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WATERPROOFING CONCRETE STRUCTURES*

By G. A. HAGGANDER.

One of the hardest problems presented in connection with the construction of the concrete subway track elevation of the Chicago, Burlington & Quincy in Chicago is the waterproofing. These subways are constructed with concrete slabs or girders 7 ft. wide, built away from the work, resting on concrete abutments at the street lines and on concrete columns and cross girders at the curb lines and centre line of street. There is a joint between the slabs longitudinally across the bridge, also one over each cross girder and one after they were set was ¼ in. at the lower part and 1¼ in. at the upper part. A board was put under the joint where the bridge seats did not prevent the mortar from leaking through and the ¼-in. space was filled with cement grout to within 1½ in. of the offset. The next 3 in. was calked with oakum soaked with an asphaltic compound. The rest of the opening was filled with cement grout and over the entire joint were placed three layers of felt painted with this compound.

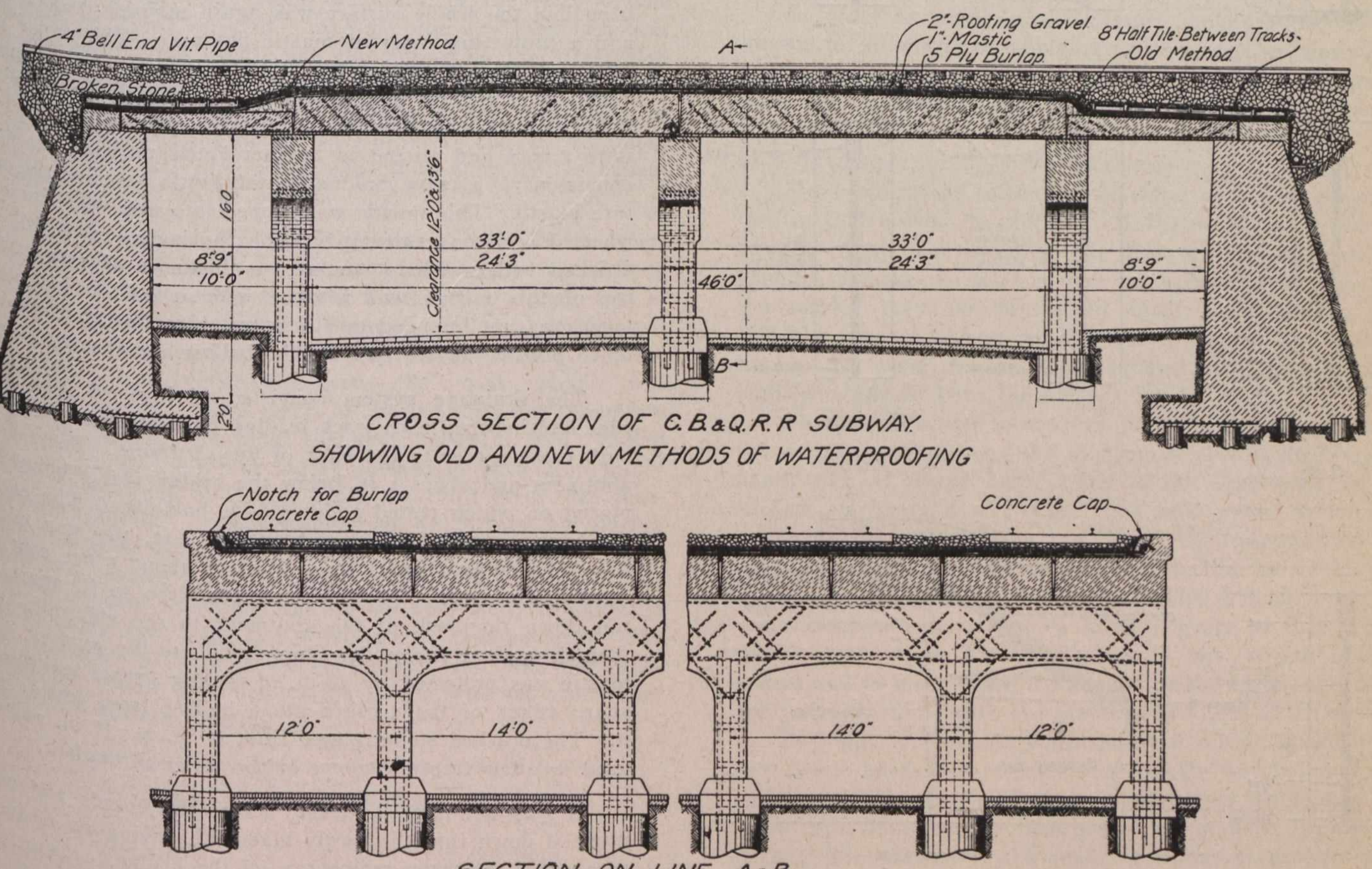

Fig. 8. Standard Method of Waterproofing Subways; C. B. & Q. Track Elevation Work, Chicago.

at the bridge seat on top of the abutment. The slabs over the strees are 2 ft. 9 in. thick over the street girder, and 2 ft. 6 in. thick over the curb cross girder. The slabs over the sidewalk are 1 ft. 5½ in. thick over the curb cross girder and 1 ft. 2½ in. thick over the bridge seat.

The first waterproofing was done in 1906. The most natural method seemed to be the closing of the joints. In order to do this the first slabs were built with the sides offset as shown in Fig. 1. The open space between them

This method was not effective, the subways leaking very badly. It did not prevent the water behind the abutment from running through the mortar joint down the face, and the joints cracked open, letting the water through. It was thought best to fill the joints with some elastic material and six schemes were tried as shown in Figs. 2 to 7 inclusive. They consist of different arrangements of oakum, cement grout, tar or some asphaltic compound and sand. In every case the bottom of the crack was calked with oakum to prevent having to use boards under the joints. None of the methods were even partly successful until the sixth was tried.

* The Armour Engineer, January, 1912.

This one failed when the tar leaked out through the oakum, but this was prevented to a great extent by the use of sand above the oakum. At first the joints were water tight, but the jar and slight working about of the slabs loosened the oakum, letting the sand and tar escape. The joint at the abutment also leaked very badly. In addition to this the water found its way through two of the slabs themselves.

These methods had been tried during 1906 and 1707, and in 1908 it was thought best to waterproof the whole surface of the bridge and to aid the water in running off by a system of drain pipes.

The method shown on the right-hand side of Fig. 8 was the one adopted. The slabs were built with a ½-in. batter on the sides instead of with an offset so that they could be

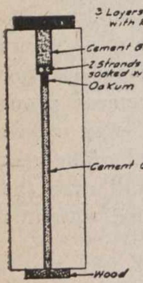

FIG-1

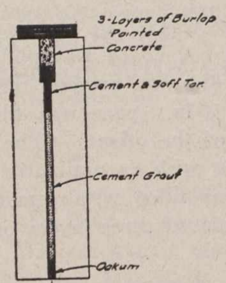

FIG:2

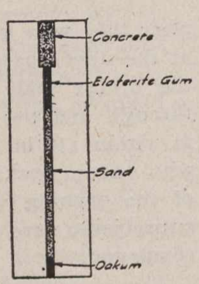

FIG.-3

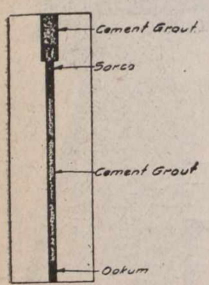

FIG.-4

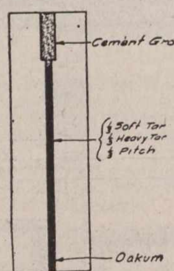

FIG 5

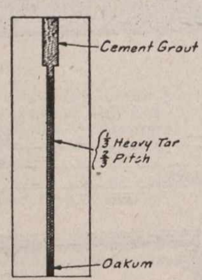

FIG.6

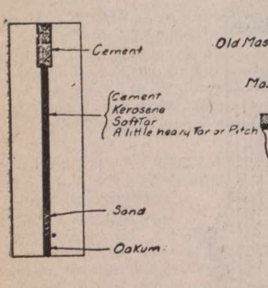

FIG.-7

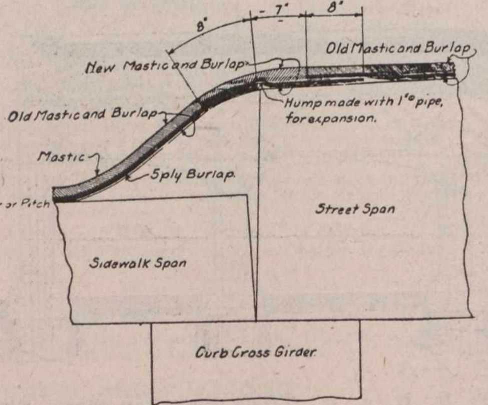

FIG.-9

calked from above. After calking the cracks with oakum they were filled with cement grout. The vertical offset of 12½ in. over the curb cross girder was rounded off by a fillet of concrete. The abutment back of the bridge seat was built up to the level of the top of the sidewalk slab. The lifting stirrups or hook bolts by means of which the slabs were placed were cut off at the top of the concrete and the surface of the bridge swept clean. As a rule only one track or a width of 14 ft. could be waterproofed at one time because of operating conditions and the fact that the force used was of such size that this was one day's work. A strip about 4 ft. wide was mopped with a coat of asphalt which had been heated to the melting point. Four kinds of asphalt were used at different times, Sarco No. 6 and No. 651, melting point 160 deg., Barber Asphalt Company's positive deal "A," melting points 140 deg. Texaco and Warren Chemical Company's asphalt cement. On this was put a strip of 8-oz. open-mesh, first quality burlap, 42 in. wide. This came in 2,000-yd. bundles and was made into rolls coiled on a 1½-in. gas pipe 7 ft. long. It was applied by starting at one end of the bridge and rolling it across. A man followed the roll and swept out any wrinkles so as to give a smooth surface and bond it to the asphalt below. The top of this burlap and a strip of concrete about 15 in. wide on one side of it was then painted with hot asphalt and another layer of burlap laid, covering two-thirds of the first layer, the rest lapping over on the concrete. This burlap and the adjacent concrete were then painted and another strip laid covering one-third of the first and two-thirds of the second strip. In this way the burlap was made three-ply. Care had been taken that the temperature of the asphalt was not high enough to burn the burlap. A melting point of 160 deg. Fahrenheit gave the best results, as asphalt with a higher melting point burns the burlap and it becomes more brittle at low temperatures. After three-ply of burlap had been laid the whole surface was again mopped with asphalt and a protecting layer of mastic put on. This layer consisted of one part of asphalt and four parts of dry engine sand. The asphalt was heated to the melting point in one kettle and the engine sand heated over an iron plate. They were mixed and stirred in another kettle until of the right consistency, a slow fire under the kettle keeping the mixture plastic. This mastic was dipped into iron wheelbarrows, wheeled on broad runways laid on the burlap, dumped, and finished with wooden trowels to a thickness of 1 in. The top of this mastic was mopped with asphalt. This 1-in. layer was not intended to aid in waterproofing, but was put on to protect the burlap from the ballast and the track tools.

The drainage system consisted of inverted 8-in. half-tiles laid between each track leading from the hump over the curb cross girder to the back of the abutment. Back of the abutment and about 1 ft. below the bridge seat a board was placed on which rested another 8-in. half-tile. The end of the burlap rested in this and another 4-in. tile was laid in it. The tiling was given a slope of about 1 per cent. toward down-pipes. These down-pipes were 50 ft. apart and ran down the back of the abutment to the sidewalk level, then through it and under the sidewalk to the gutter. The mastic was protected by ¾ in. of roofing gravel to keep the sharp edges of the crushed stone ballast from cutting into it. The crushed stone ranged from ½ in. to 2½ in. and was used to allow free movement of the water through it.

It was not long, however, before the boards and tiling crushed down into the newly made fill, giving no means of escape for the water which ran off the bridge, causing it to back up above the level of the bridge seat and find its way down the face of the abutment. This was prevented by building the concrete so as to overhang the back of the abutment about 1 ft. and letting it run down the back about the same distance. The top of the abutment was painted with a heavy coat of tar paint before setting the slabs. This effectually sealed the joint. In all abutments built after this experience a notch was left in the top, as shown on the left-hand side of Fig. 8, in which to place the tile and prevent its crushing down.

After the first year's experience with this waterproofing, it was thought advisable to increase the thickness of burlap to five-ply. Many leaks had developed over the curb cross girder due to the tearing of the burlap over the hump at the cross girder joint. This seemed to be caused by a slight expansion and contraction of the slabs and tendency of the waterproofing to travel down the slope of the hump due to the load of an engine above it. The crack which opened up was sometimes as wide as ¼ in. Some method of allowing for this had to be used so a 1-in. pipe was laid over the joint, the burlap put on in the regular way, the pipe withdrawn, and the mastic applied. This scheme was used on all work during the year 1909 and thereafter. Another precaution was taken by putting a flatter slope on the hump, the concrete being run out with about 3 ft. 6 in., so that the tendency of the waterproofing to slide down was diminished. The bridges waterproofed during 1909 are almost devoid of leaks.

The bridges which were waterproofed by filling the joints in 1906 and 1907 have since been waterproofed by the latter method. Those which were waterproofed during 1908 developed leaks where the waterproofing cracked and repair work was started during the fall of 1911. In this repair work the mastic was chipped off for a distance of 8 in. each side of the crack. The burlap was cut away from the crack to the edge of the mastic on the street slab. A 1-in. pipe was then laid over the joint and the mastic and the burlap was cut away from the crack to the edge of the mastic on the street slab. A 1-in. pipe was then laid over the joint and the mastic and the burlap on the street slab lifted up so that a new strip of burlap could be inserted under it. It was lapped under about 9 in. and then laid over the old burlap on the slope. Five-ply were laid, each painted with asphalt, the pipe withdrawn (thus allowing for expansion), and new mastic put on.

