood bands of the annual ring are so close together that if either is thoroughly saturated the adjacent one must also be wet.

The soft portion of the annual ring of redwood is more porous than the corresponding part of Douglas fir, as shown by Figs. 1 and 2. Redwood holds a natural moisture content of about 80 per cent. and the normal moisture content of Douglas fir is 33 per cent. based on the dry weight of the wood in both cases. These facts indicate a greater porosity in redwood than in Douglas fir. As a matter of practice, however, neither of these woods is justly subject to criticism from the standpoint of excessive percolation.

The author refers to the "soft summer wood and hard winter rings." Technically, the summer wood is the hard

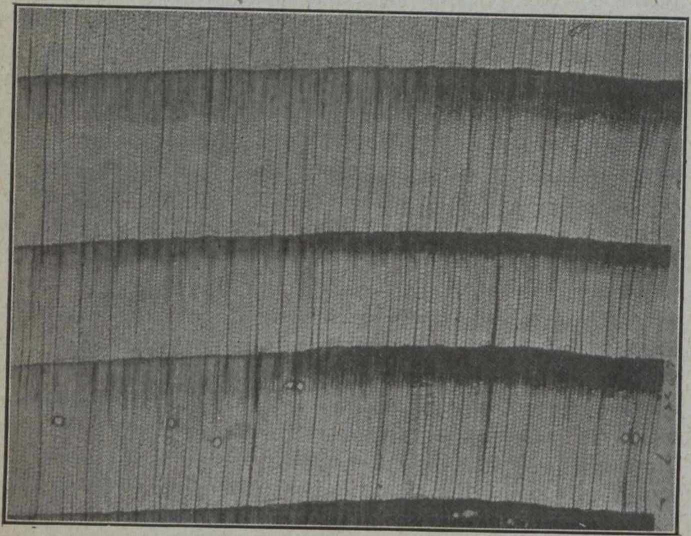


Fig. 1.—Cross-section, Douglas Fir, Showing Cell Structure (20 ins. Diameter).
A—Summer Wood B—Spring Wood

part of the annual ring, and is formed during the dry period of the tree's growth; that is, through the late summer and early fall. The soft or porous portion of the annual ring is the spring wood, and is formed in the early spring and summer, when moisture in the soil is abundant and the growing rate of the tree is most rapid.

On page 571 the author states:

"The lumber, therefore, should be perfectly dry before being used. It should be dried by the natural or air-drying process, not by the forced or kiln-drying process. By air-drying only, is perfect, sound, strong lumber obtained. Kiln-drying makes brittle and lifeless lumber. Air-drying requires time, and, as lumber should be seasoned for at least a year for the best construction, a large stock of it should be available at all times."

As a matter of fact, better results may be secured by correct methods of kiln-drying Douglas fir lumber than by air-seasoning it. Like any other process of manufacture, kiln-drying has its successes and failures. With a fundamental knowledge of wood and of the law governing successful kiln-drying, entirely satisfactory results are now obtained. It is possible to kiln-dry Douglas fir staves in such a way as to leave them in perfect condition for use. This kiln-drying may be, and is, done to-day so as to produce faultless lumber with its full original strength, in fact, much more than its original green strength, as it comes from the kiln.

Small specimens of long-leaf pine, 3/4 by 3/4 in. in cross-section, air-dried for 98 days and re-soaked in water for 47 days, showed a crushing strength of 2,213 lbs. The same material (matched pieces) after being kiln-dried 35 days and re-soaked in water 63 days exhibited 2,268 lbs. Air-dried, re-soaked specimens of red spruce, handled in exactly the same way, showed a strength of 1,553 lbs., and for the kiln-dried, re-soaked, 1,606 lbs. Chestnut was also used in this test, and exhibited 1,482 lbs. for the air-dried, re-soaked, and 1,573 lbs. for the kiln-dried as the drying does not injure the strength of the wood, as compared to air-seasoning; and it must be remembered that these tests were made on specimens which were water-soaked after being kiln-dried and air-dried, which makes the tests particularly applicable to pipe staves in service.

Mr. H. D. Tiemann, of the U.S. Forest Products Laboratory, one of the best versed men in the United States on the theory of kiln drying lumber, states:

"While aid-drying is undoubtedly the safest method, the process is ordinarily so slow, requiring a year or longer, according to species and size, that forced 'artificial' drying becomes a business necessity. Moreover, air-drying is by no means always to be preferred to kiln-drying from the standpoint of the quality of the product."

Douglas fir has considerable advantage over redwood in strength in compression across the grain. The average strength of these woods is 570 lbs. per square inch for Douglas fir and 525 lbs. for redwood. These figures show redwood to be approximately 92 per cent. as strong in side bearing as Douglas fir.

The author states: "For permanent work, redwood should be selected, or fir or pine of high-grade staves kept saturated and well painted."

It would be inviting trouble not to apply the clause "kept saturated and well painted" to redwood, as well as to fir and pine. It is the weak points in a wood pipe that cause the trouble, and in good engineering these weak points should be eliminated by proper means. Wood staves used under low heads or under intermittent service should be creosoted by the pressure process. If, for any reason, this is impossible, a brush treatment with hot creosote, or carbolineum, should be applied to the edges and ends of the staves, and also to the entire outer portion

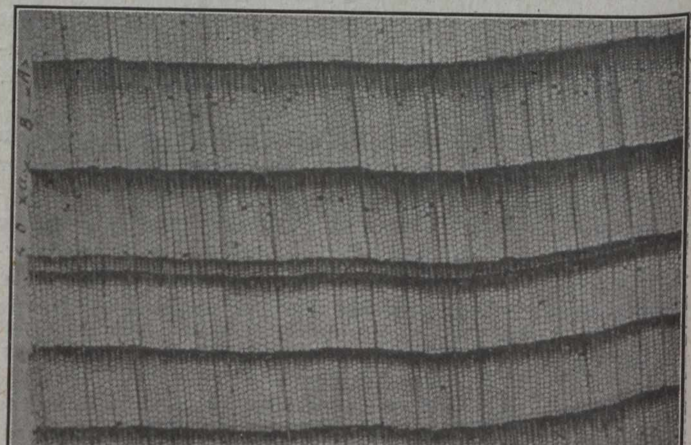


Fig. 2.—Cross-section, Redwood, Showing Cell Structure (20 ins. Diameter)
A—Summer Wood B—Spring Wood

of the pipe line. This treatment should be followed with a hot asphalt or tar coating thoroughly applied.

The West Coast Lumbermen's Association recently completed some strength tests on staves which had been creosoted by this mild-temperature method of treatment. Twelve Douglas fir staves were selected, which were entirely free from sap wood, and twelve other staves were chosen as nearly like the first group as possible, except that they contained various quantities of sap wood. All these staves were 6 ft. long, and were kiln-dried. A section 1 ft. long was cut off the end of each stave and retained for a control test. The remaining portions of each of the twenty-four staves were treated in the following manner:

They were warmed in creosote oil for 4 hours at 170° Fahr., and pressed from 0 to approximately 100 lbs. per square inch, until they had received about 16 lbs. of oil per cubic foot.

The oil was then heated from 170 to 230° Fahr. in 3 hours, and held at this latter temperature for 1 hour. The staves were then removed.

The final heating bath was for the purpose of removing the surplus oil and cleaning the stave.

Table I.—Band Bearing Test on Douglas Fir Staves, Natural and Creosoted. Staves Soaked in Water One Month Before Test

Condition of stave.	LOAD, IN POUNDS, REQUIRED TO PRESS A SECTION, 3.35 IN. LONG, OF BANDS OF VARIOUS DIAMETER, INTO THE STAVE TO A BEARING OF 60 AND 90° OF ARC.								Average for all tests.
	0.193 in Diameter.		0.226 in. Diameter.		0.497 in Diameter.		0.625 in. Diameter.		
	60°	90°	60°	90°	60°	90°	60°	90°	
Staves Containing Sapwood.									
Natural	166	371	218	453	507	1 096	608	1 334	594
Treated	171	414	250	518	620	1 338	756	1 663	716
Treated, in percentage of natural	103.1	111.6	114.7	114.4	122.3	122.1	124.4	124.7	120.5
Staves All Heartwood.									
Natural	196	460	267	574	592	1 291	714	1 572	708
Treated	210	531	332	713	752	1 596	880	1 929	868
Treated, in percentage of natural	107.1	115.5	124.4	124.2	127.0	123.6	123.2	122.7	122.6

After this treatment, the staves were free from excess of oil and easy to handle. They were then placed in a water tank with the untreated pieces, and all were soaked for about 30 days. Then both the natural and creosoted staves were subjected to a band pressure test. In making this test, four sizes of bands were used, as shown in Table I. Each band was 3.35 ins. long, and was pressed into the stave, for the entire length of the band, in a direction perpendicular to the grain of the wood, until it was embedded over an area equal to 60 and 90° of the arc. The loads required to cause this depth of compression are shown in Table I. Each stave, natural and treated, was subjected to tests with bands of each size. The results show clearly that creosoted staves of all heartwood as well as those of mixed heartwood and sap wood have strength values even greater than those obtained from the test of natural wood. The results are particularly significant, as the test approaches about as closely as possible the actual condition of staves in a pipe line in service. The creosoted staves uniformly show a slightly higher strength than the untreated staves tested under the same conditions. These results demonstrate clearly the fact that it is possible to creosote Douglas fir staves and retain all their original strength. They also indicate clearly the practicability of permitting sap wood in staves which are to be creosoted. In the staves tested, the penetration of the creosote oil in the sap wood was very complete in every case.