Records have been kept of the dates when different portions of the bridges were waterproofed. This repair work has shown that during the cold weather the asphalt that is applied to the cold concrete becomes chilled and does not penetrate the burlap which is laid on it. If the weather was very cold even the coat which was mopped on this first layer of burlap did not penetrate it, due to the fact that the cold concrete had chilled it. The second layer of burlap seemed to have been pretty well saturated in all cases, while the third layer was thoroughly saturated. In waterproofing which was laid during warm weather all of the burlap was in a good state of preservation, having been well saturated with the asphalt. The mastic seemed to protect the burlap very well, although in some cases track tools had penetrated it, causing leaks. The smaller sizes of crushed stone of about ½ in. did not penetrate the mastic as much as the larger sizes on account of the more uniform bearing.

The average force used on this work consisted of:

1 foreman	............at $.33	per hour.
3 finishers	............at .25	per hour.
1 kettleman	..........at .27½	per hour.
8 laborers	............at .20	per hour.

These men waterproofed a bridge 14 ft. wide and 75 ft. long, or 1,050 sq. ft. per ten-hour day. The average cost of the latter waterproofing was a little less than 14 cents per sq. ft. for the burlap and the mastic, not counting the concreting over the hump and bridge seat and the filling of the joints with mortar. This work was done by another gang the day previous to the waterproofing. It added about three cents per sq. ft. to the cost, making a total of 17 cents.

This work was done under the direction of C. H. Cartlidge, bridge engineer, and L. J. Hotchkiss, assistant bridge engineer, and was directly in charge of F. H. Cramer, by whom much of the material in this article was furnished.

SOME METHODS OF PREVENTING DUST ON MACADAM ROADS.*

By John F. Icke, City Engineer, Madison.

A macadam road, as we all know, is made of crushed stone of varying sizes, held in place by filling the interstices with smaller stone, stone dust, or other suitable material as a binder. In the ordinary water bound macadam a cementing action takes place between the crushed stone and the dust used as a binder, the degree of this cementing action depending upon the material used as crushed stone and the material used as a binder.

The harder the rock, the less able it is to absorb moisture, and the more difficult it is to bind. For this reason the granites are more difficult to bind than the limestones when used as a road material.

In order to keep macadam street in good condition it must receive sufficient traffic to furnish more or less dust, and moisture must be provided to aid in keeping the stone cemented. If a sufficient amount of moisture is not present then the road will ravel and will be rapidly destroyed, especially if very much automobile traffic passes over the road:

In order to supply the necessary moisture the method known to all of us of applying water with a sprinkling wagon has been used almost exclusively in the past. The water so applied furnishes the moisture which is absolutely necessary to keep the macadam well bound, and also acts as a dust layer, or dust preventative.

Many objections to the use of water as a dust preventative may, however, be urged. If the water is applied in just the right quantity to lay the dust, but not in quantities enough to make the road surface unnecessarily muddy, then the service may be considered fairly satisfactory. The difficulty lies, however, in the almost impossible task of having the water applied often enough, and in quantities sufficient only to keep the surface moist.

Another objection to the use of water is on account of the injurious effect upon the road material that the frequent application of water has. Any slight depression in the surface of the road will collect and hold water, which will soften up the road surface and hasten the formation of still greater depressions. Still another objection exists in case the supply of water is inadequate. The demand upon the waterworks system is usually already great at that season of the year when the sprinkling of the streets is most urgent and in many cases the heavy demand of the sprinklers seriously interferes with the pressure throughout the system.

For some years past engineers and others interestel in road work have been experimenting with various materials and methods of application, designed as a substitute for water as a dust layer. The use of tar or asphaltic oil applied to the surface of the road, or of tar or asphalt as a binder for the upper two or three inches of th eroad surface is now good practice in many localities.

The application of tar or asphaltic oil on the surface of the road is generally spoken of as surface treatment. The writer's experience with the use of tar in the surface treatment of macadam streets dates back to the year 1908, when the first trial was made. The material used was a prepared tar, known as Tarvia A, made by the Barrett Manufacturing Company.

The street in question was one built of crushed limestone in 1897. The surface was in ideal condition, with very

* Extract paper read at 1912 meeting Engineering Society of Wisconsin.

few depressions or irregularities The preliminary treatment of the road surface before applying the tar consisted in thoroughly sweeping the street surface to remove as much of the dust as possible. The consistency of the tar was such as to make it necessary to heat it before it could be applied. Application was by means of sprinkling cans with broadened nozzles. Approximately one-half gallon of tar was applied per square yard of surface. The surface of the tar was covered with a thin layer of coarse limestone screenings approximately one-quarter inch in diameter, from which practically all the dust had been removed. The street was rolled with a fifteen-ton roller and was thrown open to traffic as soon as possible thereafter. After a short time, and after the excess of screenings had been worn away, the street resembled, in many respects, a sheet asphalt pavement. After the lapse of two years a second treatment was given, similar in all respects to the first, except that the quantity of tar per square yard was about one-third of a gallon. This second treatment was given primarily to cover the individual stones which projected above the general surface of the pavement and were thus not thoroughly covered by the first treatment. Several excavations made in the street since the last treatment show that the tar penetrated the surface of the road from three-quarters of an inch to

Tarviated Road in Madison, Wisconsin.

one inch, and thoroughly bound the surface. How soon it will be necessary to again apply the tar it is impossible to tell; however, it is safe to say it will not be necessary to apply another treatment for at least three years, and possibly not for five or six. The above mentioned treatment has practically eliminated the formation of dust caused by the breaking down of the stone under traffic. The street is, however, not dustless, as more or less dust is brought upon it from traffic and other outside sources, and it has been found advisable to give the street more or less sprinkling with water to keep down the small amount of dust which does accumulate on the street from the sources mentioned above. The street surface is so well bound that any ordinary rain will free the surface from dust as though it were an asphalt pavement. One objection to the above mentioned treatment is that it leaves the street slippery at those times when, due to weather conditions, other pavements like asphalt are also slippery.

The cost of the first treatment was 7 cents per square yard. In this cost is included all the items which should enter, namely, the cost of cleaning the street, the cost of the tar, of heating and applying it, the cost of the screenings and applying them, and the cost of rolling. The second treatment cost 4 cents per square yard, as the quantity of tar applied per square yard was less.

In addition to applying the heavy tar mentioned above a lighter tar (Tarvia B) requiring no heating before applying, has been used with considerable success. This tar is sufficiently fluid, under ordinary temperature, to run freely from the tank cars in which it is shipped. Before applying the tar the road surface must be cleaned of all dirt so as to expose the stone surface. The cleaner the surface of the street the better will the result be in the end. If any cakes of dirt or screenings are allowed to remain on the surface then the tar will not penetrate into the macadam, but will instead be absorbed by the layer of dirt or screenings. The first heavy rain will simply loosen the dirt layer and the street will in consequence become muddy. The street may be swept either with a rotary street sweeper or with push brooms. The former method is the more economical, but is somewhat objectionable on the part of the public on account of the raising of dust while the sweeping is being done. The raising of a dust while sweeping may be lessened somewhat by sprinkling lightly with water previous to sweeping.

The tar is hauled from the tank cars to the street in wagons equipped with a sprinkling attachment attached to the rear of the wagon. Several such attachments are on the market, the general principle of all being the same. Suitable regulating valves are provided on the attachment which makes it possible to gauge the quantity of tar to be applied. In practice about one-third of a gallon of tar is applied per square yard of street surface.

The tar, especially during warm weather, penetrates into the surface of the macadam sufficiently at the end of from six to twelve hours to enable the street to be thrown open to traffic. The efficiency of the tar as a dust preventative lies in the fact that it penetrates the surface of the street from one-fourth to one-half inch and firmly binds the stone in place.

The cost of the cold tar application described above is about 1 9/10 cents per square yard. In order to get the best results a second application of tar should follow the next season after the first application. These two applications will then be sufficient for the two or three following seasons.

AN OUTCOME OF THE GREAT BRITISH COAL STRIKE.

Following the distress of the recent coal strike in Great Britain, serious attention has of late been given to the immense deposits of peat in Ireland and the best method for their economical use.

The methods of preparing peat for fuel are very primitive and would have to be changed completely to make peat fuel a real competitor with coal. An attempt was made some years ago to make turf briquettes, but the scheme, though it promised well, did not turn out as successfully as was expected and the company failed. The moisture was squeezed out of the peat by compression and the briquettes when fresh seemed to be just the thing that was wanted, but whatever defect there was in the preparation of them they were not able to stand the knocking about they got in the railroad wagons and canal boats.

The problem of making peat briquettes that can travel by train without falling to pieces has, however, since been solved in Sweden and in other countries, and this fact has given encouragement to Irishmen to take the matter up again. The coal strike has brought the question within the range of practical things as nothing else could have done.

AIR LIFT PUMP—ITS ADVANTAGES AND DISADVANTAGES.*

The essential structural features of the air lift pump are exceptionally simple and few in number, and this fact constitutes one of its principal advantages. In its simplest form, as shown in Fig. 1a, it consists of a pipe for the discharge of the water and a smaller pipe for conveying compressed air to it at a point near its lower end.

The Eduction Pipe.—The discharge pipe is designated by various writers as the eduction pipe, lift tube, lift pipe, and rising main. It should not touch the bottom of the well or reservoir from which it is to pump, but should be elevated above it, so as freely to admit the water or other liquid through its lower open end. This end of the pipe should, however, be submerged below the liquid surface a distance which, the Wisconsin experiments indicate, should be greater than the height above the water surface to which the liquid is lifted. This latter distance technically is called the lift of the pump. The distance from the water surface down to the point of admission of the air into the eduction pipe is known as the submergence of the pump. Submergence generally is expressed as a percentage of the total length of the pump, measured from the point of air inlet to the point of discharge. The discharge should be free into a reservoir at atmospheric pressure. Submergence and lift should be measured from the elevation of the water as it stands under working conditions rather than under static conditions.

The Foot-Piece.—In most air lift pumps the compressed air from the air pipe enters the eduction pipe through a casting designed to cause the air to enter in a special manner. The casting used for such a purpose technically is called a foot-piece.

Frizell's and Pohle's foot-pieces are cited as examples in design. In the former the foot-piece is an hour-glass-shaped, perforated casting, so designed for the express purpose of admitting the air in small bubbles. In the latter type the exit end of the air pipe is enlarged by bevelling off the inner edge thereof, in order to permit the free delivery of the air in mass or bulk, and thus to avoid the formation of air bubbles.

Quite a large number of different foot-pieces have been devised and patented, and, in most cases, extravagant claims have been made for them as regards their effect in increasing efficiency of the pump.

The Wisconsin experiments indicate that changes in the form of the foot-piece have little if any effect on the efficiency and capacity of the pump, other than the effect due to the amount of obstruction of the water passages; a factor which differs in the various types.

Tail-Piece.—Most forms of foot-piece are arranged for the attachment of a pipe on to their lower ends, thus extending the eduction pipe some distance below the point of air admission, for the purpose of preventing the escape of compressed air from the bottom of the eduction pipe. The pipe used for such an extension is termed a tail-piece. The tail-piece is often made a larger size of pipe than is the remainder of the eduction pipe. The length and size to be used for a tail-piece are problematical.

A number of distinct types of air lift pump have been produced through the various methods that have been devised for piping the wells. The methods in most frequent use are illustrated in Figs. 1 and 2 and are described below.

*Abstract of Bulletin No. 450, University of Wisconsin, by G. J. Davis and C. R. Weidner of the Department of Hydraulic Engineering

Side Inlet Pump.—The side inlet pump, in which the air pipe is on the outside of the discharge pipe, is shown at (a) in Fig. 1. The air pipe is connected to the bottom of the eduction pipe by means of standard fittings, special castings, or one of the various patented foot-pieces. This method is used when the well is large enough to admit of the air and water pipes being placed side by side from top to bottom and is probably the most economical of the systems shown.

Annular Air Tube Pump.—Fig 1 (b) shows the annular air tube pump in which the well top is sealed and the air passes down through the annular space between the discharge pipe and the air pipe or well casing.

Many annular tube pumps have been built with no foot-piece or opening in the side of the pipe. In such pumps the air forces the water level in the well down until the bottom of the discharge pipe is uncovered. Air then enters the discharge pipe and the pressure in the annular space is lowered. This causes the fluid to rise again in the air space and discharge pipe until the pressures balance and then the operation is repeated. This causes the water in the well approaching the bottom of the eduction pipe to surge more violently than it would if it were allowed to rise in the well around the eduction pipe to its normal height, as it does in the side inlet system. It is claimed for pumps built in this way that this surging promotes the entrance of the water and air into the eduction pipe in a manner conducive of high efficiency.

Central Air Tube Pump.—Fig. 1 (c) shows the central air tube pump which uses the well casing as the discharge pipe, and introduces the air through a small pipe usually fitted with some special device or foot-piece attached at the bottom through which the air escapes. Usually a number of small holes are drilled, or a number of slits are cut into the lower joint of the pipe and the end plugged. An objection to this method is that when the well is cased for only a portion of the distance, the air and water may escape out of the well into fissures in the rock. The hydraulic radius of the water passage in the discharge pipe is reduced by the air pipe, which increases the fractional losses and so diminishes the efficiency, but in this method of piping the entire cross-section of the well, less the area of the pipe, is available for use as a discharging pipe; so a well piped in this way will have a greater theoretical capacity than wells of the same size piped by the other methods; notwithstanding the obstruction caused by the central air pipe. This fact is shown by the following comparison of the three methods. Assuming in each case that the wells are 6 ins. in diameter, the largest eduction pipe which can be got into the well with a 1-in. air pipe beside it, is 3½ ins. in diameter, while the annular tube method of piping a 4½-in. eduction pipe can be accommodated. In the central tube system it is assumed that a 1½-in. air pipe is used with the 6-in. casing serving as the eduction pipe. It may be noted from Table I. that the hydraulic radius of the central air tube pump is less than that of the annular tube pump, but the net area of the former is nearly twice as large as that of the latter. The discharge through a pipe under a given head is proportional to the product of the area and the square root of the hydraulic radius of the pipe. This product has been calculated and tabulated in the last column and shows the relative capacities of the wells piped according to the three different methods, assuming the value of the co-efficient of pipe friction and slip to be the same in all three cases.