W. H. R. Nimmo: The writer, having had occasion to deal with numerous lines of wood pipe, especially of the machine-banded type, for town water supplies, has been much interested in this paper. Wood pipes as used in Tasmania, whether of the continuous-stave or machine-banded type, are almost always constructed of fir, known locally as Oregon fir. Although some engineers are fully aware of the superiority of redwood, yet, owing to its greater cost, pipes of this timber cannot be obtained from stock, and it is necessary to have them manufactured especially for each job. In the smaller sizes, up to about 6 ins., redwood pipes cannot usually compete with cast iron or reinforced concrete. This State possesses some fine timbers, which may possibly prove superior to redwood, yet, at the present time, owing to lack of a sound forest policy, they cannot be obtained as cheaply as Oregon fir.

Machine-banded pipes, after receiving a first coating of bituminous composition, are usually wound spirally with a strip of Hessian, and are then given a second coating of composition and rolled in sawdust. The Hessian covering and second coating increases the cost slightly, and is omitted in some cases.

If galvanized wire of good quality is used, a factor of safety of four against breaking is considered sufficient. In computing the stress on the winding, the question arises as to the exact diameter of the pipe to be used. In a wood pipe, which is saturated, the joints between the staves must contain water under pressure, and in designing such pipes, the writer assumes that the pressure varies uniformly from the full pressure at the inner surface to zero at the outer surface, and the mean diameter of the pipe is used in computing the stress in the wire. This is a matter of no importance in a large pipe, but, in small sizes, its effect on the size of the wire is appreciable. The writer has not seen the question dealt with by any authority.

In the case of continuous-stave pipe, the design of shoes has not always received sufficient attention. A type of shoe is sometimes used in which the tension of the two ends of the band are not in the same vertical plane, thus adding a horizontal bending stress to the direct tensile stress in the bands near the shoe.

A combination of inserted joints with a collar is now generally used on machine-banded pipes, and has been found to be fairly satisfactory.

The increase in shipping weight due to the coating may not be of great importance. Freight by sea is usually charged by measurement, and special rates by rail can frequently be obtained for complete carloads. The smaller freight and handling charges on wood pipe, as compared with other kinds of pipe, however, are often the determining factors in its selection.

In all specifications for machine-banded pipes a clause should be inserted requiring each pipe to be clearly branded with letters indicating the job, and figures indicating the head for which it is intended. The writer knows of cases where pipes intended to be laid near the intake of a line, under a low pressure, have been carelessly laid in places where the pressure was comparatively high, resulting in considerable trouble in maintenance.

Anthracite beds have been discovered in the Alps at Chiappera, the last "borough" close to the border on the way from Italy into France.

LOCOMOTIVE DESIGN AND CONSTRUCTION FROM A MAINTENANCE STANDPOINT*

By W. H. Winterrowd
Assistant to Chief Mechanical Engineer, Canadian Pacific Railway.

It is a question if there has ever existed a locomotive house foreman who has not, at some time or other, had the feeling that if some part of a locomotive had been designed a little differently, he could make repairs quicker, easier, and at less expense. While in many instances he may have been justified in this feeling, there are, however, cases influenced by other factors which may have been of greater importance from the standpoint of ultimate economy of operation.

The type and size of a locomotive have an important bearing on certain details of design. A discussion of the factors relating to the selection of the desired type and size is far beyond the scope of this paper, as it would involve a thorough consideration of the economics of railway operation. Some of these factors, usually considered from the standpoint of both present and future, are grades, track curvature, train speeds, train resistances, kind and nature of business, size and type of existing locomotives, transportation expenses, maintenance of equipment, and physical conditions, such as clearances, bridges, turntables, locomotive houses, repair shops, terminal and water facilities, etc. Occasionally certain of these factors may be such that some detail of the resulting design, while undesirable from a maintenance standpoint, is unavoidable. However, the majority of locomotive details are free from other than purely local restrictions and may be designed almost entirely from a maintenance standpoint.

It should not be inferred from what follows that mechanical and operating men, as well as locomotive builders, have not given a great deal of consideration to the points mentioned. Very many locomotives in service to-day bear witness of such consideration. However, there are at present justifiable reasons for emphasizing and reviewing the importance of locomotive design from a maintenance standpoint. To-day, under changed conditions, the railways are being called upon to render greater service than ever before. But little new equipment is available other than that which the railways may build in their own shops. Repair shops are being worked to capacity. Skilled railway mechanics are scarce. Material of all kinds is difficult to obtain. All of which means that maximum service must be obtained from every bit of existing equipment. It is, therefore, essential to consider every legitimate means whereby the out-of-service period of a locomotive may be decreased and the in-service period increased. All new locomotives should be constructed to give maximum service with minimum maintenance. All locomotives being rebuilt, or modernized, should be turned out of the shops prepared to give similar results. Any improvement that can be made to any locomotive, new, modernized, or under repairs, which will result in increased service, increased efficiency, or decreased maintenance, will help to increase the capacity of the railways. The following covers briefly a few of the points worthy of consideration:

Boiler.—It is hardly necessary to state that a well-designed boiler of ample capacity is easier and cheaper to maintain than one of smaller capacity and which has to be forced continually. The importance of ample capacity can scarcely be overemphasized, either from a maintenance or operating standpoint. Within its limits of weight and size, a boiler should be designed to have a capacity as large as possible, consistent with other governing factors. In this connection the valves of the superheater, the brick arch, and the feed water heater are unquestionable. These values have been practically demonstrated from the standpoint of economy as well as locomotive capacity. The maintenance of locomotive boilers is an important factor, the greatest difficulties being leaky flues, leaky mud rings, broken staybolts, and cracks in firebox sheets.

Knowing that firebox heating surface does a great deal more work per square foot than flue heating surface, boiler capacity does not depend upon long flues. Short flues are the easiest to maintain. Flue location and spacing should be carefully considered, so as to permit easy maintenance, proper distribution of stresses, with a minimum amount of staying, and also to facilitate washing out, particularly in bad water districts. Many failures are frequently the result of crowding in too many flues, placing them too close to the heel of the flue sheet flange, and the use of too small a bridge. The flue sheet flange radius should be carefully considered in relation to the flue layout. Too small a radius, with flues located close to the heel, will not give as much flexibility as may be desired and will make the top flues difficult to maintain. Continued expanding of the flues will cause the sheet to flow, often resulting in flange cracks. The bead on the flues adjacent to the flanges should always rest on the flat surface of the sheet and never on the curved inside surface of the heel. With 2¼ ins. or greater diameter flues it is best that the width of bridges be not less than ¾ in. Assuming that these points have been taken into consideration, it is important to see that the shop layerout and driller follow the design. There have been cases where a layerout has located flues incorrectly and also added one or more. It is also important that flue sheet holes be drilled the proper diameter as it is almost impossible to keep flues tight in holes that are too large.

The radii of door and back head sheet flanges should be studied in relation to the staybolt stresses. A moderately large back head sheet radius will reduce the stress in outer rows of bolts by transferring a portion of the load to the wrapper sheet. Too small a door opening radius will frequently result in cracking of the sheet at this point as provision is insufficient for expansion.

Mud ring corners of ample radius will be easy to construct and maintain. Trouble due to small radius has, in many instances, been overcome by electric or acetylene welding the bottom edges of the sheets at this point to the mud ring.

Flexible staybolts reduce staybolt breakage. A careful investigation will indicate the zones of maximum staybolt stress and sheet movement. In these zones the flexible bolts will give good results and reduce staybolt renewals.

Washout plugs should be so located that all points of the firebox and barrel can be easily reached with standard washout equipment.

Grates should have sufficient air space, be free as possible from dead spots, and be easy to remove. Where certain kinds of fuel are used, properly designed dump grates may be a means of reducing the time the engine is on the ash pit.

As far as possible, all brackets, clamps, or fittings applied on the boiler or firebox should be so located that staybolts, rivets, or portion of caulking edges will be accessible with a minimum of labor.

*Paper read before the Canadian Railway Club.

In connection with the barrel of the boiler, points which may be mentioned are: throttle and dome arrangement which will permit interior inspection of the boiler without the removal of the standpipe; also the elimination, as far as possible, of all small studs. The latter will apply equally to all parts of the boiler under pressure.

Expansion slides, instead of an expansion sheet, under the front of the mud ring, will eliminate the maintenance of a considerable number of bolts and rivets. Proper consideration of all other expansion sheets will further reduce maintenance of many bolts and rivets and tend to eliminate the many resulting troubles as well.

The front end, or smoke box, should be arranged to permit of access to all parts with the least possible work.

Frames.—Frames should be of ample cross-section and well braced to hold them rigid. Maximum cross-section may be of little avail unless accompanied by sufficient and properly located bracing. In this connection, it hardly seems necessary to mention the advantages of a valve gear located outside the frames. The outside gear has made possible better frame bracing, to say nothing of the advantages of easier inspection and maintenance of the gear itself. As far as possible, bolt holes in frames should not be located where stresses are greatest. Where cylinder design will permit, a one-piece frame with a top tie splice seems desirable. Where large cylinders prevent the above arrangement, a one-piece frame with ample depth under the cylinders and having no reduction in thickness, will give excellent service.

Cylinders.—The advantages of outside steam pipes are self-evident from the standpoint of both construction and maintenance. Cylinders should have saddle faces well bolted together to prevent working. All other things being equal a double row of bolts is better insurance than a single row. Weakening grooves cut in covers will reduce repairs to a minimum in case of failure.

Motion.—All bearing pressures should be as low as consistent with good practice in order to reduce the wear and resultant replacement. Ample pin length is desirable in order to obtain lateral stability. Arrangement of motion and design of back steam chest and back cylinder covers should be such that both valve stem and piston rod packing will be easily accessible. Fillets on pins, axles, etc., should be of ample radius. Small fillets are frequently factors in failure. Where possible, a piston rod of sufficient length to permit piston ring renewals without the removal of the rod from the cross-head will reduce maintenance cost. Rod bolts and wedges may be dispensed with by the use of solid bushes. Rods should be designed and arranged so that it may be possible to remove them with a minimum of labor.

The C.P.R. has found that knuckle pins with a small extension on the threaded end through which a strong, flat cotter can be placed have been excellent insurance against the usual consequences of loose nuts. Valves of light weight will reduce the load on all valve parts and result in reduced maintenance. Selection of high-grade, close-grained cast iron for cylinder and valve bushes, piston heads and rings, and in some cases rod bushes, is more than warranted in view of the increased mileage obtainable and the corresponding decrease in maintenance. If conditions permit the consideration of heat treated, or alloy steels, unbalanced forces may be very materially reduced by the use of light reciprocating parts. The reduction of such forces will in turn tend to reduce maintenance of pins, bushings, etc.

Equalization.—Locomotives should be equalized so as to secure the most efficient guiding power from both leading and trailer trucks, or wheels. This involves the proper distribution of weight and a means of keeping the proper amounts on the various axles at all times. In general, the best results seem to be obtained by dividing the equalizing system so that the division between the front and back systems is as directly under the centre of gravity of the locomotive as wheel base and other conditions will permit. The spring gear and equalizing system should receive particular attention when being erected and also when being repaired. The tops of the driving boxes should be milled out squarely and in a plane parallel with the journal bearings. The equalizer and saddles should be fitted to their seats squarely with the pin holes so that the engine will ride squarely on her springs and track properly. The same will apply to the trailer truck equalizers and spring rigging. Trailer trucks that do not carry the back of the engine level are responsible for much avoidable tire wear.

Spring and Brake Rigging.—The application of bushes will facilitate and cheapen renewal of worn parts. Hangers and their connections should be accessible and easily removable. A driver brake main fulcrum shaft in two pieces of equal length, the outer ends supported in bushed bearings integral with the main frames and the central portion supported by a sleeve, will give more even distribution of braking power and maximum accessibility for repairs and adjustments. Brake cylinders, if at all possible, should be located vertically, in order to reduce packing wear and provide accessibility. Brake shoe heads and hangers should be so constructed and hung that shoes will swing clear of wheels when pressure is released and permit easy application of new shoes. Safety hangers should be provided to support and prevent sagging of brake rods. The ratio of brake cylinder to brake shoe pressure should be kept as low as consistent, and should not exceed commonly accepted ratios. This will insure that false travel will be kept to a minimum.

Piping.—The importance of ample clamping and provision for expansion cannot be overemphasized. Piping should be as short as possible consistent with conditions. Accessibility is of prime importance. Piping should be so located that there is no obstruction of washout plugs, arch tube covers, pads, etc. Where pipes pass through the front of the cab, provision should be made for clearance or for sleeve protection to prevent wearing or cutting. The C.P.R. has found it a decided maintenance economy to place lubricator piping from cab to cylinders, etc., in a slightly larger wrought iron pipe where the feeds pass beneath the jacket and lagging. By this means the feed pipes can be removed or applied without the necessity or removing any outside covering. Air brake and steam piping should drain properly and contain no traps in which water can accumulate and freeze. It is desirable that pipes from the sand dome be as nearly vertical as possible, the bottom ends being securely clamped in alignment with the rail.

Miscellaneous.—Ash pans should be as simple as possible, and the sides should have sufficient slope to prevent the accumulation of ash under the grates. Swing doors can be suspended so that their own weight helps to keep them closed. This results in less strain on the door operating rigging.

Easy inspection and maintenance results from placing main reservoirs in an accessible location. Where this is impossible, and drain cocks are hard to reach, an extension handle, the end of which is easily accessible, makes the reservoir easy to drain.

Removable liners on locomotive and tender truck pedestals makes it easy to take up wear and reduce pedestal renewals. To prevent rapid wear between wheel hub liner face and driving box sufficient provision for lubrication should be made.

Shoes and wedges should be so designed that wear can be easily reduced and wedges kept in their proper place with a minimum of labor. Improperly maintained shoes and wedges soon result in increased maintenance of boxes, rods, pins, etc.

Pilots made of scrap boiler flues cost less to maintain than those of wood.

All oiling points should be made as accessible as possible. Handholds or small steps, properly located, to make some oiling points accessible, will soon pay for themselves. Lubricator chokes should be placed in proper position and located as near to the cylinder, or steam chest, as possible. Proper inspection and maintenance of chokes has been found the key to many lubrication troubles. The location of the lubricator in the cab where the feeds may easily be seen and adjusted will result in better lubrication. When located close to the front of the cab, or where the light is poor, proper adjustment is exceedingly difficult.

Four-pane cab side windows are easier and cheaper to maintain than those containing one large pane.

Boiler jacketing should be applied in sections so that panels can be removed with a minimum of labor.

The foregoing are but a few of the multitudinous details which merit most careful thought. But little mention has been made of the possibilities of simplified design by the use of cast steel. It is felt that with the development of the cast steel industry and the production of castings which are practically equivalent to wrought iron, locomotive construction in the future may be greatly simplified. We are to-day using castings that ten years ago would have been deemed impossible to successfully cast. For example, one-piece locomotive frames are now under consideration and will soon be in experimental service. These consist of the two main frames and all cross-braces cast in one piece. This is an indication of the degree of simplification that may be obtained. The maintenance of such parts has in turn been made possible by the development of the art of electric and acetylene welding.

The foregoing are simply a few indications of the importance of design in its relation to maintenance. To mention all the points that merit attention and to discuss them in detail would be far beyond the scope of this paper. Good and far-reaching results can be obtained by inviting criticism and suggestions from those directly responsible for construction and maintenance. Simplicity, correlated with efficiency, should be one of the key-notes of locomotive design. This principle, which in other words is simply good judgment, will make for that degree of efficiency which will be reflected, not only in reduced maintenance costs, but also in the increased capacity of the locomotive plant as a whole.

A recent report issued by the American Highway Association states that the new highway laws of Indiana provide for a penalty of $5 to $25 for blocking the drainage of roads at the entrances to farms, and that if this law is enforced it will gradually do away with one of the greatest troubles experienced in maintaining country roads, as it is impossible to keep a road in good condition unless the roadbed is well drained, and it is impossible to keep the roadbed drained unless the ditches are kept clear.

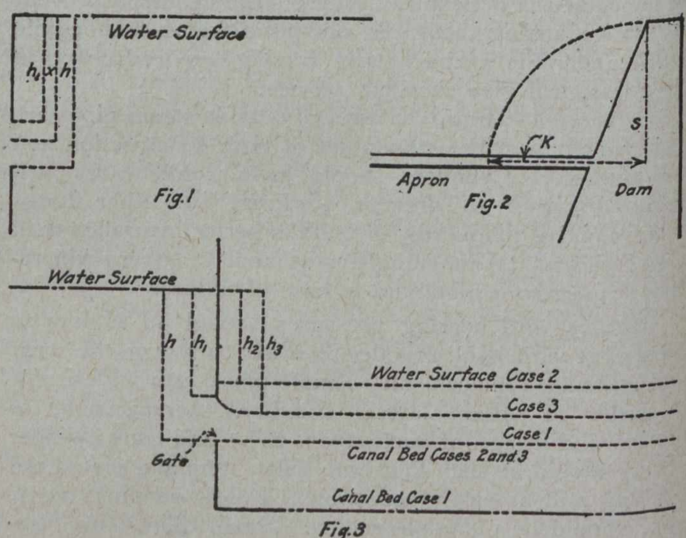
CALCULATIONS FOR DESIGN OF IRRIGATION STRUCTURES*

By Chas. W. Helmick

In designing headworks for irrigating canals it is frequently necessary to construct a low diversion dam across the channel of the river furnishing the water supply, not for the purpose of an impounding reservoir, but merely to divert the water to the intake canal.