Table I.—Hydraulic Properties of Three Types of Air Lift Pump.

TYPE	Nominal size of wells.	Nominal size of eduction pipe.	Nominal size of air pipe.	Approx. net area of eduction pipe.	Approx. wetted perimeter	Hydraulic radius.	Discharge function*
	Ins.	Ins.	Ins.	Ins.	Sq. ins.	Ins.	Ins.
Side inlet pump	6	3½	1	9.89	11.15	0.89	9.33
Annular tube pump..	6	4½	6	15.96	14.62	1.13	16.9
Central air tube pump	6	6	1½	26.05	25.02	1.04	26.5

* Area of eduction pipe in square feet multiplied by the square root of the hydraulic radius.

Combination Pump.—Fig. 1 (d) shows a combination of the annular air tube and central air tube methods of piping. It is evident that the hydrostatic head in the well cannot be greater than that due to the ground water to permit of continuous operation. Therefore, no special advantage is to be gained in introducing compressed air above the water surface in the well, unless the increased surging, due to the less depth of water on the outside of the eduction pipe, might affect the size of bubbles of air admitted. The results of the Wisconsin experiments show that with the well piped according to the side inlet method, using a Harris Air Pump Company's foot-piece, there was no appreciable difference when compressed air was introduced above the water surface in the well and when the well was open to atmospheric pressure, the percentage of submergence and lift being the same in both cases.

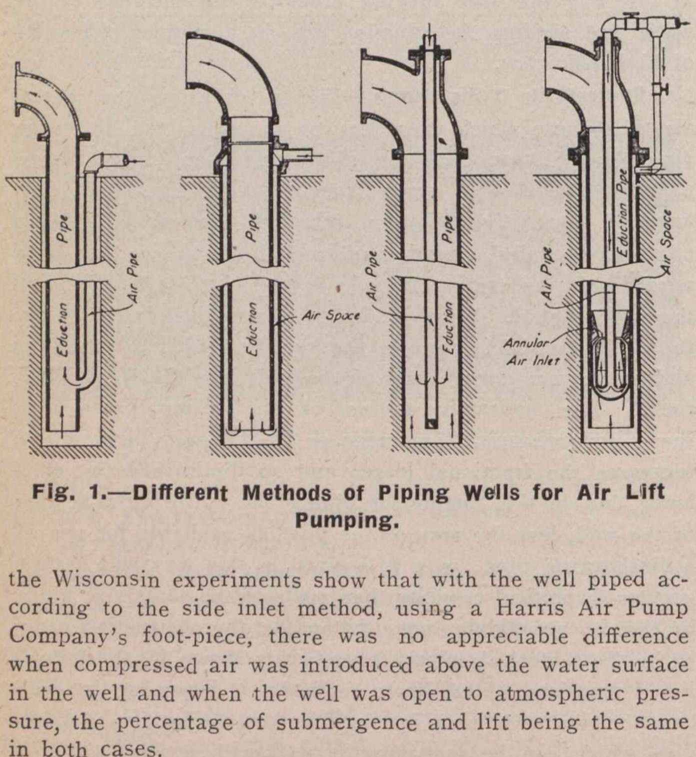

Fig. 1.—Different Methods of Piping Wells for Air Lift Pumping.

Multiple Air Lift Pump.—When the lift is very high and the proper submergence difficult to obtain, the arrangement shown by Fig. 2 may be used where the cross-section of the well permits of its use. This arrangement employs a series of successive lifts and it is claimed that it works more economically than when the water is raised in a single lift. The cross-sectional area of the ordinary deep well will not permit of such an arrangement, but it may be used to advantage in a mine shaft.

Return Air Pump.—In rising through the eduction pipe there is a transfer of heat between the air and the water; the temperature of the two being practically equal at the point of discharge. Therefore, where the air lift is being used to pump from underground supplies, the temperature of the air issuing from the discharge pipe will be cooler than the atmosphere during the warm months of the year. For each five degrees fall in temperature of the free air entering the compressor, a saving of about 1 per cent. in the expenditure of energy used in doing the work of compression may be effected. Hence, where the wells are situated in close proximity to the power house, considerable economy may be effected by connecting the air inlet of the air cylinder of the compressor with the top of the well casing head. An air separator used for this purpose consists of a cylindrical drum about 18 ins. in diameter and 8 or 10 ft. long, attached to the casing head from the side of which the discharge from the well passes out. From the top of the cylindrical drum the air is piped to the compressor, as shown in Fig. 3. The return-air method may be used with any of the types illustrated. The air separator described above is useful also where it is desired to pump to points situated some distance from the well.

Diverging Outlet Pump.—When the eduction pipe is of uniform diameter throughout, the velocity of discharge is comparatively high, and there is considerable energy lost. To conserve this kinetic energy of the water an eduction pipe which increased in diameter towards the top has been used. In this form of eduction pipe as the compressed air expands in rising the velocity is not greatly increased. This device could be used with any type of foot-piece and any method of piping. A few experiments by the authors of the bulletin indicate that a considerable saving may be effected by the use of a diverging outlet of proper design.

The Plant.—An air lift pumping plant comprises the motive power, an air compressor, an air receiver, and an air pipe leading to one or more pumps such as have been described in the preceding paragraphs.

Fig. 4 serves to illustrate, in a general way, the machinery and other essential apparatus.

The compressor and receiver should be located where the expense of installing and operating the plant will be the least. They often are situated a considerable distance from the wells. The power used to drive the compressor may be either steam, electric, water or internal combustion engines.

The Compressor.—The type of compressor installed will depend on the pressure required to pump the wells, the nature and amount of power available for compressing the air, and the number and size of the wells. Where the pressure required is small and the quantity to be compressed not very large, the ordinary straight line or duplex compressor may be used. Where high air pressures are necessary economy demands the cross compound type fitted with an intercooler.

The Receiver.—The receiver is used to store and equalize the air pressure. It acts in much the same way as the air chamber on a force main and reduces the effects of the pulsations of the compressor. It also acts as a separator to catch the water and oil which are carried by the air. It is quite necessary to provide some kind of separator for this purpose to prevent the air pipes becoming clogged, and where a foot-piece with small air openings is used it is especially desirable to have the air free from any clogging material. The air receiver is usually built of boiler iron and designed so as to permit a steady flow of air to the well. The air from the compressor passes down from the top of the receiver through a pipe and discharges beneath the surface of some water which is usually kept in it. The outlet pipe for the air is located near the top of the receiver, and a drain is provided at the bottom to carry away the oil and water.

The Air Line.—From the receiver the main line runs to the wheels. The piping to the wells should be arranged to avoid unnecessary valves, elbows and bends, as these reduce the efficiency of the plant. The same precaution should also be taken in the design of the water pipes. A valve should be placed on the air main in the power house so that the wells may be controlled from a central point. It is desirable to place a regulating and a stop valve at each well so that after the proper amount of air has been adjusted to the conditions of lift, submergence, etc., at the well, it will not be necessary to disturb the adjustment in order to shut down the well.

In the bulletin the discussion is confined to the air lift pump alone, leaving out of consideration the efficiency of the air transmission pipes, compressors and other appurtenances, which have an important bearing on the desirability of installing air lift pumping plants, but the consideration of which is beyond the scope of the bulletin.

Disadvantages of the Air Lift Pump.—The air lift pump, in common with every other device, has a number of disadvantages, the principal ones being its low efficiency, the great depth of submergence required and its poor adaptability to conditions requiring the discharge to be conveyed great horizontal distances.

Low Efficiency.—The most serious of the above-mentioned disadvantages is the low hydraulic efficiency of the pump. The pump is generally credited with efficiencies of only 25 to 33 per cent., but notwithstanding the low efficiency of the pump itself, the entire air lift pumping plant in some cases develops a duty which compares favorably with other systems of pumping.

Great Depth of Submergence.—A single air lift pump cannot be used in a shallow well or reservoir except to raise the liquid a very small distance, owing to the high percentage of the total length of the pump which must be submerged to give good efficiencies. This fact limits the field of the air lift pump principally to deep well pumping. The multiple stage previously described overcomes the difficulty, but probably at the cost of reduced efficiency.

Limited Horizontal Pumping.—Several plants have been installed where the air lift was used to pump the water a considerable horizontal distance after it had been raised to the surface of the ground, but such plants are not considered efficient. The air in passing through the horizontal or even an inclined pipe, is not likely to be evenly distributed throughout the cross-section of the pipe, but is likely to pass along under the upper side, allowing a large space in the lower portion of the pipe for the water to slip back past the bubble. In a horizontal pipe the air cannot exert any buoyant effort to aid in discharging the water, and its expansive force, which might be used in overcoming pipe friction is not likely to be effective on account of the serious amount of slip which occurs under these conditions. Where it is desired to convey the water to a point distant horizontally from the well, the eduction pipe should be carried vertically above the well a height equal to the friction head of the water in the horizontal conductor, and at its top it should be fitted with an air separator, such as the one previously described. From the separator the water would flow by gravity to the desired point.

Aeration.—The thorough aeration of the water pumped is generally regarded as an advantage, but under some circumstances it is a disadvantage. It doubtless promotes the rusting and consequent destruction of the eduction pipe and in some cases causes a deposit of salts which clogs the water passages, especially in the foot-piece. The opinion has also been expressed that compressed air causes an excessive growth of algae. The bacterial content of water is somewhat increased by the air lift unless the air supply is filtered.

Advantages of the Air Lift Pump.—The air lift pump possesses many features which give it decided advantages over other types of pumps, when applied to certain conditions.

Large Capacity.—Its principal claim to superiority lies in its large capacity. When the conditions are suitable for its installation, an air lift pump will discharge more liquid from a well of small bore than will any other type of pump. This is due to the fact that almost the entire cross-sectional area of the well is available for the flow of liquid and the action is nearly continuous. The quantity that can be discharged by an air lift pump is only limited by the capacity of the well and the expense of pumping at unreasonably high rates; while deep well pumps, the majority of which are single acting, limit the discharge by the allowable piston speed, which usually does not exceed 100 ft. per minute. The air lift affords a ready means for testing the capacity of a well even if it is not to be permanently installed.

Low Maintenance Cost.—Owing to the simplicity of the pump the expense of maintenance of the plant is very low, and is due principally to the expenses in connection with the compressor. The operation of the air lift is exceedingly simple and the life of the pump is almost indefinite. Sometimes the air pipes and foot-pieces become clogged with the oil carried over from the compressor cylinders and in that case have to be removed and cleaned, but this rarely occurs, and when it does the cost is small compared with the cost of replacing a mechanical pump. The fact that there are absolutely no moving parts in the well makes the pump especially fitted for handling dirty or gritty water, sewage, mine water and acid or alkaline solutions in chemical or metallurgical works, or other corrosive liquids. Mechanical pumps suffer from fine sand in the water, which cuts the packing, plungers and valves in a short time and makes frequent repairs necessary. To repair such pumps they have to be stopped for a period of several days, resulting in a consequent waste of time and increase in expenses. Liquids that attack metals such as brine, sulphuric acid, etc., may be pumped by the air lift pump, because the pump and appurtenances may be replaced at a small expense and loss of time. The application of the air lift as a dredge pump has been tried and found successful, but it has not been extensively used for this purpose.

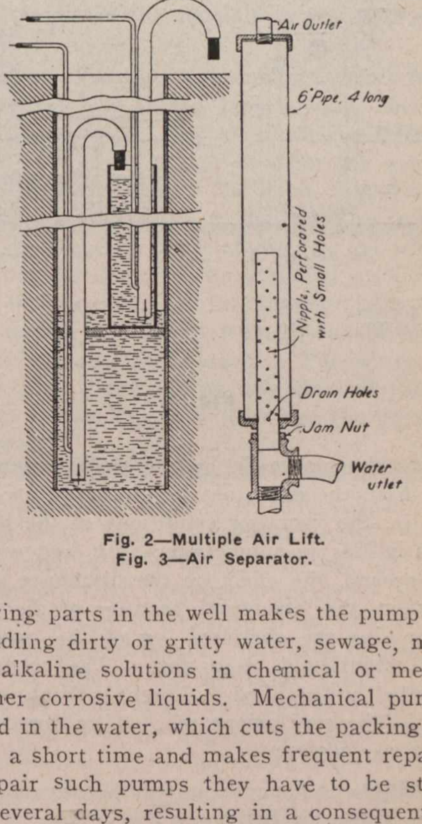

Fig. 2—Multiple Air Lift.
Fig. 3—Air Separator.

Low Operating Cost.—In places where the wells are scattered over a considerable area, or are remote from the power house, the air lift pump has an advantage over the steam-driven pump. In a deep well pump driven by steam each well must be equipped with a separate and working barrel, which entails heavy condensation losses through long steam supply pipes. The expense of attendance of a plant of this sort with its scattered pumping units is great. In the air lift pump the transmission loss is much smaller and as no attendance at the well is required, they may be put in operation or controlled by a valve in the power house.

Not Affected by High Temperatures.—Fluids of different densities and temperatures may be handled to advantage by the air lift in cases where the use of other types of pumps would be prohibited. In the case of a hot liquid the air absorbs part of the heat of the liquid and hence is increased in volume, so that the discharge of liquid for the same expenditure of free air is greater with hot than with cold liquids. This results in a considerable gain in efficiency for the pump.

Aeration.—Where the water is to be used for a domestic supply and there are impurities in it such as iron, it has been noticed that the iron is oxidizd by the aeration of the water and the supply is thereby improved Aeration is especially advantageous in the pumping of sewage on account of the aid it gives in the oxidation of the impurities.

Reliability.—Air lift pumps are not liable to sudden stoppages or breakdowns.

The Wisconsin eyperiments were not made on actual wells, but the apparatus was designed to reproduce as nearly as possible the practical working conditions of the air lift pump.