If the dam be a low one, raising the water but a few feet above the general river bed, and the waste weir extend over the greater part of the channel, the drop from the crest of the weir to an apron below may be made in one step so as to break the fall, or the drop may be into a water cushion, which is preferable when such can be economically constructed.

The crest of the weir should be at the height that the water should stand above the gates of the intake canal to provide the maximum volume that the intake canal is to carry to the impounding reservoir or to the lands to be irrigated, for in many cases the low water flow will be found to have been acquired by prior appropriators, and only the flood waters, supplemented by what water can be obtained from the river when its water is not otherwise



Figs. 1-3.—Diagrams for Flow Calculations

being used, will be found to be available for the new project.

The prior rights will therefore necessarily have to be first provided for, and gates of ample capacity leading downstream must be provided for all such whose diversion lie below the diversion weir, and as it will generally be found to be more economical to construct the headworks to the intake canal and the gates for prior appropriations in one structure, and in the location of the canal, this idea should be given due consideration.

The quantity of water required for the prior rights taken below the diversion, together with the maximum as wanted through the intake canal, will determine both the number and dimensions of the gates when the head upon the same shall have been determined. Flashboards may, however, be used to increase this head, but they are difficult to operate, and the preferable plan will be found to be to increase the number of gates rather than to be troubled with their continued operation.

*Extracts from article in "Transit."

Calculations

Large orifice in a thin plate and its adaptation to a weir (Fig. 1):

Let the notation be as shown in Fig. 1, breadth being unity.

$dQ = (2g)^{\frac{1}{2}} x^{\frac{1}{2}} dx.$; integrating, $Q = \frac{2}{3} (2g)^{\frac{1}{2}} (h^{\frac{3}{2}} - h_1^{\frac{3}{2}})$ Eq. (1)

If $h_1 = O$, then $Q = \frac{2}{3} (2g)^{\frac{1}{2}} h^{\frac{3}{2}}$ - - - Eq. (2)

Divide by h, we have $v = \frac{2}{3} (2g)^{\frac{1}{2}} h^{\frac{1}{2}}$ - - Eq. (3)

which is the maximum mean velocity of the water over the weir. Taking the coefficient of 0.62, this will give practically the well-known weir formula.

To find where jet will strike the apron with velocity from Equation 3 (Fig. 2):

Time of falling through (s), $t = \frac{(2s)^{\frac{1}{2}}}{(g)^{\frac{1}{2}}}$

$k = vt = \frac{2}{3} (2g)^{\frac{1}{2}} (h)^{\frac{1}{2}} \frac{(2s)^{\frac{1}{2}}}{(g)^{\frac{1}{2}}} = \frac{4}{3} (s)^{\frac{1}{2}} (h)^{\frac{1}{2}}$ - Eq. (4)

As no coefficient for velocity was used, these results are but approximate, but they are probably sufficiently accurate for general work.

The apron must be made wide enough to fully break the jet and, in practice, a wave will form at the apron which will form a water cushion but which will also tend to increase the scour below.

Flow through gates.

Case I. Free flow from gate with no back water.

$Q = \frac{2}{3} (2g)^{\frac{1}{2}} (h^{\frac{3}{2}} - h_1^{\frac{3}{2}})$. Eq. 5, same as Eq. 1.

Case II. Surface of water in canal, above top, or at top of gate.

Evidently, the only head producing flow is (h_2).

$Q = \frac{1}{2} (2g h_2)^{\frac{1}{2}} \quad (h - h_1)$ - - Eq. (6)

Case III. Water surface of canal higher than bottom of gate.

This is evidently a combination of Cases II. and I., the flow through the portion of the gate between floor and water surface corresponding to Case II.

$Q = (2g)^{\frac{1}{2}} \quad (h - h_3) \quad h_3^{\frac{1}{2}} + \frac{2}{3} (2g)^{\frac{1}{2}} \quad (h_3^{\frac{3}{2}} - h_1^{\frac{3}{2}})$ - - Eq. (7)

$= (2g)^{\frac{1}{2}} [\frac{2}{3} (h_3^{\frac{3}{2}} - h_1^{\frac{3}{2}}) + (h - h_3) h_3^{\frac{1}{2}}]$

In the above no account is taken of the velocity of approach in the river channel, and this may generally be neglected unless it exceeds 2 ft. per second, as owing to wave action the errors in measuring the water surface in the canal are necessarily large. No coefficient of contraction is given.

If there be but one opening to the intake canal or river, and this through a broad face, it will very likely range about 0.62 to 0.64, inasmuch as there will be contraction on but three sides.

If there are two or more openings which are wide compared with distances between them, it will range much higher, possibly 0.65 to 0.75, depending on conditions of flow in the canal. Case III. will be found to be the one under which measurements will generally be made, but the great difficulty will be in measuring the distance h_3, even approximately, as the velocity of the water through the gate with $h_2 = 2$ to 2.5 ft. will approximate 10 ft. per second, which causes violent wave action and a piling up of the water below the gate until the normal velocity in the canal is approached.

Case I. will rarely be used in a main canal, but it may come into use in turnouts to laterals.

Case II. will be found useful when there is an abundance of water to fill the canal to its maximum capacity, and if a reasonably close measurement of h_2 can be obtained the velocity of approach in the river channel when it is 2 ft. per second or greater should be considered.

STUDY OF WOOD PRESERVATIVES AND MARINE BORERS*

By C. H. Teesdale and L. F. Shackell

SINCE 1914 the United States Forest Service and the United States Bureau of Fisheries have been studying the various borers. None but those familiar with shipping can adequately appreciate the enormous losses due to the attack of marine borers against wooden structures, such as boat bottoms, piling, etc.

For hundreds of years search has been made for an efficient protective against the attacks of marine borers. During the past 50 years the use of creosote oils, particularly those obtained from coal tar, has made great headway; until at present impregnation under pressure with coal-tar creosote may be considered a standard method of preserving piling. This method is, however, expensive, and its effectiveness by no means invariable. For example, 12 years is about the average life obtained from piling given an 18-lb. treatment and installed at Pensacola, Fla., and it is the practice of one of the railroads to use a tile protection around creosoted piles where renewals are very expensive.

Coal-tar creosote is a highly complex mixture of organic compounds (no two creosote oils being identical in composition), and methods of analysis are limited mainly to fractional distillations carried out under arbitrary conditions, together with determination of a few physical constants. Furthermore, it has not been known whether the effectiveness of a creosote oil against marine borers is due to its toxic constituents, to its viscosity, to high-boiling, practically non-volatile compounds, or to some combination of the foregoing. The development within recent years of a ready market for individual constituents of creosote—the phenols, naphthaline, tar bases, and so forth—has led to the widespread use against marine borers of oils from which these constituents have been removed in part so that the composition of the oils must be widely different from that of the straight distillate oils used 20 to 50 years ago, and it is uncertain how the effectiveness of the oils is impaired. It is these oils, however, that have furnished the service data on which the

Summary of Tests in All Locations After Five to Six Years' Service

Preservative.	No. of specimens.	Condition. No attack.	Very slight attack.	Slight attack.	Medium attack.	Severe attack.	Very severe attack.	Destroyed.	Lost.
Fraction I.	16	..	..	..	..	8	6	2	..
Fraction II.	16	..	..	..	2	5	4	4	1
Fraction III.	16	..	..	3	6	4	1	2	..
Fraction IV.	16	..	2	7	5	..	1	..	1
Fraction V.	16	..	5	3	7	..	..	1	..
Coal-tar creosote	20	..	..	5	14	..	..	..	1
Copperized oil	8	..	..	..	..	1	..	7	..
Water-gas-tar creosote	8	..	..	2	4	2	..	..	..
Hardwood tar	8	..	..	..	..	..	..	8	..
Timber asphalt	8	..	..	..	..	..	..	8	..
Untreated	24	..	..	..	..	..	..	24	..

*Abstracted from the Proceedings of the American Wood Preservers' Association for 1915 and 1916.

reputed effectiveness of creosote oils in general has been based.

The first series of tests was started in 1911 and 1912 with treated specimens of southern yellow pine, each about six inches in diameter and two feet long. Specimens treated with coal-tar creosote fractions were installed at Pensacola, Fla., Gulfport, Miss., and San Francisco, Cal., and specimens treated with various other preservatives were installed at Gulfport and San Diego. A second series of tests was started by installing additional specimens in 1914 and 1915. The pieces treated with coal-tar creosote fractions in 1911 were given an absorption of 18 lbs. per cubic foot and the later ones an absorption of 8 lbs. per cubic foot.

Comparing the results obtained on the five fractions of creosote, it was noted that there was a progressive increase in resistance to attack as the boiling point of the preservative was raised. Thus, all of the specimens treated with Fraction I. were either severely attacked or destroyed, while only one treated with Fraction V. was destroyed. Those treated with coal-tar creosote were about comparable to those treated with Fraction IV. The high boiling water gas-tar creosote was almost as effective as coal-tar creosote. Of the other preservatives used, copperized oil, hardwood tar, timber asphalt, and Spirittine were not at all effective. Hence, it is concluded that products of petroleum and of the distillation of hard and soft woods are not effective in preventing attack by marine borers.

The later experiments indicate that low boiling water gas-tar distillates are ineffective. Zinc chloride or copper salts added to crude oil were of little value, while ferric chloride or copper salts added to creosote considerably increased the resistance, especially to limnoria attack. Naphthalene added to creosote decreased its resistance to the borers, especially limnoria. While the results indicate that additions of tar to creosote reduced the resistance to attack, this was due to the fact that the tar increased the difficulty of penetration, and, with the low 8-lb. absorptions, resulted in narrow, poorly penetrated strips near the surface, in which the borers obtained a start. Where the specimens were well treated, the general surface conditions indicated that tar increased the resistance to attack to a considerable extent. Ferric acetate solutions were of no value.

The shipworm, xylotrya (often confused with a less common relative, teredo), is perhaps the most destructive borer in American waters, and though a microscopic organism at the time of its entrance into a piece of wood, it may attain a length of several feet and a diameter of an inch. Widely different from this mollusc is the tiny crustacean borer, limnoria, which rarely attains a length above one-eighth inch, and yet because of vast numbers is fairly destructive. In spite of the great structural differences between these two forms, their reactions toward creosote poisons were strikingly similar. This was determined from the following summary, which applies equally to both xylotrya and limnoria. Over 1,000 specimens of xylotrya and more than 12,000 limnoria were used.

The preparations investigated consisted of the creosote and creosote fractions used in the above described service tests; a series of creosote light oils; a series of tar acids; a series of tar bases, and a series of crystalline coal-tar hydro-carbons. The light oils tested were benzol, toluol and a mixture of the isomeric xylols. The tar acids consisted of phenol, orthometa—and para-cresols and alpha—and beta-naphthols. The samples of mixed tar bases consisted of four fractions obtained by the Hempel distillation of crude bases. The temperature limits of these distillates were, respectively, 94 to 167 deg. C., 170 to 210 deg., 210 to 250 deg., and 250 to 315 deg. Experiments were also made with a sample each of pure pyridine and of synthetic quinoline. The crystalline hydrocarbons studied were naphthalene, acenaphthene, phenanthrene and anthracene.

1. The toxicity of creosote fractions decreases as the boiling point rises; that is, the creosote and its distillates, arranged in the order of decreasing toxicities, are: Fraction 1, fraction 2, creosote, fraction 3, fraction 4, fraction 5. The high toxicity of fraction 2, which was solid with naphthalene, was probably due mainly to tar acids.

2. The creosote light oils are definitely poisonous for the borers. Benzol is the most, and xylol the least toxic. The toxicity of toluol lies between these two.

3. The tar acids are all highly poisonous to the borers. Their toxicity steadily increases with a rise in molecular weight; that is, arranged in order of increasing toxicity, they are: Phenol, the cresols and the naphthols. The three isomeric cresols, which exert practically the same degree of toxic action, are about twice as poisonous as carbolic acid; while the two naphthols, also equally toxic, are ten or more times as poisonous as phenol.

4. Tar-base fractions all show a high toxicity for the borers; and this toxicity increases with a rise in the boiling point of the fractions. Pure quinoline, boiling at 239 deg. C., is several times as poisonous as pyridine with a boiling point of 115 deg. The toxicities of the tar bases are fairly comparable with those of tar acids of approximately the same boiling points.

5. In comparison with the tar acids or bases or even the lighter hydrocarbon oils the solid hydrocarbons of creosote are only very slightly toxic. Arranged in the order of decreasing effectiveness, they are: Naphthalene, phenanthrene, acenaphthene and anthracene. Naphthalene is perhaps five times as toxic as anthracene.

The following specifications were adopted at the 1917 convention of the American Wood Preservers' Association and provide a distillate oil containing more high-boiling constituents than any previously adopted for use in pressure treating plants. While it was intended for treating paving blocks it is also the best specification thus far adopted that could be used for piling. Such an oil need be used only in the most heavily infested waters. At least 22 lbs. per cubic foot should be injected.

The oil shall be a distillate of coal-gas tar or coke-oven tar. It shall comply with the following requirements:

1. It shall not contain more than 3 per cent. of water.

2. It shall not contain more than 0.5 per cent. of matter insoluble in benzol.

3. The specific gravity of the oil at 38 deg. C. shall be not less than 1.06.

4. The distillate, based on water-free oil, shall be within the following limits: Up to 210 deg. C., not more than 5 per cent.; up to 235 deg. C., not more than 15 per cent.

5. The specific gravity of the fraction between 235 deg. and 315 deg. C. shall be not less than 1.02 at 38 deg./15.5 deg. C.

The specific gravity of the fraction between 315 deg. and 355 deg. C. shall be not less than 1.10 at 38 deg./15.5 deg. C.

6. The residue above 355 deg. C., if it exceeds 10 per cent., shall have a float-test of not more than 50 seconds at 70 deg. C.

7. The oil shall yield not more than 2 per cent. coke residue.

8. The foregoing tests shall be made in accordance with the standard methods of the American Wood Preservers' Association.

Summary

1. The economic losses due to the activities of adult shipworms can never occur as long as treatments of wood for marine structures are able to prevent attack by the microscopic and apparently insignificant shipworm larvae.

2. Heavy treatments with a proper type of creosote will still prove inadequate as long as areas of superficially treated sapwood, heartwood, knots, and so forth, are left exposed for the lodgment of shipworm larvae.

3. It appears that a proper creosote oil for marine work should contain a large proportion of constituents boiling above 320 deg. C., as well as considerable amounts of high-boiling tar acids and bases.

STEEL STEAMSHIPS FOR THE BRITISH GOVERNMENT

Canadian Allis-Chalmers, Limited, have contracted with the Imperial Munitions Board, of Ottawa, for the construction of four general cargo freight steamships of 3,500 tons each for the British government.

These ships, which will be built at the company's shipyard on the Niagara River, near Bridgeburg, Ont., will be 261 feet long overall, 43½ feet breadth moulded and 23-foot depth moulded, of steel construction throughout and are to class 100 A1 with British Lloyd's Register of Shipping. They will be of the usual bulk-cargo type but with special features adapting them for use during the present war-time conditions, being provided with appliances to protect the vessels against submarine attacks, in addition to being arranged with a view to evade visibility and identification. The steel entering into the construction of these steamers will be furnished by the British government through the Cunard Steamship Co., and it is understood that a considerable tonnage of this steel will be available for delivery this year, enabling the builders to start operations immediately.

The propelling machinery is to be constructed at the company's large shops at the Davenport Works, Toronto. The main engine will be of the triple expansion type, the size being 20-in., 33-in., and 54-in. by 40-in. stroke and of the surface condensing type. The boilers will be two in number, 14 feet diameter and 12 feet long, constructed for a working pressure of 180 pounds. They will be fitted, for economical working, with the Howden heated draught system.

The coal bunkers will be located under the bridge deck and in the wings of the boiler space and will hold over five hundred tons.

The cargo holds will be three in number, Nos. 1 and 2 holds to have one cargo hatch each and the No. 3 hold abaft the engine room being provided with two cargo hatches. Each cargo hatch will be served by two independent cargo derrick booms, each of five tons capacity, and each boom with its independent cargo winch. The steam steering engine will be located on the upper deck in a special house abaft of the engine casing. The life-saving equipment will include two 26-foot life boats and one 18-foot working boat. The water ballast tanks, 3 feet deep amidships, will extend the entire length from the collision bulkhead forward to the peak tank aft. The accommodations throughout the ship will be steam-heated and the lighting throughout will be by electricity.

WATER POWERS OF CANADA

The second meeting of the 1917-18 session of the Canadian Society of Civil Engineers was held at headquarters, 176 Mansfield Street, Montreal, on Thursday, November 8th, at 8.15 p.m., the chair being occupied by Capt. J. Duchastel de Montrouge, M.Can.Soc.C.E.

The subject of the evening was "The Water Powers of Canada." A series of motion pictures illustrating the water powers tributary to Vancouver, B.C., Calgary, Alta., Winnipeg, Man., and Montreal, Que., were shown, with an introduction prepared by J. B. Challies, M.Can. Soc.C.E., superintendent, Water Powers Branch, Department of the Interior, through whose courtesy the films were placed at the disposal of the society.

Owing to Mr. Challies' inability to be present the following introduction, prepared by him, was read by Prof. H. M. Mackay, M.Can.Soc.C.E.:—

"Prior to and shortly after the commencement of the war, the Canadian government received many requests from influential educative, financial and commercial organizations in the United States for motion picture films covering the natural resources for Canada. A particularly urgent request was made for films showing the water power situation in the Dominion and the government instructed the Dominion Water Power Branch to undertake the preparation of suitable scenarios. It was found very difficult to develop a scenario of a semi-popular nature, which at the same time would be sufficiently technical to interest the technologist. Furthermore, it was exceedingly difficult to evolve scenarios showing in a comprehensive way the water power situation in the Dominion, without incorporating an undue amount of statistics and text. It was finally decided that the most satisfactory method would be to show in a semi-popular way, the power situation developed and undeveloped, contiguous to several of the more important commercial cities of the Dominion, including Montreal, Toronto, Winnipeg, Calgary and Vancouver.