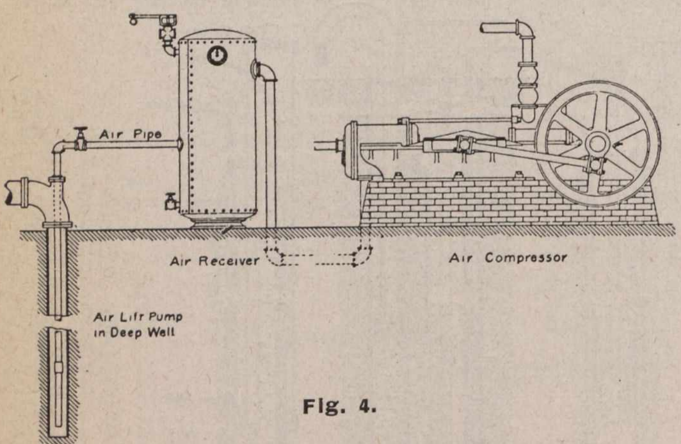

Fig. 4.

The experiments made by the writers were planned to determine, first, the effect on the discharge and efficiency of variations in the working conditions of the air lift pump, such as variations in submergence, lift and quantity of air used, and second, the effect on the discharge and efficiency of changes in the structural features of the pump. The bulletin contains the complete log of the experiments, arranged in tables and diagrams. The coefficients which were evaluated and applied to Lorenz's theory of the air lift are given. The conclusions reached by Messrs. Davis and Weidner are as follows:

Conclusions.—A comparison of the advantages and disadvantages of the air lift pump shows that there is a field of usefulness of sufficient magnitude to make it an important apparatus deserving of further theoretical and experimental study. From a study of the discussion and accompanying data given in the bulletin, ideas in regard to improvement in the design will no doubt be suggested to the designer or experimenter. However, a full realization of the complexity of the action must be appreciated, as also the number of variables which enter into the problem. In order to facilitate the study of results, the variables which may affect a particular type and size of pump are again given at this place. They are (1) percentage of submergence, (2) lift, (3) discharge, (4) volume of air, (5) pressure of air. The conclusions which may justifiably be deduced from the Wisconsin experiments are given below, and hold only for the particular type, size and length of pump on which the experiments were performed. The inference, however, may be drawn that these conclusions would hold for other types and sizes.

(1) The central air tube pump has the greatest theoretical capacity for a given size of well.

(2) The coefficient of pipe friction and slip decreases as the discharge increases, and decreases as the ratio of volume of air to volume of water increases.

(3 The coefficient of pipe friction and slip varies with the length of pump, but seems to be independent of the percentage of submergence and of the lift.

(4) The length of pump, the percentage of submergence, and therefore, the lift remaining constant, there is a definite quantity of air causing the maximum discharge. This quantity of air for maximum discharge, as also the ratio of volume of air to volume of water, differs for different percentages of submergence and lift, the length of the pump remaining constant.

(5) The length of pump remaining constant, the maximum output (e.g., foot gallons) occurs at about the same percentage of submergence for all rates of air consumption, being at from 61 to 65 per cent. for the pump used in the Wisconsin experiments. At other submergences the output varies as the ordinates of a parabola having vertical axis. Under these conditions the lift does not remain constant as the percentage of submergence varies.

(6) The length of pump and percentage of submergence remaining constant, and therefore constant lift, the efficiency increases as the input decreases; that is, the highest efficiencies are obtained at the lowest rates of pumping.

(7) By varying the percentage of submergence, and therefore the lift, the length of pump remaining constant, the maximum efficiency is obtained at approximately 63 per cent. submergence for all rates of input or discharge.

(8) The lift remaining constant, the efficiency increases as the percentage of submergence increases, for all rates of input and all practical percentage of submergence.

(9) With the same size and type of pump the percentage of submergence remaining constant, the efficiency increased as the lift increased for the small lifts experimented on; that is, up to about 24 ft. From a theoretical study, however, the indications are that a point will be reached from which the efficiency will decrease as the lift increases.

(10) Other conditions remaining constant, there is no advantage to be gained by introducing compressed air above the surface of the water in the well.

(11) The type of the foot-piece has very little effect on the efficiency of the pump, so long as the air is introduced in an efficient manner and the full cross sectional area of the education pipe is realized for the passage of the liquid. Anything in the shape of a nozzle to increase the kinetic energy of the air is detrimental.

(12) A diverging outlet which will conserve the kinetic energy of the velocity head increases the efficiency.

THE TRANS-AUSTRALIAN RAILWAY.

Full plans and complete specifications for the construction of the railway between Port Augusta in South Australia and Kalgoorlie in Western Australia have been prepared by the engineers of the Commonwealth government. The delay in making the plans available is said to be caused by important questions of policy—such as the gauge to be decided upon and the wages to be paid to laborers. It is understood that the construction will be carried on by day labor, but parts of the work may be done by contractors.

COST OF GIRDER AND SLAB CONCRETE HIGHWAY BRIDGES.*

By B. H. Piepmeier.

The purpose of this paper is not to discuss the practice of the Illinois Highway Commission in the design of through girder and slab types of concrete highway bridges, but to develop a ready means of ascertaining the approximate number of cubic yards of concrete in a completed structure of a known span, height of abutments and length of wings, as well as to develop a means of making preliminary estimates of the cost of completed structures without calculating the quantities in detail.

The bridge work of the commission requires a personal inspection of the bridge site with the local officials, and at this meeting the necessary data are obtained for the design of the bridge. Almost invariably the officials expect that an estimate of the cost of the proposed work be given them at this time. Consequently, it is desirable to be prepared to give an estimate of the proposed bridge that will closely approximate the one that is made from the detailed drawings. This is usually a somewhat difficult matter unless the time is taken to compute the number of cubic yards that will be in the bridge.

With the increased interest in concrete bridge work the past four or five years, it is needless to say that the commission has been called upon for engineering assistance more frequently each year, until to-day it is almost impossible to meet all the requests. For this reason a system of standards was devised and all computations tabulated. This greatly improved the office efficiency and made it possible to answer a large number of requests.

Again, in our office, it has been necessary to do considerable figuring to determine the best make up for a bridge. Frequently a series of small slabs on piers would sum up much cheaper than the larger spans, and vice versa. It is sometimes advisable to compare a steel bridge for the same site. With curves worked out by Mr. H. E. Bilger on the cost and the number of cubic yards in substructures for steel bridges, we are able to get a very accurate estimate of the cost of a steel bridge complete. It, therefore, became desirable that some ready means be devised for determining the approximate number of cubic yards in concrete slab and girder bridges, for both office and field use.

From the large number of computations we have made of various concrete bridges, it was thought possible that a complete tabulation of quantities or a system of curves could be worked out that would enable one to determine readily the contents of either the slab or the girder type of bridges. It is proposed, therefore, to correlate all computations and data on the flat top type of bridge, and to arrange it in a convenient form for both office and field use in determining the number of cubic yards in ordinary bridges, besides obtaining an approximate estimate of the cost. Before proceeding, however, it may be well first merely to outline in a general way the slab and the girder bridges as designed by the Illinois Highway Commission, and give a few dimensions that you may better understand the types of bridges under consideration.

Slab Bridges.—For reinforced abutments for slab bridges the main wall is made 12 inches thick from top to bottom, the steel reinforcing being placed on the stream side, and the percentage of steel increased as the height increases. The abutments rest on an 18-in. reinforced footing, which is made of sufficient size to allow but 3,000 lb. per square foot bearing on the foundation. When a soft foundation is encountered, this same size footing is usually sufficient to permit the proper spacing of the required number of piles.

The reinforced wings for slab bridges are of the standard cantilever type, the base being 33 per cent. of the total height. The wing wall proper is 12 in. thick for heights up to 16 ft. For greater heights the base of the wall increases in proportion to the height. Nearly all wings for this type of bridge have a drop of 18 in. to 5 ft. at the end to conform to the 2 to 1 slope on the sides of the road. I may say here that the cantilever type of wing for extreme heights has been found much more satisfactory than the buttress type, as the increased thickness at the base and the large percentage of steel does not equal the extra cost of forming necessary for the buttress type.

Reinforced concrete slab bridges are designed with various roadways, ranging from 16-ft. upward. The side rails usually average 8 in. thick and 3½ ft. high. On this type of bridge the slab and the side rails come flush with the back of the abutment walls. The top of the wings comes up along the outside of the rails to catch the side slope on the road. In determining the thickness of the slab, its entire dead load is considered, the load of the cushion wearing surface, and a 24-ton engine live load. Excluding temperature stress, the steel is figured at 12,000 lb. per square inch; the compressoin in the concrete is assumed at 800 lb. per square inch.

Girder Bridges.—For the reinforced abutments for girder bridges, the general type is the same as that for the slab bridges, with the exception that all abutment walls proper are 18 in. thick, and the width of base for the wings is 40 per cent. of the total height. The extra thickness in the abutments is for bearing of the girders. The extra width of base under the wings is for stability, as the wing walls are cut away from the abutment walls proper by a 1-in. partition to allow for expansion of the superstructure. They can, therefore, receive no support from the abutments, as is the case with wings on slab bridges. The wings on this type of bridge also come up on the sides of the girders and drop several feet at the ends to follow the general side slopes on the road.

The reinforced concrete girder superstructures are designed with roadways from 16 to 30 ft. The roadway usually required is 16 to 20 ft. The side girders average from 4 to 16 ft. in height, and 16 to 30 in. wide on the top. On the side girders there are heavy depressed panels to lighten the web and to give the proper appearance to the finished bridge. The floor slab and side girders on this type of bridge also extend to the back side of the abutment wall. The floor slab is designed to carry its own dead load, the cushion wearing surface and a 24-ton engine live load. The side girders are designed to carry the entire dead load of the superstructure, plus a live load of 125 lb. per square foot on the roadway, or a 24-ton engine, whichever gives the greater moment.

Abutment Diagram.—For the purpose of determining offhand the approximate yardage in a pair of reinforced concrete abutments for either slab or girder bridges, Fig. 1 has been prepared, and is applicable within the specific cases used. For abutments of slab bridges, 40 different designs were taken from the files of the commission, and the number of cubic yards in the two abutments of each design was plotted against H (R + 2W), where H is the distance from the finished roadway to the bottom of the footings, R is the clear roadway of the slab bridge, and W is the length of one wing measured on the stream side. R was taken as the clear roadway of the bridge, as this figure is always secured at the preliminary inspection of the bridge site. W, the length of the wing, can always be assumed in the field or

*A paper read before the Illinois Society of Engineers and Surveyors.

computed in the office, knowing first the general conditions of the bridge site.

It will be noticed that the number of cubic yards in the two abutments varies approximately as the height of the abutments; also, that the maximum deviation from the curve does not exceed 2 cu. yd., and more often it is less than 1 cu. yd. In fact, for heights of abutments up to about 16 ft., or where H (R + 2W) does not exceed 900, the quantities so plotted follow practically a straight line, and might be represented by the straight line formula, cubic yards = 0.09 [H (R + 2W)] — 1.37, which often is convenient when the curve sheet is not at hand.

For a particular bridge, suppose the distance from the crown of finished roadway to bed of stream is 10 ft., and the footing should be carried 4 ft. below bed of stream. Then H = 14 ft. Now assume the wings are each to be 13½ ft. long, and that the finished bridge will have a 16-ft. clear roadway. We have now H (R + 2W) = 600, the value to be read at the bottom of Fig. 1.

It will be seen by locating the point on the curve and going across to the left-hand side that there are about 53 cu. yd. in the two abutments. Where the quantity at the bottom of the figure exceeds 900, we readily see that the curve begins to rise above the straight line. This is expected, as abutments exceeding 16 ft. in height have the base of the wings spread to allow for the proper percentage of steel. This extra width of base is added to the back of the wing wall by a batter, the batter extending up from the footing 4 to 8 ft., according to the height of the wall. This batter does not extend to the top of the wall, as the drop at the end of the wing would increase its thickness at the end, and this does not give the best appearance to the finished bridge. The abutment walls remain 12 in. thick up to 21 ft. high, and from there on the thickness increases as the height. The slight variation from the curve in solving specific cases may be attributed to the difference in the angle of the wing with respect to the abutment, and the difference in width of footing for bearing. The more nearly the direction of the wing approaches a parallel with the centre line of the road, the higher will be the wing at the end, thereby increasing the number of cubic yards, but as the corner formed by the intersection of the abutment wall and wing is measured twice, these two quantities tend to compensate one another.

For the reinforced abutments on girder superstructures 25 designs were taken from the files of the commission, and the number of cubic yards in the two abutments plotted against H (R + 2W), the notation being the same as before.

It is to be noted here that the number of cubic yards is somewhat greater than the number of yards in the abutment for slab bridges. This is due to the extra thickness of the abutment walls proper, to give the desired bearing and the extra width of footings under the wings. It will be noted on this curve that some of the specific cases used had a wide variation from the mean. This can be attributed to the fact that some of the abutments had extremely long wings that were level on top and also the different length of spans requires a little different width of footing under abutments to take the required bearing. A curve of this kind could not take into account all of these conditions, and while several points fall several yards off the curve, the mean is close enough for the purpose that it is to meet.

For a particular case, take the same dimensions that were considered before; clear roadway, 16 ft.; height, 14 ft., and length of wings, 13½ ft. We now have 600 to read off at the bottom of Fig. 1. Getting the intersection with the curve for girder spans, we find that the two abutments contain 67 cu. yd. instead of 53 cu. yd. in case of the slab span, a difference of 14 cu. yd. in favor of the slab bridge. Fig. 1 then is a ready means of comparing the substructures of the two types of concrete bridges and to determine the approximate number of cubic yards in each.

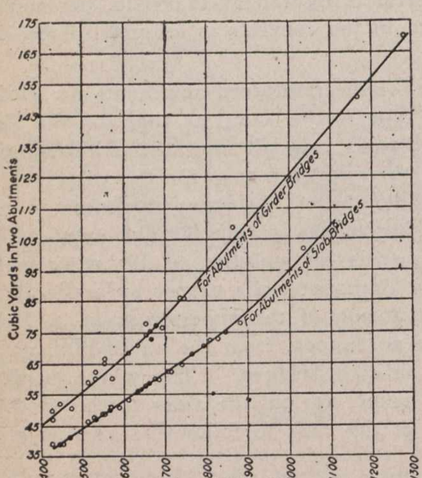

Fig. 1

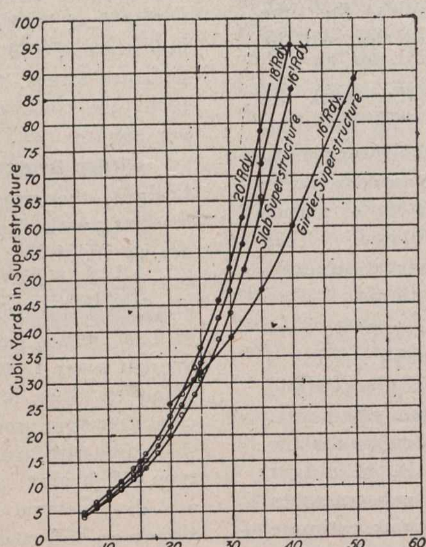

Fig. 2

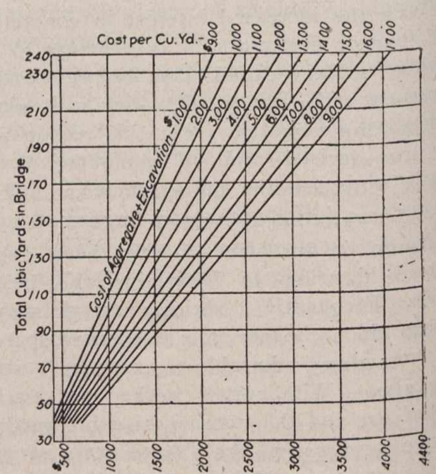

Fig. 3

Diagrams for Determining the Approximate Cost of Through Girder and Slab Bridges.

Superstructure Diagram.—The next thing of importance is to determine the number of cubic yards in the superstructures of the two types of bridges. For this, Fig. 2 has been prepared, and is applicable for the flat top type of bridges up to 50 ft. in span. For slab superstructures 48 designs of different roadways and spans were taken from the files of the commission, and the total number of cubic yards in the superstructure was plotted against the clear span length, the curves drawn through the points having 16, 18 and 20 ft. roadway. The three curves will meet the requirements of the majority of highway bridges. Occasionally a special case arises, such as a skew or extra wide roadway, and then it is necessary to make special computations to determine the number of cubic yards.

For a special case, assume a bridge to have a 30-ft. clear span and 16-ft. roadway. We readily see the number of cubic yards to be about 43.2.

We may wish to consider for the same site the 30-ft. girder type with 16-ft. roadway. Here we see that the number of cubic yards is about 38.6, or a difference of 4.6 cu. yd. in favor of the girder superstructure. But you will notice for the same height substructure the difference in all cases is in favor of slab bridges. If it should happen that for a single span the girder bridge and the slab bridge should have the same yardage, an advantage still rests with the slab type, as it has been found that contractors usually bid more favorable on this type. There is also another very important point in favor of the slab type. If for any reason there should be any defective material placed in the rail, or poor alignment in its construction. it may be torn down and replaced without disturbing the floor, even after the falsework has been taken down.

Cost Diagram.—Having found the expression that is the measure of the number of cubic yards in the abutments and superstructures of concrete slab and girder bridges, the next step is to combine the quantities with a unit price that we may determine the approximate cost of each type. For this purpose Fig. 3 has been prepared.

It has been found from the cost data of a large number of slab and girder type concrete bridges built under the supervision of the Illinois Highway Commission, that it is possible to get a very close figure on each individual item that goes to make up the cost of the bridge; first, the cost at the bridge site of sufficient cement to make 1 cu. yd. of 1:2½:4 concrete; second, the cost of the necessary lumber for forming 1 cu. yd.; third, the cost of reinforcing steel per cubic yard of concrete; fourth, the labor cost in mixing and placing 1 cu. yd. of concrete; fifth, the cost of sufficient aggregate to make 1 cu. yd. of concrete; sixth, the cost per cubic yard of concrete to make the necessary excavation to start the concrete of the footings. The two items that largely control the cost of a structure of this kind are the excavation and the necessary aggregate for the concrete. We find that the cost per cubic yard of concrete for cement, forms, reinforcing steel, and the mixing and placing, have narrow limits in their variation.

It therefore appears possible that some definite quantities may be fixed to the first four items and a curve plotted for the last two, combining them in such a way that the total cost may be readily determined after we have learned the number of cubic yards in the bridge.

The cost at the bridge site of sufficient cement to make 1 cu. yd. of concrete for a 1:2½:4 mixture may vary from $1.75 to $2.10. While the price of cement, the distance it has to be hauled, and the amount required for some aggregates, vary slightly, the extreme variation would not be over 20 cents per cubic yard from the average. From a general average of all cost data on this item, it would seem that we are probably safe in choosing for cement about $1.90 per cubic yard of concrete.

The cost of forms includes all the necessary falsework, bracing and form lumber for completing the bridge. While this item varies somewhat for different localities, and will vary again where the contractor can use some of his old lumber, it will fall between the limits of 75 cents and $2.50. Experience has shown that about $1.50 for the ordinary type of bridge is usually sufficient and might well be chosen for this cost curve.

The reinforcing steel varies from 50 lb. per cubic yard for substructures to 170 lb. per cubic yard for superstructures, or an average of about 110 lb. for the two combined. This steel delivered at the bridge site under ordinary conditions and bent ready for placing in the structure will cost about $2.10.

The item for mixing and placing concrete might vary from $1.50 per cubic yard for crushed rock concrete mixed by hand to possibly as low as 40 cents for gravel concrete mixed by machinery. This item should also provide for the necessary work in spading the concrete next to the form and securing the desired finish. In spite of the possible wide variation, we find the cost of this item varies but little from the fixed amount of $1.25. While all these quantities given above may seem somewhat in doubt as to their reliability, yet experience has determined that they are not far from the correct figures for normal conditions on the average bridge.

The item of excavation, which includes also cribbing, sheet piling, pumping, and all necessary work to start the concreting of the footings, has been found from the cost data on file to vary from 50 cents to $5 per cubic yard of total concrete in the bridge. The 50 cents per cubic yard is found only in some very favorable cases and on the smaller spans, where there is practically no cribbing, sheeting or pumping necessary. On the other hand, the cost of $5 per cubic yard of concrete is caused by a soft, seepy soil where cribbing, sheet piling and excessive pumping are necessary. Quite often the wide variation in the item for excavation is due to poor management on the part of the foreman in charge. This item, therefore, may vary considerably, but with experience with the excavation that is to be handled and with the type of bridge that is to be built, one is able to estimate this item sufficiently close for all practical purposes.

It will be seen that the cost of the aggregate delivered to the bridge site is the second item determining the price per cubic yard of concrete. Under the most favorable conditions with respect to location of a satisfactory aggregate supply, it would likely cost at least 50 cents per cubic yard to haul it to the mixing plant. On the other hand, the cost of aggregate at the bridge site might exceed $4 per cubic yard, as the structure may be isolated from a railroad station, and it may be necessary to ship in either gravel or crushed rock and sand, besides hauling it several miles into the country.

In the light of the wide range on these two items, Fig. 3 has been prepared to give the total cost of the bridge complete, including profit to the contractor under conditions where the cost of excavation, plus the cost of aggregate at the bridge site, might vary from $1 to $9.

For a specific case, we will assume that a concrete bridge has 120 cu. yd. of concrete. We will next investigate the condition of the foundation, and assume the cost for completing this part of the work, and express it as so much per cubic yard of concrete. We then approximate the cost of delivering at the bridge site the necessary aggregate to make 1 cu. yd. of concrete. For convenience let us say that these two quantities amount to $3 per cubic yard of concrete. Entering Fig. 3 with 120 cu. yd. at the left-hand side, and following this across to the $3 curve, or the $11 per cubic yard, which is the same thing, and then to the bottom of the figure, we find the cost of the bridge complete to be $1,300. The total cost per cubic yard of concrete is shown at the top for aid in determining the unit price.

From the figures heretofore given, we are able to determine approximately the number of cubic yards in either the slab or the through girder type of bridges, besides having a ready means of determining the probable cost. While the curves here developed apply only to the slab and through girder types of bridges, similar curves might readily be developed for the deck girder, the through girder floor beam type, or the arch, and would prove of equal service to the highway engineer, but their development is beyond the scope of this paper.

The foregoing is not intended to supply a substitute for engineering ability, but rather to furnish aid that will safely direct the engineer who will interpret with judgment and experience.

BRITISH COLUMBIA'S FOREST WEALTH.

The lumber industry and the lumber trade both showed very satisfactory returns for the year 1911, stated Hon. Price Ellison in the British Columbia Legislature when introducing his budget. "I ventured to predict in my last budget speech that 1911 would prove a prosperous year in the lumber trade. My forecast was correct. The steadiness of the lumber market enabled the mills to operate during the entire year though some of those in the interior curtailed their output during November and December, on account of the American mills dumping their surplus out on the markets of the northwest at less than cost price.

"According to the returns made to the chief timber inspector the lumber cut for 1911 was as follows:

"Logs officially scaled west of Coast range 619,000,000 feet; cut from Esquimalt & Nanaimo Railway lands, 144,000,000 feet; logs officially scaled east of Coast range 297,000,000 feet; total, 1,060,000,000 feet.

"Of this amount the total manufactured into lumber was 113,000,000 feet, and the total exported 47,000,000 feet.

"The royalty collections for 1911 exceeded those of 1910 by no less than $50,734.

"The causes of this better return may be summed up as follows:

"1. The crops in the prairie provinces compared favorably with those of 1910.

"2. The record number of incoming settlers increased the demand for dwelling and other houses.

"3. The checks on the dumping from the United States effected by the enforcement of the customs regulations by the new government at Ottawa will prevent the importation of other than real rough lumber.

"4. The lesson taught by the prolonged shutting down of mills in the United States has produced a lasting effect.

"I look forward, therefore, to a still greater stimulus in the lumber trade in 1912—especially as there will be a larger amount demanded provincially owing to our development.

"The supply of pulpwood in the eastern United States has been hopelessly insufficient for the present needs of their people, and they already import one-quarter of the whole of the raw material for their paper mills from Canada. We are also exporting to them $4,000,000 worth of manufactured pulp for the paper mills of the eastern states.

"I look forward to a rapid growth in that industry. I may add that the completion of the Panama canal in 18 months time cannot but have enormous influence in the development of our lumber trade. It can hardly fail in fact to become by far the most profitable of our staple industries. The cheaper freight rates, which will necessarily accompany the opening of the canal, must give an unprecedented stimulus, and will at the same time prevent a recurrence of periods of depression. With an easy means of communication secured to us by water as well as by land the depletion of the world's timber in other regions cannot fail to make the timber output of our forest lands a most permanent source of revenue for generations to come.

"This province more than two years ago outstripped Quebec in the production of lumber, while in 1910 her output was on a par with that of Ontario. It does not require the eye of a prophet to see that, with a vast proportion of her virgin forests still untouched she will, in proportion to her size take prominent place within a year or two among the great timber producing countries in the world.

"In order to bring about this end and to encourage the establishment of the paper making industry in the province the government granted in 1901, 21 year leases of pulp forests to companies on liberal terms. In 1903 the law granting pulp leases was repealed. The annual rental now paid under these leases, is two cents per acre and a royalty of 25 cents per cord of pulp wood cut. Four companies are now either erecting or operating plants, the British Canadian Wood Pulp Paper Company, the Swanson Bay Forests Wood Pulp & Lumber Mills, the Ocean Falls Company, Bella Coola and the Powell River Paper Company. As proof of the prosperity of the industry the last named company is filled up with orders for all the paper and pulp it can produce.

"I believe that the mills of Powell River, Swanson Bay, Howe Sound and those of the British Columbia Wood Pulp and Paper Company, vast as they are, are but the pioneers of an enterprise which will fling its tentacles all over the world.

"Looking forward into the centuries, one can imagine a time when the great forests of this province will be denuded of most of their timber; but even then, if all the wealth were gone, British Columbia would remain the greatest producing region in the world. No country shares with us our climate or our soil. It is the most congenial for the cottonwood, spruce, balsam, hemlock, and Lombard poplar, which produce the best paper. Already our ships are conveying the output of our forests in pulp and paper to Australia, New Zealand and the Orient, and no far sighted man can doubt that in the near future half of the whole world will be the market place of the pulp and paper produce of British Columbia.

"We have in this province a combination of the three factors which together insure the prosperity of the pulp and paper trade—factors without which the industry can nowhere be successfully maintained. These three factors are (1) cheap water power; (2) cheap timber; (3) cheap transportation in close juxtaposition. Washington, Oregon and California have the last two but they lack that most essential factor—cheap water power. My conviction is, therefore, that we can always compete successfully against other producing countries in capturing the pulp trade."

IRON ORE IN QUEBEC.

The iron ore industry of the Province of Quebec has, in the last few years, shown a serious decline. The bog iron ore deposits of the St. Maurice district and of Drummond county seem to be passing away, and, so far, no other iron ore deposits have been brought into prominence to replace them. In 1911, only 931 tons of local ore were charged into the Drummondville furnace, of the Canada Iron Corporation, the main supply of ore having had to be imported from Ontario. The Radnor furnace of the same company went out of blast in the summer of 1910 and was not blown in during 1911.

INDUSTRIAL ACCIDENTS.

According to the record of industrial accidents kept by the Department of Labor, 61 persons were killed and 178 injured during February, 1912. This record compares very favorably with that of January, when 86 workmen were killed and 214 injured. Compared with February, 1911, the record is still more favorable, as 93 were killed and 197 injured in that month. The worst disaster of the past month was the premature explosion of dynamite on construction work near Fort Frances, Ont., on the line of the Canadian Northern Railway, by which 13 construction hands were killed and six others seriously injured.

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ESTABLISHED 1893.

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IMPROVEMENT IN HOME CONDITIONS.

It is a familiar phrase among Canadians that the western portion of the country is "land mad," and the statement is strengthened to some extent by the many sheets in the newspapers given up to the description and offerings of western real estate.