"Under the immediate direction of B. E. Norrish, A.M.Can.Soc.C.E., an engineer of the Dominion Water Power Branch, the motion picture operators, with their assistants, were set at work in the fall of 1916. Owing to climatic conditions, it was found exceedingly difficult to secure, in certain cases, wholly satisfactory pictures, and some of the field work had to be repeated. The general results were, however, fairly satisfactory. During the winter of 1916-17 the several thousand feet of film was assembled, arranged and titled, and after trial screenings, the scenarios as they now appear, were finally decided upon. The cost of these films was shared by the Departments of Interior and Trade and Commerce. Through the foreign trade commissioners of the latter department, they are now being screened throughout the world wherever war conditions will permit.

"It is probable that these films will be so arranged that they will be suitable to be shown in the various circuits and motion picture theatres in Canada and the United States. It is considered that the net result to Canada will be not only the harnessing of general public interest in Canada and the United States to our water power resources, but the attraction of capital to the development of new water powers and the location of new industries to use power now developed.

"It is interesting to note that a few days ago one complete set of the films was despatched to London, England, at the special request of a member of the Inventions Board of the Admiralty, to be shown to high government and scientific officials, probably in connection with the solution of some war problems with special reference to the fixation of nitrogen.

"The screening to date of these films before important groups of bankers, stock exchanges, boards of trade, educative institutions and government officials throughout the United States has already resulted in a tremendous increase of active interest in the water power situation in the Dominion."

At the close of the meeting the chairman expressed the sincere appreciation of the society to Mr. Challies in placing these interesting and educative motion pictures at the disposal of the members.

During the evening the members present were given an opportunity to subscribe to the tobacco fund for overseas members.

CANDIDATES NAMED FOR NEW ENGLAND WATER WORKS ASSOCIATION

The following candidates for office during the year 1918 have been selected by the nominating committee of the New England Water Works Association:

For president, Carleton E. Davis, chief, Bureau of Water, Philadelphia, Pa.; for vice-presidents, Samuel E. Killam, superintendent pipe lines and reservoirs, Metropolitan Waterworks, Boston, Mass.; Henry V. Macksey, superintendent of public works, Woburn, Mass.; Frank A. Barbour, consulting hydraulic and sanitary engineer, Boston; Percy R. Sanders, superintendent of waterworks, Concord, N.H.; Thomas McKenzie, superintendent waterworks, Westerly, R.I., and Henry R. Buck, consulting engineer, Hartford, Conn.; for secretary, Willard Kent, civil engineer, Narragansett Pier, R.I.; for editor, Henry A. Symonds, hydraulic engineer, Boston.

The committee has also chosen as candidates for the executive committee: Frank J. Gifford, superintendent of waterworks, Dedham, Mass.; A. R. Hathaway, water registrar, Springfield, Mass., and H. T. Sparks, superintendent of waterworks, Brewer, Me. For the finance committee, the selections are: George A. Carpenter, city engineer, Pawtucket, R.I.; Edwin L. Pride, public accountant, Boston; Bertram Brewer, superintendent sewers and waterworks, Waltham, Mass.

The nominating committee, whose report has just been sent out to the membership, consisted of R. C. P. Coggeshall, chairman, George A. Stacy, W. T. Sedgewick, Frank E. Hall and F. T. Forbes.

After 14 years of preliminary work, costing over $2,000,000, coal-mining operations are about to begin on a deposit of coal at Keresley, England. The output is expected to reach more than a million tons a year and to last 80 years.

A company is being formed in Copenhagen for the construction of reinforced concrete ships. It is believed the industry will have a future in Scandinavia owing to the rapidity with which such tonnage can be produced. Norway already has launched its first concrete ship.

In the manufacture of special steels in Japan the use of electricity is now coming into vogue. The Wakamatsu Iron Works and the Fujitagumi Steel Works at Kirokawa, Inawashiro, are now equipped for this purpose. The latter employs 3,000 kilowatts of electricity and produces chiefly ferro-silicon, and at Osaka Harbor also tungsten and chrome alloys. Some other concerns are engaged either in trials or in the manufacture of the special products mentioned. At Yasuki and Yoneko ores prepared from sand iron are being dealt with in electric furnaces.

CANADIAN SOCIETY OF CIVIL ENGINEERS, OTTAWA BRANCH

The fifth luncheon of the Ottawa Branch of the Canadian Society of Civil Engineers for 1917 will be held at the Chateau Laurier on Thursday, November 15th, when the speaker will be Mr. Fraser S. Keith, general secretary of the society, Montreal, who will speak on "The Awakening Recognition of the Engineer."

TORONTO SECTION, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The next meeting of the Toronto section of the American Institute of Electrical Engineers will be held on Friday, November 16th, at the Engineers' Club, 96 King Street West, Toronto. A series of three papers will be read and discussed as follows: "A Commercial Method of Taking the Ratio of Current Transformers," by Harry S. Baker, Ontario Power Co.; "Demand Meters," by Perry A. Borden, Hydro-Electric Power Commission, "Relays," by C. W. Baker, Canadian Westinghouse Co.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MANITOBA BRANCH

The following program has been arranged for the 1917-18 session of the Manitoba branch of the Canadian Society of Civil Engineers:—

1917—November 19th, "Compressors and Compressed Air," Wm. Carter; December 6th, "Munitions," J. Chalmers; December 17th, "Lignite Coal as Applied to Modern Steam Plants," T. L. Roberts.

1918—January 3rd, "Single Phase Power from Three Phase Systems," F. H. Farmer; January 21st, "Durability of Concrete in Western Canada," F. J. Greene; February 7th, "Electrical Systems for Automobiles," J. F. M. Wilson; February 18th, "Foundations for High Buildings," B. S. McKenzie; March 7th, "Operation of the Winnipeg Electric Railway," R. H. Long; March 18th, "Modern Steam Practice," Theodore Kipp; April 4th, "The City Light and Power Department," C. V. Caton and J. G. Glassco; April 15th, "Operations of Hydrographic Department," M. C. Hendry; May 2nd, "Powdered Fuels," George Pratt; May 20th, "Rates for Electric Service," R. A. Sara.

On the 1st instant a most interesting paper on "Fixation of Atmospheric Nitrogen" was read by Mr. V. J. Melsted. He described the mechanical equipment necessary and the various chemical actions which take place in the process of manufacturing nitrates under the four distinct processes in vogue at the present time.

CORRECTION

In the article in last week's issue of *The Canadian Engineer* by E. H. Darling on "Specifications for Steel Highway Bridges," the numbers of the diagrams got mixed. Fig. 1 should have been Fig. 3, Fig. 2 should have been Fig. 1, and Fig. 3 should have been Fig. 2. However, the mistake was not such as would confuse any one who is really interested.

The Canadian Engineer

Established 1893

A Weekly Paper for Canadian Civil Engineers and Contractors

Terms of Subscription, postpaid to any address:

One Year	Six Months	Three Months	Single Copies
$3.00	$1.75	$1.00	10c.

Published every Thursday by
The Monetary Times Printing Co. of Canada, Limited

JAMES J SALMOND, *President and General Manager* — *ALBERT E. JENNINGS*, *Assistant General Manager*

HEAD OFFICE: 62 CHURCH STREET, TORONTO, ONT.
Telephone, Main 7404. Cable Address, "Engineer, Toronto."
Western Canada Office: 1208 McArthur Bldg., Winnipeg. W. G. GOODALL, Mgr.

PRINCIPAL CONTENTS OF THIS ISSUE

ENGINEERING CO-OPERATION

Attention has been drawn at intervals to the fact that industry as a whole is dependent upon the lesser as well as the greater elements in its composition. The directing brain is only possible because there are minor posts and trained men to fill them, in exactly the same manner as a general is a possibility only by the existence of an army to command.

Sport and industry depend essentially upon the factor of co-operation, for without its spirit any pastime and also the greater game fail to accomplish anything worth while. To be successful in organized sport or organized work means that the individual must make his personal aims subservient to, or dovetail into, a common purpose.

Tradition, method and national spirit are not easy to build, but to these, multitudes of unknown units have contributed and their work survives. In this sense the unrecorded units have a perpetual life. This merely emphasizes the importance of the individual unit, for if he default, the collective result is thereby the poorer.

It is team effort with a divisible reward; individual responsibility with a common aim, which makes an industry or profession a national success exactly as it makes sport successful. One unit bulks so small against the mass, seems so trivial, that the common whole must suffer by individual default.

Whatever may be the case elsewhere, responsibility in engineering matters rests as surely upon the man lower down as upon the chief who takes the whole responsibility and incidentally the entire blame. This responsibility is both individual and collective and to foster and intensify its realization is wise policy. The gradations in engineering effort are perhaps more numerous than anywhere else save in military matters. Each unit in the scale is essential, none are contemptible, all are necessary, and responsibility for the total result rests upon each in accordance with his task.

The human machine of industry is astonishingly complex; its mechanism so varied that an organization successful in one connection may prove faulty if transferred bodily elsewhere. To build up an organization worth anything means unremitting thought and labor, constant patching of weak places and a balanced judgment on the part of its executive.