It is particularly noticeable that these land booms follow, almost invariably, the extension of the railways, and that the erection of railway yards or other property is always an incentive to the realty men to increase their prices for late comers and industrial concerns.

In the City of Calgary, Alta., the scene of considerable real estate activity, the Canadian Pacific Railway have recently erected a large railway yard, and in order to protect their employees from the high prices of the agents have decided to open a tract of land adjoining the shops for the purpose of giving their employees a chance to erect and build homes and dwellings for their own use.

The lots will be sold at very reasonable prices, and when the employees have been given enough land for this purpose the balance will be offered to the public.

It is not a common thing for the management of our large industrial enterprises, in this country, to take an interest in the home life of their working men. In Great Britain it is much more prevalent, and the results in almost every instance have been satisfactory in the highest degree. The village of Port Sunlight, in England, is almost entirely under the control of the Lever Brothers and their employees, and the result is that laboring classes, speaking generally, have better home conditions than the average mechanic in this country. In the first place the worry of rent payment is entirely eliminated, and the fear of higher prices being asked from time to time is done away with, and the sanitary conditions are kept up to a certain standard.

It is just possible that should more capital industries follow the course of the railway in this matter, the high cost of living would decline.

MUNICIPAL EXPENSES.

Ratepayers and supporters of municipal finances are only too well acquainted with the reckless and thoughtless expenditure of civic moneys by municipal controllers and council men. We have recently had an example of a direct waste of several thousand dollars in waterworks material in one of our larger cities, and the following increase in the tax rate that must result from this expenditure that will never return dividends monetary or otherwise. Recently in and during the council meeting in a Canadian city, a controller questioned a small item for ornaments for the mantel shelf of the Mayor's office. The articles in question may be procured for a few cents, and as they were for decorative purposes only the council man requested that the item be referred back for an explanation.

In due course the item returned with the amount lessened by the sum that had been questioned when the bill was presented for payment. Accompanying the bill a written explanation was offered, and from the composition a reader would be at once impressed with the friction that must exist between certain departments in the civic organization.

As stated above, the item was small but the principle of the thing was apparent from the start. The council man was already aware of the large deficit carried forward from last season and here saw an opportunity to reduce the civic expense. He did not object to the articles of decoration, but expressed his opinion that a lower price could have been paid for the same value and appearance. If the article had been some municipal requirement where utility was the all important point, sarcasm given in answer to a suggestion for expense reduction could not be overlooked; but surely the council member deserves the approval of the citizens in his attempt, however small, to reduce needless civic expenditure.

A GOOD CHANGE IN TENDER WORDING.

In a recent advertisement for the supply of road machinery for one of the smaller municipalities of this country a clause was inserted in the composition to the effect that "Any firm or dealers who personally or through their agents canvass members of the County Council or officials of the council will be disqualified from having their tenders accepted."

This is an unusual clause to notice in a municipal tender but surely it is a criterion of the fair minded intentions of the council members to see that the ratepayers are supplied with the worth of the staple dollar for dollar as well as giving the smaller manufacturer an equal chance in the competition.

PUBLIC HEALTH.

The recent announcement from the Federal Government regarding the new methods to assist the public in the matter of health is the outcome of several suggestions and ideas on the part of municipalities and communities who have tried to combat disease and found themselves handicapped owing to the limited extent of their powers.

The Federal Government are the proper body to direct this campaign for many reasons, chief of which is the unlimited powers enjoyed by that party owing to no restriction being made by boundary lines or municipal borders.

But the federal powers may be greatly strengthened by co-operation of the municipal authorities, and in return the municipal health officers may feel increased powers with the knowledge that suggestions, if practical, will be adopted and enforced with powers that they as individuals do not enjoy.

It is to be hoped that the new office will prove of equal value to the Canadian public with the benefits of the Government inspection of live stock.

Honorable Frank Cochrane has given notice of a resolution providing for a subsidy not exceeding $6,400 a mile for the Temiskaming and Northern Ontario lines, described as follows: From North Bay to Cochrane, not exceeding 252.8 miles. From Englehart to Charlton, not exceeding 7.8 miles From Cobalt to Kerr Lake, not exceeding 3.9 miles. From Iroquois Falls to Timmins, not exceeding 33.6 miles. From Nipissing Junction to North Bay, not exceeding 2.18 miles. Provision is made for the payment of the subsidy upon the certificate of the chief engineer of the Department of Railways and Canals as to the mileage constructed in such manner and in such amounts, and subject to such conditions, if any, as the Governor-in-Council may deem expedient.

THE FIRST COLD WEATHER REINFORCED CONCRETE JOB.

It is interesting to note that the first reinforced concrete factory ever built, the Pacific Coast Borax Refinery at Bayonne, N.J., was constructed partly during the winter of 1897-1898. Reinforced concrete buildings are now so general that it is hard to appreciate the boldness of the conception to construct a building to carry actual working loads of 400 lbs. per sq. ft. out of a material which had been previously used almost exclusively in foundations and at a time when the placing of concrete in the winter was considered absolutely erroneous. The contractors for this building were the Ransome & Smith Company, while Ernest L. Ransome was the designer. That the work was well done and the design well made is evidenced by the way the building stood the severe fire which visited it in the spring of 1902.

The construction was begun late in the fall of 1897 when the ground was frozen. In placing the foundations salamanders with long legs were placed in the excavations to keep the concrete from freezing. Most of the broken stone was brought down in scows from the Palisades of the Hudson River and was piled near the cement shed. The size of the stone was limited to particles passing a 2-inch ring, while for much of the work a 1-inch size was employed. There was so much fine material left in the rock that only a small quantity of sand averaging not more than 10 per cent. was needed. This stone pile was heated by steam pipes from a central plant to a temperature of about 80 deg.

The cement and stone were measured in barrows, dumped into a hopper which discharged into a car. This car was hauled by a cable through a subway and then up an incline to about 30 ft. above the hopper and about 400 ft. distant, where it was automatically tipped into a chute leading to the mixer. Salt was added to the water used in the proportion of 8 lbs. of salt to each barrel of water. The mixer was one of the early Ransome mixers, and it discharged into a trough containing a screw conveyor which delivered the concrete to a vertical bucket elevator and this hoisted the material to the storey where it was required, and dumped upon a platform which held about one cu. yd. A steam engine operated the car, mixer and elevator, besides operating a number of machine tools.

One of the most interesting points of this building is the double walls. The total thickness of all of the walls is 16 ins. for the entire height of the building, the hollow space varying from 10 ins. to 12½ ins. These walls were constructed in three feet sections and the concrete was kept from freezing by placing salamanders in the hollow walls. The work was enclosed by canvas, floor by floor, and salamanders were also used here. This method of concreting in cold weather proved very satisfactory, and the cost of this building per cu. ft. of contents was less than 5 cents, which is a remarkable showing when everything is considered.

PANAMA CANAL REPORT.

The recent report of the volcano under the Panama canal has proved, upon investigation, to be false; the steam and other manifestations of heat are said to arise solely from the oxidation of pyrites and that the trouble is disposed of after the portion is uncovered for a few days.

THE PRINCIPLES OF SPECIFICATION AND AGREEMENT WRITING.

By C. R. YOUNG, A.M. Can. Soc. C.E.

Final Article.

THE AGREEMENT.

In the agreement is recorded the formal promise of the Contractor to perform certain labor and supply certain materials in return for a specified consideration promised by the Owner. The general business and legal relationships involved in the whole arrangement between these two parties thus properly require statement here, rather than in the "General Clauses" of the specifications.

While it is impracticable to here attempt an outline of all the stipulations which might find place in engineering agreements, the following matters are of essential importance to such instruments and have mention, in one form or another, in most of them. The items set down do not necessarily represent the titles of corresponding clauses, but merely ideas which should be embodied in some form or other in the agreement:—

(1) A title clause.
(2) Description of subject-matter.
(3) Inclusion of specified documents.
(4) Satisfaction of the Engineer.
(5) Contractor's Risk and Obligations.
(6) Commencement and Completion.
(7) Liquidated damages.
(8) Disputes and Arbitration.
(9) Dismissal of Contractor.
(10) Liens.
(11) Assignment of Contract.
(12) Consideration.
(13) Binding of Successors and Assigns.
(14) Dating.
(15) Signatures.
(16) Witnessing.

(1) **A Title Clause.**—This clause, which is naturally the first one of the agreement, records the making of an agreement on a certain day between parties who are named, numbered and described. The following is a simple illustration:—

> "ARTICLES OF AGREEMENT, made this twentieth day of March in the year One Thousand Nine Hundred and Twelve between the Jones Construction Company, hereinafter called the "Contractor," of the First Part, and the Municipal Corporation of the Town of Blankville, hereinafter called the "Corporation," of the Second Part."

The order in which the parties are named is immaterial, but usually the Contractor's name is placed first.

(2) **Description of Subject-Matter.**—Only a very concise description of the work which the Contractor binds himself to do in return for the consideration mentioned should be placed in the agreement. A description by title and location merely, affording some aid to the identification of the plans and specifications, is sufficient. For the general and detailed descriptions of the work, reference is made in this clause to the plans and specifications which are declared to be a part of the agreement. An example of a clause embodying the above-mentioned features, and which would form the second clause of the agreement, is the following:—

> "WITNESSETH, that in consideration of the payments and covenants hereinafter mentioned to be made and performed by the Corporation, the Contractor hereby agrees to furnish all materials, tools and appliances and perform all labor necessary for the construction of a Reinforced Concrete Arch Bridge over the White River on Robert Street in the Town of Blankville, and in the Province of Ontario, in accordance with the plans and specifications prepared by John James Smith, Civil Engineer, which are hereby incorporated with and declared to be a part of this contract."

(3) **Inclusion of Specified Documents.**—It is necessary, in order that plans and specifications may be included as a part of the contract, that such incorporation be declared, either in the clause setting forth the subject-matter, as above, or in a separate clause. The inclusion of detail or explanatory plans may be covered by this separate clause or, as has already been pointed out, by the specific clause of the specifications referring to plans.

(4) **Satisfaction of the Engineer.**—Although it may have been provided in the specifications that the work is to be done under the general supervision of the engineer and to his satisfaction, it is desirable to include this statement in the agreement as well. The status of the engineer and the important relation which he is to bear to the contracting parties is thus acknowledged and declared in the agreement—the very soul of the contract.

(5) **Contractor's Risk and Obligations.**—The conditions under which the Contractor accepts the contract, in so far as legal responsibilities of a general character are concerned, should be stated here. It must be made plain that the Contractor cannot secure immunity from the pledges of the contract on the ground of unforeseen obstacles or accidents. One of the reasons for the Owner letting the work by contract at all is to relieve himself of the risks and responsibilities incidental to the project, and when a Contractor agrees to do the work for a certain sum it is assumed that he has taken full account of all eventualities in his tender. He, therefore, cannot secure a release on the grounds of undue difficulties if the work be capable of performance by human agencies. Responsibility for accidents due to his own operations should be made to include the defence of all suits for damages arising from this source. A customary and satisfactory phrasing adopted in this clause is that "the Contractor shall indemnify and save harmless the Owner with respect to actions and damages, etc." Conformity to existing building and sanitary laws is to be required of the Contractor, and the responsibility for their violation placed upon him.

(6) **Commencement and Completion.**—If the times of commencement and completion and the required rate of progress have been defined in the specifications, as has been recommended in the present discussion, it is sufficient for the agreement to state that in these respects the work shall be done in accordance with the provisions of the specifications.

(7) **Liquidated Damages.**—Failure of the Contractor to complete the work on time, should entitle the Owner to collect such damages as may have been actually sustained by the default. The legality of fixing beforehand, or "liquidating," the damages has been confirmed

many times by the courts, and there are on record numerous cases where damages have actually been collected from a delinquent Contractor.

But while this principle is well established, it is a matter of common observation that the cases where damages have been recovered from the Contractor are very few compared with those which have been decided in his favor. The reasons are to be found both in the defective preparation of contracts and in the failure of the Owner to comply with the conditions upon which the Contractor's promise was based.

Perhaps the most frequent evidence of weakness in contract stipulations respecting non-completion on time is the fixing of liquidated damages far in excess of the actual damages. In such a case only the actual damages can be recovered from the Contractor, since the contract illegally provides for the exaction of a penalty. The disguising of a penalty under the term "liquidated damages" cannot affect the character of the clause, for its exact nature is judged from the contract as a whole and not by the particular term employed. If, however, the actual damages cannot be determined, any amount which does not appear grossly disproportionate to the value of the work done may be collected provided all other conditions have been complied with.

The circumstance which most frequently deprives the Owner of the right to collect damages from the Contractor for failure to complete on time is the contributory delay of the Owner himself. This may result from the Owner failing to deliver up the site to the Contractor at the time specified in the contract for commencement or from delays or suspension of work during progress. It is possible that this contingency might be met in a legal manner by providing in the contract that delays caused by the Owner up to a certain maximum number of days should automatically extend the time of completion by an equal number of days, and that liquidated damages should be calculated from this altered time of completion.

Contrary to the popular impression, it is not essential that a clause conferring on the Owner the right to collect liquidated damages must, in order to be legal, be accompanied by a corresponding bonus clause. There are many cases on record where damages have been recovered without a bonus clause in the contract at all. This much may be said, however, that its inclusion imparts to the contract an increased degree of mutuality and removes to some extent the stigma of one-sidedness. In addition, the reasonableness of the amount fixed as liquidated damages is enhanced by the declared willingness of the Owner to pay a similar amount per day for every day by which his possession of the work is hastened.

(8) **Disputes and Arbitration.**—Most disputes arising under the contract are preferably subject to final settlement by the engineer, as has already been pointed out in discussing the General Clauses of the specifications. These decisions will be upheld by the courts unless the existence of prejudice, partiality or fraud is proven. There are nevertheless many questions upon which an appeal from the decision of the engineer to a specified board of arbitration should be allowed. In this category would come disputes relating to payments, alterations, extras, Contractor's delay and similar business or non-technical matters, upon which a mixed board might properly pass. To safeguard findings by arbitration, its conduct should be such as is sanctioned by law. The character of the tribunal should be definitely fixed in the contract, the scope or subject-matter of arbitration fixed, and the procedure of the board should be proper and without partiality. While the common practice is to specify a board of three arbitrators, much may be gained in despatch at least by the reference of disputes to one man of large experience and of undisputed ability and integrity.