It is the spirit of co-operation more than any other intangible factor which lubricates the system, a desire to be helpful and subordinate self which makes the machine move smoothly, without friction and its attendant drawbacks.

Individual enterprise is a very valuable thing, but individualism which will not assimilate, will not co-operate, is not to be commended. No large enterprise can come to fruition, no business, no scheme can arrive at a successful result lacking this desire on the part of those interested.

There may be two parties holding diverse views, but compromise upon a common denominator acceptable to both or conviction of superiority by one upon the other is essential. Having reached a decision, all must loyally press forward, having only one opinion. In such wise good work can be done,—two viewpoints necessary, perhaps, but only one end to achieve.

That engineering works of great magnitude have been accomplished in the teeth of many impediments, natural and otherwise, proves that the human machine by which they were performed carried co-operation to a very high plane, for unless all hands had been animated by the right spirit, such tasks were humanly impossible.

WHY NOT A MINISTER OF PUBLIC HEALTH?

Questions concerning public health are being discussed to-day more than ever, and properly so, as the conservation of health means conservation of man power. Disease weakens workers, cripples industry and reduces production.

Societies, the primary object of which is to discuss ways and means of promoting public health, are becoming quite numerous. Greater attention is being given to such matters as water purification, sewage disposal, scavenging, street cleaning, and many other phases of engineering which have a bearing on the public welfare.

From an economic point of view, authorities now realize how important is the safeguarding of public health.

In view of these facts, it is too much to hope that before very long, possibly after the war is over, steps will be taken toward the establishment of a federal department of health, with a minister of public health at the head, under whom there should be a co-ordination of all the different existing agencies dedicated to public health? With such a department, under the leadership of a man with broad views and not too limited powers, much really valuable sanitary survey and research work could be done in co-operation with provincial and municipal boards of health.

PERSONALS

W. J. Stephens, of Victoria, B.C., has been appointed surveyor of shipbuilding for the port of Victoria by Lloyd's register of shipping.

Arthur Hatton has been appinted chairman of the newly organized Canadian Railway Association of National Defence.

H. W. Foulds, formerly of the Montreal staff of the Southern Canada Power Company, has resigned to join the American army.

E. O. Ewing has resigned from the staff of James, Loudon & Hertzberg, Limited, Toronto, and joined the University Officers' Training Corps.

Samuel J. Hungerford has been appointed general manager for Eastern Lines of the Canadian Northern Railway, in succession to L. C. Fritch, resigned. His office will be in Toronto.

Hon. T. H. Johnson, formerly minister of public works for the province of Manitoba, has been appointed attorney-general, and Geo. Grierson, M.P.P., will enter the cabinet as minister of public works.

Graham A. Bell, financial comptroller of the Department of Railways, has been appointed government director of the Canadian Northern Railway Board in succession to Senator H. A. Richardson.

Lieut. H. O. Leach, a graduate of the School of Practical Science, Toronto, class of 1915, has been reported wounded. Lieut. Leach lived in Winnipeg and went overseas with the 184th Battalion from that city.

P. T. Davies, formerly power sales manager of the Montreal Light, Heat and Power Company, has accepted the position of manager of the new business department of the Southern Canada Power Company, Montreal.

R. W. Dickey has been appointed by the Toronto city council as resident engineer on the Yonge Street storm sewer and F. L. Dinsmore, Jr.Mem.Can.Soc.C.E., has been appointed resident engineer on the Rosedale Creek sewer extension.

William Rodger, for the past year construction engineer with Fraser, Brace & Company, has resigned his position with that firm and has started business for himself as a lumber broker, with offices in the McGill Building, Montreal.

Lieut. Leslie R. L. Green, of Toronto, a graduate of the School of Practical Science, has been wounded. Lieut. Green enlisted in Montreal with the Engineers and went overseas in December last and has been in France since October.

Lieut. A. R. Wells, B.A.Sc., University of Toronto, class of 1916, has been awarded the Military Cross. He went overseas with a draft from the C.O.T.C. in February, 1916, and is now a signal officer in the 13th Battalion, Essex Regiment.

Major A. Chipman, who went overseas as second in command under Lieut.-Col. McRobie, is suffering from gunshot wounds in the left shoulder and is in a London hospital. Major Chipman, previous to enlisting, was Montreal manager of Hughes-Owens Co.

John T. Stirling, chief inspector of mines for Alberta, has been appointed a member of a sub-committee of the Advisory Council for Scientific and Industrial Research to deal especially with the subject of mining and metallurgy. He will represent Alberta on the committee.

W. B. Fortune, who was superintendent of construction for the St. Lawrence Bridge Co., in connection with the erection of the Quebec Bridge, has severed his connection with that company, having accepted a position as superintendent of United States International Shipbuilding Plants, at Philadelphia, Pa.

OBITUARIES

Major Kenneth Lock Duggan, B.Sc., 5th Mounted Rifles, Canadian Expeditionary Force, has been reported killed in action. Major Duggan, who was the son of Mr. G. H. Duggan, of the Dominion Bridge Company, and past-president of the Canadian Society of Civil Engineers, was born in 1893, and was educated at St. Albans' School, Brockville, and in Switzerland. He graduated in mechanical engineering in 1914 from McGill University. During the summer vacation of 1910 he was engaged in irrigation work for the C.P.R. near Calgary, 1911 C.P.R. near Oshawa, 1912 in connection with the construction of the Abitibi Pulp and Paper Co., and in 1913 in the draughting office of the Dominion Bridge Co. At the time of joining the forces he was on the engineering staff of the Harbor Commission, Montreal. He was appointed major in September, 1916, and was mentioned a number of times in General Haig's despatches. Major Duggan was well known as an expert small yacht sailor and owned and raced several boats with great success. His only brother, Herrick Duggan, of the Royal Engineers, was killed at the battle of Loos two years ago.

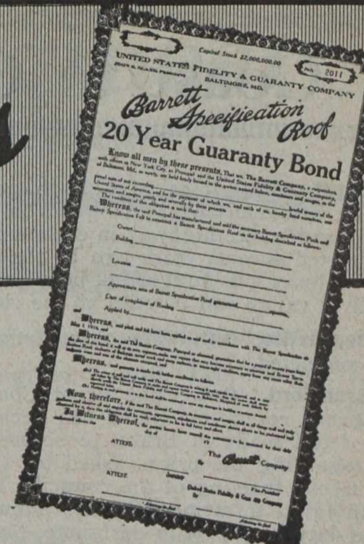
Lieut. Frederick John Anderson, son of Mr. Frank Anderson, of Niagara Falls, and a graduate of the School of Applied Science, Toronto, class of 1908, has been killed in action. He went overseas with a battalion raised in his home district.

Sergt. James Galbraith Bell, who was employed in the engineering department of the Dominion Bridge Co., Limited, at Lachine, P.Q., was killed in action on October 18th. He went overseas with a battery of field artillery from Montreal. He was born at Lachine, and was twenty-one years of age.

Lieut. J. J. Campbell, Jr.Mem.Can.Soc.C.E., of Galt, Ont., a graduate of the School of Applied Science, Toronto, 1914, previously reported wounded, was killed in action on October 26th. Deceased was in his 28th year. On graduating he became identified with the engineering firm of Chipman and Power, Toronto, and had charge of the installation of the sewage system at Burlington and also of work in Bowmanville and other places.

Barrett Specification Roofs

Made in Canada



An Ideal Factory—
and an Ideal Roof

THE modern manufacturer floods his workrooms with sunshine, and his workmen keep in better health and do better work. Here is one of these factories. It is built in the most modern and scientific manner and is covered with a Barrett Specification Roof.

This is not to be wondered at. The wonder would be if some other type of roof had been specified, because most of the permanent structures of the country are covered with Barrett Specification Roofs.

This preference is due to the fact that such roofs cost less per year of service than any other kind; that they are free from all maintenance expenses and, further, because they are guaranteed for twenty years.

In addition, Barrett Specification Roofs take the base rate of fire insurance.

This combination of 20-Year Guaranty with low cost and low insurance rate has put these roofs in a class by themselves.

Guaranteed for 20 Years

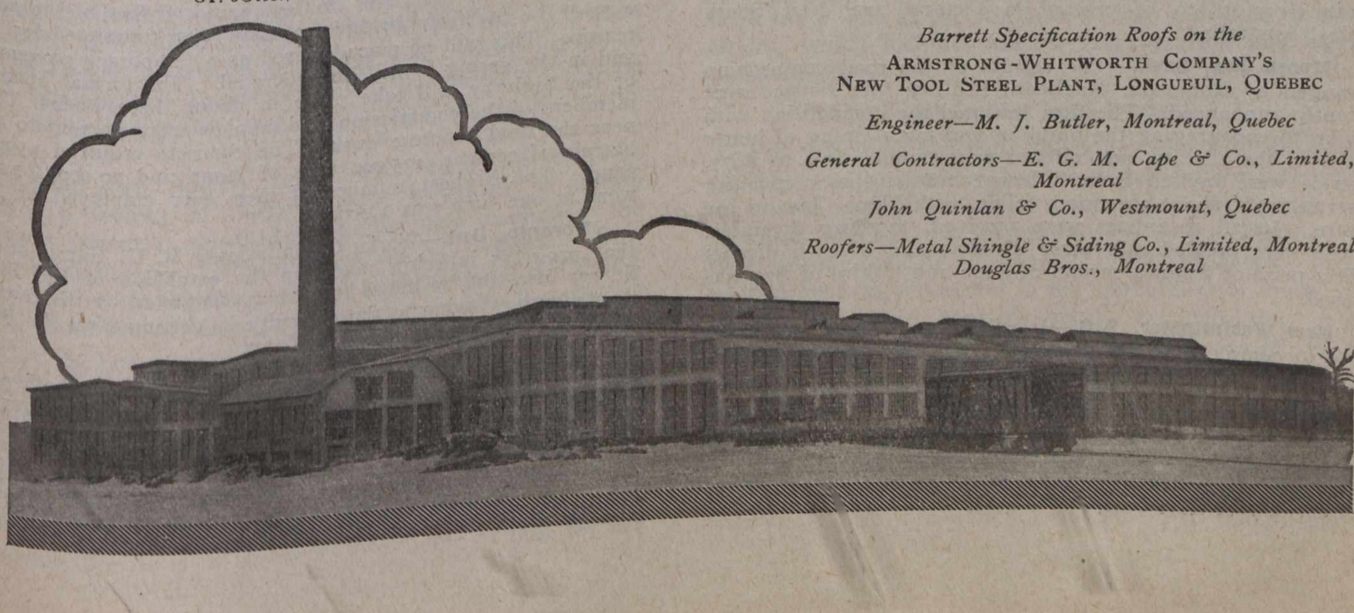
We are now prepared to give a 20-Year Surety Bond Guaranty on every Barrett Specification Roof of fifty squares and over in all towns of 25,000 population and more, *and in smaller places where our Inspection Service is available.*

This Surety Bond will be issued by one of the largest surety companies in the world and will be furnished by us *without charge.* Our only requirements are that the roofing contractor shall be approved by us and that The Barrett Specification dated May 1, 1916, shall be strictly followed.

A copy of The Barrett 20-Year Specification, with roofing diagrams, sent free on request.

The Barrett Company
LIMITED

MONTREAL ST. JOHN, N.B. TORONTO HALIFAX, N.S. WINNIPEG SYDNEY, N.S. VANCOUVER



Barrett Specification Roofs on the
ARMSTRONG-WHITWORTH COMPANY'S
NEW TOOL STEEL PLANT, LONGUEUIL, QUEBEC

Engineer—M. J. Butler, Montreal, Quebec

General Contractors—E. G. M. Cape & Co., Limited, Montreal
John Quinlan & Co., Westmount, Quebec

Roofers—Metal Shingle & Siding Co., Limited, Montreal
Douglas Bros., Montreal

Coast to Coast

Banff, Alta.—It is possible that the coming spring will see the commencement of work on the completion of the Banff-Windermere highway in eastern British Columbia, which was started several years ago by the Provincial Government. This highway will form a link between Alberta and the Columbia River valley and possibly to the coast as well.

Beachville, Ont.—The new Hydro-Electric substation is now completed.

Brantford, Ont.—The Brant County Council instructed the special committee which has been working for the abolition of toll roads in Brant, to secure more definite information regarding the prices asked for the roads, and to report to a special meeting of the council. Warden A. B. Rose was appointed as a member of the suburban area commission, whose duty it will be to designate, build and repair suburban roads.

British Columbia, Province of—The proposal that the Dominion government should assist in the establishment of a steel plant in this province is receiving close attention at Ottawa.

Dashwood, Ont.—Hydro-Electric power is now being supplied to this village over a 4,000-volt line constructed from the Exeter substation.

Dublin, Ont.—Hydro-Electric power has been turned on in Dublin, this power being supplied from a line which taps the 26,000 volt line between Mitchell and Seaforth, and is stepped down at Dublin through a 50 kw. outdoor type transformer station.

Galt, Ont.—A by-law will be submitted to the ratepayers at the municipal elections authorizing the amalgamation of the Hydro-Electric and waterworks commissions.

Galt, Ont.—The new Manchester school which is now practically completed cost the city the sum of $55,333.84.

Hamilton, Ont.—Work has been started on the new by-product coke ovens being erected here by the Steel Company of Canada. Altogether some eighty of these ovens are to be built. They are of the most modern type, and will have a capacity of from 300,000 tons to 400,000 tons per annum. It is expected that the process of turning the coal into coke will give by-products of considerable value to the company. The work of construction will be carried on as speedily as possible.

Maple, Ont.—The Hydro-Electric Power Commission of Ontario have started work on the power line joining Maple with the substation at Woodbridge. Two-thirds of the line have already been completed, and it is expected that the current will be available in Maple for lighting purposes by the middle of December.

Montreal, Que.—The John S. Metcalf Company, Ltd., of this city, have prepared plans for a number of government grain elevators to be erected in Victoria and New South Wales, Australia.

Moose Jaw, Sask.—The results of the road competition arranged by Robinson, MacBean, Ltd., in this district were recently announced. The firm initiated the competition with a view to encouraging the building and maintaining of better roads in the vicinity, and offered prizes amounting to $975. Entries were invited from different municipalities covering a territory of about 36 square miles, with Moose Jaw in the centre. In all 16 entries were received, totalling 65 miles. These were divided into three districts and in each district a first prize of $150, a second of $100 and a third of $75 was offered.

New Westminster, B.C.—It will take probably two years more to complete the Glenbrook trunk sewer to Tenth Ave., City Engineer Stewardson stated.

North Vancouver.—The shareholders of the Burrard Inlet Tunnel and Bridge Company at a special meeting agreed to instruct the company's legal representatives in Ottawa to make application for the renewal of the charter which expires on February of next year.

Ottawa, Ont.—The ninth annual meeting of the Commission of Conservation will be held here on November 27th and 28th. The fuel and Hydro-Electric power problems will be given special attention.

Toronto, Ont.—A new firm has recently been incorporated, known as the Bond Engineering Works, Limited, with a capital stock of $100,000, head office in this city.

Toronto, Ont.—J. R. W. Ambrose, chief engineer, Toronto Terminal Railway Company, stated that the outside work on the new Union Station is likely to be completed by the end of the year, but that the offices and platforms within may not be finished for another year, due primarily to the exigencies of the war, the quarries now working on a somewhat irregular basis, and supplies from the United States and other outside markets coming in very slowly. When completed the new station will have a length of approximately 750 feet and a depth of 600 feet, and will comprise eleven platforms, each accommodating at one time two incoming and two outgoing trains.

Toronto, Ont.—The Board of Education has given its permission for the use of 25 rooms of the new Park School for military hospital purposes. The school will be finished at the beginning of next year. General Logie has offered to supply men from the ranks to assist in rushing it to completion.

Toronto, Ont.—The construction of the new Masonic Temple on North Yonge Street is progressing as rapidly as the contractors can get the material into place. The exterior is all but finished and the work of the carpenters and steamfitters is now going on. So far as is known now, the temple will be ready for occupancy about the first or second week in January.

Toronto, Ont.—The Harbor Commission are making good headway with the reclamation work at Sunnyside, and expect to have the filling in completed by about December 10th. The hydraulic dredge started work about the middle of October, and has a daily capacity of between 10,000 and 20,000 cubic yards. The dyke is practically finished, and the filling in will be continued until the present level is raised between five and seven feet, or within two feet of the dyke of earth. This will make the new boulevard considerably higher than the present roadway, but plans show that the present Lake Shore road is the radial land allowance and will be raised 17 feet, and a new road surveyed on the reclaimed area.

Toronto, Ont.—There is a strong probability that the Crawford Street extension scheme, which includes the acquisition and filling in of Sully Crescent, will be proceeded with early next year.

Toronto, Ont.—With the laying of the last block of concrete, and the placing in it of a bronze plate on which were engraved the names of the commissioners, and the words, "Last concrete laid here, November 6, 1917; H. S. Van Scoyoc, Chief Engineer," the roadway proper of the Toronto-Hamilton highway was completed. Certain portions of the road on either side of some of the bridges have not been completed, owing to the fact that new bridges are to be built. They have been delayed because of the difficulty of getting steel in war time. Fifteen hundred feet of the road, west of the Etobicoke bridge, have not been completed for this reason. This will be macadamized as a temporary pavement, and in the spring it will be concreted. The formal opening of the highway will take place in about three weeks. The members of the commission and officials were present to witness the final concrete work. The concrete required 150,000 barrels of cement, 125,000 tons of stone and 70,000 tons of sand. The highest number of men ever employed on the work at one time was 1,000.

Toronto, Ont.—Works Commissioner R. C. Harris stated that progress is being made on the extension of the Bloor St. car line, and he hopes to have it completed by the first of next month. Owing to the difficulty in getting steel the Pape Ave. car line is still being held up.

Vancouver, B.C.—There were issued from the office of City Building Inspector R. A. McKenzie during October 74 permits, which had an aggregate value of $233,585.

Welland, Ont.—Building records for the last month reached $21,004 as compared with $16,927 for October last year. The total for the first ten months this year is $226,184 and for the first ten months of last year $176,125.