However much the contracting parties may have endeavored to prevent litigation by carefully-framed provisions for arbitration, either party may refuse to be bound by the award of the arbitrators and appeal to the courts. The law will not allow any one to barter away his right of being heard in a court of justice. On the other hand, if the arbitration has been properly conducted and the award made in good faith, the courts will generally confirm the decision, so that it rarely pays a dissatisfied party to attempt to upset the findings of the arbitrators.

(9) **Dismissal of Contractor.**—The interests of the Owner demand that he should have the power to terminate the contract for any one of several causes. Sufficient ground for such an act should be afforded by the abandonment of the work by the Contractor or its suspension for over a certain number of days; undue delay in the prosecution of the work; failure to complete the work as a whole or in part by the times mentioned in the contract; violation by the Contractor of any of the covenants or conditions of the contract; or his refusal to comply with the instructions or orders of the engineer. The right of the Owner to take possession of the entire work, including unused materials and the Contractor's plant and camps must be retained, for otherwise great delay and inconvenience might result from the dismissal of the Contractor and the resumption of operations under new auspices. The Owner should also stipulate in the contract that the work may be completed by day labor, by contract or by any means which may seem desirable to him under the circumstances. In case the entire work should under these conditions cost more than the tender of the original Contractor, the means of recovery of the difference should be stipulated.

(10) **Liens.**—The Owner should reserve to himself in the contract the right to discharge all liens or formal claims filed against the Contractor and to deduct the amounts thus paid from any moneys due the latter under the contract.

(11) **Assignment of Contract.**—Assigning or subletting a contract should not be permitted without the consent of the engineer. Otherwise, the Contractor might delegate work to irresponsible and incompetent persons whose incapacity or tardiness might bring great loss to the Owner and chagrin to the engineer.

(12) **Consideration.**—The consideration passing from the Owner to the Contractor may take the form of a lump sum or certain prices per unit of measurement for each of the different classes of work covered by the contract. The prices for extras and the basis of remuneration for Force and Material Account work should also appear in this portion of the agreement.

(13) **Binding of Successors and Assigns.**—Each of the contracting parties, should in his own interests, require the contract to extend to and bind the heirs, executors, administrators and assigns of the other, if an individual, or the successors and assigns of an incorporated company or municipal corporation.

(14) **Dating.**—It is not desirable to date an agreement twice, because of the liability of disagreement and consequent invalidating of the contract. For this reason it is a common practice to record the signatures as being

made the "day and year first above written." Where a contract is drawn in one Province, State or country to be enforced in another, it is desirable to establish the place of its closing, since the question of the laws under which the contract is to be interpreted should not be clouded by uncertainty as to the place of making.

(15) **Signatures.** — Signatures should obviously correspond precisely to the names of the parties in the body of the contract. If an incorporated company, commission or governmental corporation is entering into a contract, the signatures of its proper officers should be required and in case of a governmental corporation the Corporate seal should also be affixed.

(16) **Witnessing.** — The various signatures to the contract should, for purposes of identification, be witnessed. It is preferable to have the execution of the instrument acknowledged before a notary public or other public officer authorized to act in such a capacity. The courts will in this case accept the instrument as identified and admit it at once as evidence.

PRACTICAL SUGGESTIONS.

Language, Spelling, Punctuation, etc. — Since the guiding principle in the interpretation of contracts is the intention expressed by the parties, it is evident that the best kind of language to use in the preparation of such instruments is that which most clearly expresses this intention. There is no special virtue in legal phraseology and the engineer has no need to employ it except, perhaps, in special cases where definiteness of statement may be furthered by its use. The safest practice for one without special legal training is to employ only simple, plain langauage involving words ana terms the meaning of which is well understood in the locality where the work is to be done. Clearness requires the employment of short rather than long sentences and it is frequently desirable, rhetorical principles notwithstanding, to repeat words and phrases where other expressions would not convey precisely the same meaning. Brevity, although commendable, should not be secured by the omission of words as understood, since the avoidance of ambiguity should be one of the first cares of the contract-writer. In this connection it is well to remember that the intention of the contract is judged by the meaning of the words and not by what the engineer may allege he intended to express. While specifications and agreements are not a proper field for the rhetorician, the inelegances of the imperative mood and of such barbarisms as "the same" should be avoided. Mistakes in grammar, spelling or punctuation will not be allowed to invalidate the contract, but their occurrence may precipitate disputes and ultimately lead to litigation. Anything which distorts a sentence or obscures the meaning of the instrument in any particular should therefore be avoided. Even if accuracy in this respect does not serve to keep the case out of the courts, the task of interpreting the contract will be much facilitated thereby.

Balanced Treament.—Each of the various matters covered in a contract should be given that consideration which its importance demands. It frequently happens that an engineer through lack of familiarity with certain phases of the work covered in his specifications dismisses them with the statement that they shall be "to the satisfaction of the engineer," while pages of space are given over to the description of relatively unimportant matters with which he was well acquainted. The incorporation of characteristically brief manufacturers' specifications for certain materials and apparatus in the specifications of the engineer is likely to result in this curious lack of due proportion. From the placing of undue emphasis on certain matters the Contractor may be led to slight things of equal, or perhaps greater, importance in his endeavor to live up to the letter of the contract.

Arrangement.—The clauses of a contract should not be thrown together in a haphazard manner but should be arranged in some logical order. It is most convenient to divide the specifications up into divisions corresponding to the various contracting interests affected, or sometimes even to issue a separate specification for each. Within these divisions an orderly arrangement should, of course, be followed. This may be in chronological order or in the order of importance, but neither can be followed rigidly. The best order is a combination of these and one in which one clause or subject suggests another. Each item should be contained in an individual numbered clause, a unit in itself and not dependent upon any other clause. It should be remembered also that the ease with which a specification may be used is greatly enhanced by the use of marginal references.

Checking.—All specifications and draft agreements should be carefully checked before being issued from the office of the engineer, and in case of important contracts this should be done by a lawyer as well as by the engineer. Checking of his own work by the writer of the contract should not be done immediately after its preparation but preferably a few days later. In no case should the work of a typist be allowed to go out unchecked.

Changes and Corrections.—Changes in the text of the contract should not be made by erasure but by lining out the words or portions altered. In this way it is established that most, and perhaps all, of the changes were made while the document was being transcribed and before it was finally signed. As a safeguard, it is well also to have each signer of the contract initial such changes. Care should be taken to see that the requisite changes in the plans are made at the same time.

WATERWORKS OF ST. THOMAS, ONT.

This department of the city's utilities showed a net profit of $18,500 during the past year, according to a report recently issued by the water commissioners of that city. The population of this city is placed at 15,240, and the water is conveyed to the citizens by means of 29 miles of street mains; the hydrants number 168, and the reservoir capacity is 25,000,000 gallons.

The source of supply is Kettle Creek and from artesian wells, and this water is filtered before reaching the taps by means of six coagulating filters using alum, ⅔ grain to the gallon, as a coagulant.

Under the present system the water is pumped directly from the suction well through the filters into the mains. The coagulant is applied in the well, so that its opportunity for performing its work before entering the mains is very limited.

Under the new system, now in course of construction, the water will be taken from the present suction well by an electrically driven centrifugal pump. The pump is manufactured and supplied by the Canadian Boving Company, and has a capacity of 2,100 imperial gallons per minute. It pumps against a head of 58 ft.; speed 720 r.p.m. It is driven by a 3 phase Lancashire motor capable of developing 60 b.h.p. when running at 720 r.p.m. A reserve steam driven centrifugal pump will also be installed, which is also manufactured and supplied by the Canadian Boving Co. This pump has a capacity of 3,500 imperial gallons per minute. It pumps against a head of 58 ft.; speed 550 r.p.m. It is driven by an Alley and MacLellan high speed engine capable of developing 94 h.p. at 550 r.p.m., when steam is at 100 lbs. per square inch.

The above mentioned pump will raise the water through an 18-inch cast iron pipe to the aerator and coagulating basin, located on the high ground to the north-east of the works. At the aerator it will be broken into a spray so that every particle will come into contact with the air. From the aerator, it will pass into the coagulating basin which has a volume of about 400,000 gallons. Here, the water will remain four hours or more, giving the coagulant time to have its full effect, and settle the matter held in suspension, before passing through the 20-inch pipe line and through the filters by gravity. From the filters it goes to the clear water basin, where one million gallons of filtered water will be held in reserve. From there it will be pumped directly into the mains by the pumps which are at present in use.

In addition to the 12-inch vitrified pipe from the dam directly to the suction well, an 18-inch cast iron pipe line has been laid. A man-hole and sluice gate is placed in the pipe line. This will furnish ample supply from the dam when the reservoir is emptied.

The following table shows the amount of water pumped for the year, tabulated monthly, and the amount of fuel and alum used:—

	Coal		Wood	Alum	Gallons of
	Tons.	Lbs.	cords.	lbs.	water pumped.
January	83	500	½	3,100	45,322,560
February	76	1,000	½	3,400	41,342,570
March	80	900	1	5,100	44,207,695
April	76	1,600	1	4,800	40,853,250
May	78	100	1½	4,000	42,549,455
June	76	1,300	1	4,000	44,521,645
July	79	1,200	½	2,800	44,125,560
August	82	700	½	2,800	43,829,415
September	76	1,400	1	2,500	41,314,455
October	80	1,700	2½	3,100	40,602,060
November	80	900	2½	2,800	41,462,955
December	91	900	½	3,000	42,634,985
	963	200	13	41,400	512,766,605

COAL IN WESTERN CANADA.

It is estimated by the Geological Department of Canada that the total coal content of the three Provinces of Manitoba, Saskatchewan and Alberta, together with Eastern British Columbia, is 143,490,000,000 tons, covering an approximate area of 22,506 square miles. In the above total it is estimated that the various classes of coal occur in the following proportions:—

	Tons.
Anthracite	400,000,000
Anthracite and semi-anthracite	860,000,000
Bituminous and semi-anthracite	43,070,000,000
Coal and Lignite Coal	99,160,000,000
	143,490,000,000

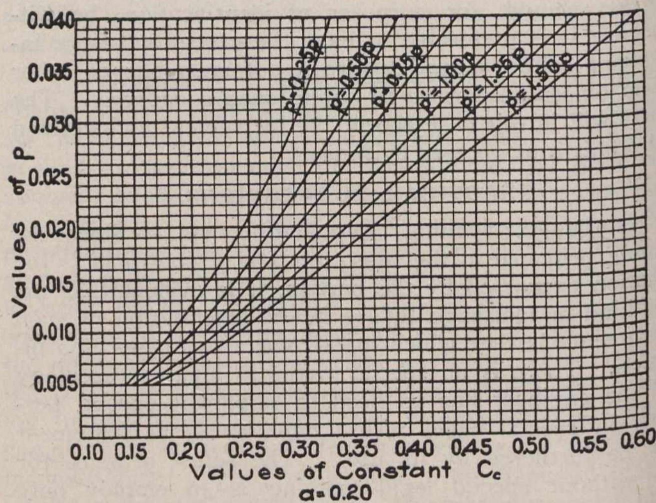
The total coal production of the Province of British Columbia for the year 1910 was 2,800,046 tons; Alberta [illegible],000 tons, and Saskatchewan 224,500 tons.

THE PRACTICAL DESIGN OF REINFORCED CONCRETE FLAT SLABS.

By Sanford E. Thompson.

(Continued from last issue.)

Moment at Centre of Slab.—It is possible to adopt the Eddy theory to the design of the centre of the slab as well as to the supports. In practical design, however, as has been indicated, the thickness of the slab is determined by the thickness at the support, which is always the greater. But, in order to avoid too wide spacing of the bars and to adapt the centre reinforcement to that over the supports, more steel is generally run through the slab than the results of tests would show to be necessary. Consequently, instead of considering this from a theoretical standpoint alone, safe values for the bending moments may be selected, based on general principles of mechanics and qualified by actual tests.



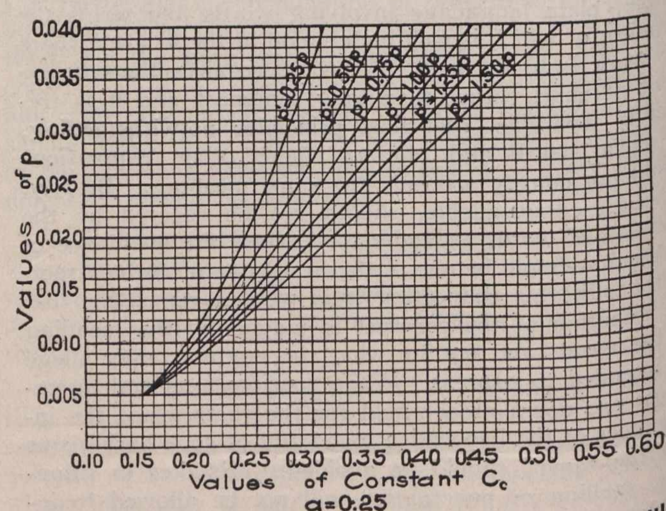


Fig. 6.—Diagram Giving Values of Constants in Formula.

$$f_c = \frac{M}{C_c b d^2} \text{ for } \alpha = 0.20 \text{ and } \alpha = 0.25$$

$$\alpha = \frac{\text{Depth of Steel in Compression.}}{\text{Depth of Steel in Tension.}}$$

$$p = \frac{\text{Area of Steel in Tension.}}{\text{Area of Concrete above Steel.}}$$

Let l_1 = distance between lines of inflection. This distance will be about 3/5 of the net span between column heads

For the rectangular reinforcement, if the slabs between the points of inflection were simply supported, we should have a moment of $wl_1^2/8$. However, the bending moment in the Minneapolis tests, based on the maximum stresses under uniform working load is about $wl_1^2/33$. It would appear amply safe, therefore, to adopt a value of $M = wl_1^2/12$.

For the diagonal reinforcement, the steel runs in two directions, and considering both theory and test, a value of $M = wl_1^2/24$ is conservative to use for the steel in each direction.

Cross Steel Between Columns.—In flat slab floors, cracks are apt to occur between columns on rectangular lines, because, since the span is shorter, the deflection is less than in the centre of the slab. To prevent these cracks, it is advisable to place cross reinforcement of small bars in the top of the slab.

Tables for Design of Slabs.—The accompanying tables give thicknesses of slab, reinforcement, and size of column head, for various column spacings and loads.

Three arrangements for steel over the column head are chosen: The first where the area of steel in the top is twice the area of steel in the bottom; the second where the two are equal; and the third where the area of steel in the bottom is one and a half times that in the top. This gives the designer a variety of thicknesses of slab. The percentages of steel selected are those which produce, with the given conditions, a compressive stress of 800 lb. per sq. in. in the concrete and 16,000 lb. in the steel. In order to allow 800 lb. in the concrete, it should be mixed in proportions as rich as 1 part cement to 2 parts fine aggregate to 4 parts coarse aggregate. Poisson's ratio is assumed as 0.1, which from recent tests appears to be a fair value.

$$fc = \frac{\quad}{Ccbd^2} \text{ for } \alpha = 0.30$$

$$\alpha = \frac{\text{Depth of Steel in Compression.}}{\text{Depth of Steel in Tension.}}$$

$$p = \frac{\text{Area of Steel in Tension.}}{\text{Area of Concrete above Steel.}}$$

Table 1.—Design of Flat Slabs.

Thickness of Slab, Areas of Steel and Sizes of Column Head are Given for Different Spans and Percentages of Steel. Live Load 100 lb. per sq. ft.

Span between centres of columns in feet. ft.	Ratio of cross-section of steel in tension to concrete below steel. (p)	Ratio of cross-section of steel in compression to concrete below steel in tension. (p')	Distance from bottom of slab to centre of gravity of steel in tension. (d) in.	Approximate total depth of slab. (t) in.	Diameter of column head. ft.	*Area of steel over column in tension. sq. in	*Area of steel over column in compression. sq. in.	Minimum area of steel between columns per foot of width of diagonal band. sq. in.	Minimum area of steel between columns per foot of width of rectangular band. sq. in.
12	0.014	0.007	4¼	5½	2.00	4.50	2.25	0.16	0.09
12	0.017	0.017	3¾	5	2.00	4.81	4.81	0.17	0.09
12	0.022	0.033	3½	4¾	2.50	7.26	10.90	0.18	0.09
14	0.014	0.007	5	6¼	2.25	5.94	2.97	0.19	0.11
14	0.017	0.017	4½	5¾	2.75	7.93	7.93	0.20	0.11
14	0.022	0.033	4	5¼	3.00	9.96	14.95	0.21	0.11
16	0.014	0.007	6	3½	3.00	9.51	4.76	0.22	0.12
16	0.017	0.017	5¼	6½	3.25	10.95	10.95	0.23	0.12
16	0.022	0.033	4½	5¾	3.75	14.01	21.05	0.24	0.12
18	0.014	0.007	6¾	8¼	3.50	12.48	6.24	0.26	0.14
18	0.017	0.017	6	7½	3.75	14.42	14.42	0.27	0.14
18	0.022	0.033	5	6¼	4.50	18.67	28.00	0.28	0.14
20	0.014	0.007	7¾	9¼	4.00	16.36	8.18	0.30	0.16
20	0.017	0.017	6¾	8¼	4.50	19.47	19.47	0.31	0.16
20	0.022	0.033	5¾	7¼	5.00	23.89	35.80	0.32	0.15
22	0.014	0.007	8½	10¼	4.50	20.21	10.11	0.34	0.18
22	0.017	0.017	7½	9	5.00	24.05	24.05	0.34	0.17
22	0.022	0.033	6½	8	5.75	31.05	46.60	0.35	0.16
24	0.014	0.007	9½	11¼	5.00	25.10	12.55	0.38	0.20
24	0.017	0.017	8¼	10	5.75	30.41	30.41	0.39	0.20
24	0.022	0.033	7	8½	6.50	37.80	56.70	0.40	0.19

* Area of steel over column head = circumference of column head in inches × d × p or p' depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in. (See example.)

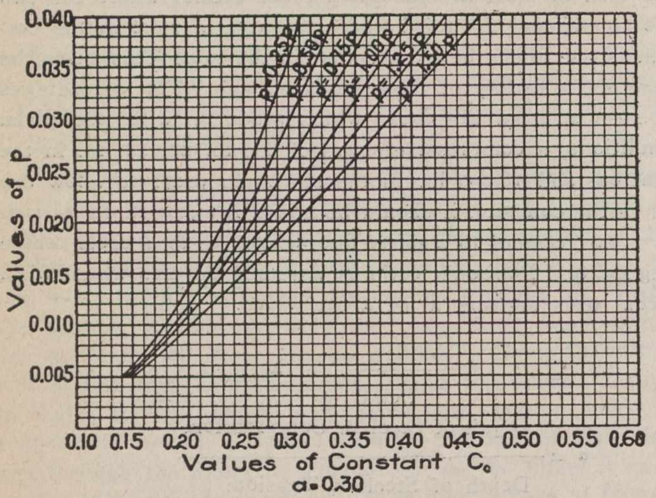


Fig. 7.—Diagram Giving Values of Constants in Formula

The size of column head has been figured for a shear of 60 lb. per sq. in. on a circle a distance, t, (the thickness of slab) outside of the column head. This shear is used simply as measure of the diagonal tension. The value is somewhat larger than is permitted in beam design but appears to be warranted in the case of flat slabs.

The steel in the centre of the slabs has been figured for a stress of 16,000 lb.

Diagrams for Designing Slabs.—To provide for cases not covered by the table, curves for values of C_s and Ce are given so that the moment under various conditions can be readily figured from the formula for the bending moment given in a preceding paragraph.

Diagrams for Determining Steel in Top and Bottom of Beams or Slabs.—In Figs. 5 to 8, curves are plotted for finding the values of the constants Cc and Cs in the formulas for the steel and concrete stresses in beams or slabs with steel in top and bottom. The curves are drawn for different values of α, the ratio of distance of steel in com-

Table 2.—Design of Flat Slabs.

Thickness of Slab, Areas of Steel and Sizes of Column Head are Given for Different Spans and Percentages of Steel. Live Load 150 lb. per sq. ft.

Span between centres of columns in feet.	Ratio of cross-section of steel in tension to concrete below steel. (p)	Ratio of cross-section of steel in compression to concrete below steel in tension. (p′)	Distance from bottom of slab to centre of gravity of steel in tension. (d)	Approximate total depth of slab. (t)	Diameter of column head.	*Area of steel over column in tension.	*Area of steel over column in compression.	Minimum area of steel between columns per foot of width of diagonal band.	Minimum area of steel between columns per foot of width of rectangular band
ft.			in.	in.	ft.	sq. in	sq. in.	sq. in.	sq. in.
12	0.014	0.007	4¾	6	2.25	5.64	2.82	0.18	0.10
12	0.017	0.017	4¼	5½	2.50	6.81	6.81	0.19	0.10
12	0.022	0.033	3½	4¾	3.00	8.72	13.09	0.21	0.10
14	0.014	0.007	5½	7	3.00	8.72	4.36	0.22	0.12
14	0.017	0.017	5	6¼	3.50	11.22	11.22	0.23	0.11
14	0.022	0.033	4¼	5½	3.75	13.22	19.82	0.24	0.11
16	0.014	0.007	6½	8	3.50	12.03	6.02	0.26	0.14
16	0.017	0.017	5¾	7¼	3.75	13.83	13.83	0.27	0.13
16	0.022	0.033	4¾	6	4.50	17.75	26.60	0.28	0.13
18	0.014	0.007	7¼	8¾	4.00	15.32	7.66	0.31	0.16
18	0.017	0.017	6¼	7¾	4.50	18.05	18.05	0.32	0.15
18	0.022	0.033	5¼	6¾	5.50	24.00	36.00	0.33	0.14
20	0.014	0.007	8¼	10	5.00	21.80	10.90	0.34	0.17
20	0.017	0.017	7	8½	5.50	24.70	24.70	0.35	0.17
20	0.022	0.033	6	7½	6.25	31.14	46.70	0.36	0.16
22	0.014	0.007	9	10¾	5.50	26 15	13.08	0.38	0.18
22	0.017	0.017	7¾	0¼	6.25	31.07	31.07	0.39	0.17
22	0.022	0.033	6¾	8¼	7.00	39.24	58.80	0.40	0.17
24	0.014	0.007	0¾	11¼	7.00	36.05	18.03	0.42	0.21
24	**0.016**	**0.013**	**8¾**	**10½**	**7.00**	**36.95**	**29.57**	**0.43**	**0.20**

The values printed in black type are figured for a column head 7 ft. in diameter and the thickness of the slab is increased to withstand the shear. (See example.)

* Area of steel over column head = circumference of column head in inches × d × p or p′ depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in.

If the reinforcing rods are so bent that more than 60 pounds in shear can be allowed on the concrete the thickness of the slab may be decreased, provided the steel areas are increased sufficiently to give the desired strength.

pression from compression sufrace to distance of steel in tension from compression surface, and for different values of p^1/p, where p = ratio of cross-section of steel in tension to concrete above it,* and p^1 = ratio of cross-section of steel in compression to this same area of concrete.

Example.—For a warehouse floor with a live load of 150 lb. per. sq.ft. and a column spacing of 20 ft. each way, what is the necessary thickness of slab, size of column head, and amount of steel?

Solution.—From Table 2 the thickness of slab is given as 8½ in., the size of column head 5.5 ft., and the area of steel as 24.7 sq. in. at top of slab and same amount at bottom of slab over column, using ratio of area of steel in tension to area of concrete below steel as 0.017. Dividing

$$fs = \frac{M}{Csbd^2}$$

* Where the tension steel is at the top, as over the support of a flat slab or beam, the concrete area is taken below the tension steel.

$$\alpha = \frac{\text{Depth of Steel in Compression.}}{\text{Depth of Steel in Tension.}}$$

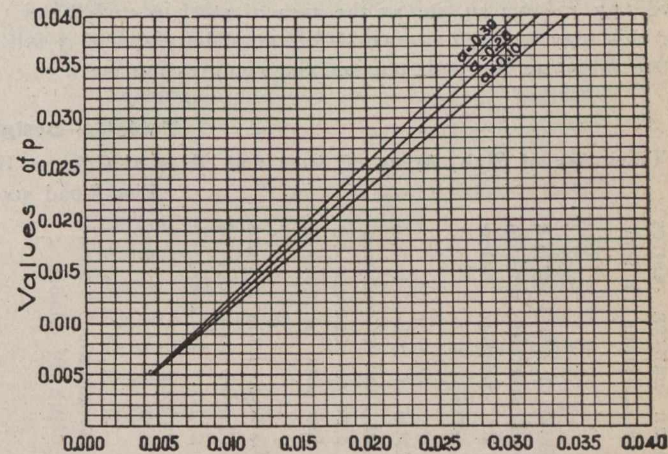


Fig. 8.—Diagram Giving Values of Constants in Formula

Table 3.—Design of Flat Slabs.

Thickness of Slab, Areas of Steel and Sizes of Column Head are Given for Different Spans and Percentages of Steel. Live Load 200 lb. per sq. ft.

Span between centres of columns in feet. ft.	Ratio of cross-section to concrete below of steel in tension steel. (p)	Ratio of cross-section of steel in compression to concrete below steel in tension. (p')	Distance from bottom of slab to centre of gravity of steel in tension. (d) in.	Approximate total depth of slab. (t) in.	Diameter of column head. ft.	*Area of steel over column in tension. sq. in	*Area of steel over column in compression. sq. in.	Minimum area of steel between columns per foot of width of diagonal band. sq. in.	Minimum area of steel between columns per foot of width of rectangular band. sq. in.
12	0.014	0.007	5	6¼	2.50	6.60	3.30	0.20	0.10
12	0.017	0.017	4½	5¾	3.25	9.38	9.38	0.21	0.10
12	0.022	0.033	3¾	5	3.75	11.70	17.55	0.23	0.10
14	0.014	0.007	6	7½	3.25	10.31	5.16	0.24	0.13
14	0.017	0.017	5	6¼	3.75	12.02	12.02	0.25	0.12
14	0.022	0.033	4¼	5½	4.50	15.88	23.80	0.26	0.11
16	0.014	0.007	6¾	8¼	4.00	14.26	7.13	0.28	0.14
16	0.017	0.017	5¾	7¼	4.50	16.60	16.60	0.30	0.14
16	0.022	0.033	4¾	6	5.50	21.70	32.55	0.32	0.14
18	0.014	0.007	7½	9	4.75	18.80	9.40	0.33	0.17
18	0.017	0.017	6½	8	5.50	22.92	22.92	0.34	0.16
18	0.022	0.033	5½	7	6.50	29.70	44.60	0.35	0.15
20	0.014	0.007	8½	10¼	5.50	24.71	12.36	0.37	0.18
20	0.017	0.017	7¼	8¾	6.25	29.08	29.08	0.38	0.17
20	**0.019**	**0.029**	**6¼**	**7¾**	**7.00**	**31.35**	**47.85**	**0.39**	**0.16**
22	0.014	0.007	9½	11¼	6.25	31.38	15.69	0.42	0.20
22	**0.016**	**0.012**	**8¼**	**10**	**7.00**	**34.90**	**26.15**	**0.42**	**0.19**
24	**0.014**	**0.006**	**10¼**	**12**	**7.00**	**37.90**	**16.24**	**0.46**	**0.22**

The values printed in black type are figured for a column head 7 ft. in diameter and the thickness of the slab is increased to withstand the shear. (See example.)

* Area of steel over column head = circumference of column head in inches × d × p or p' depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in.

If the reinforcing rods are so bent that more than 60 pounds in shear can be allowed on the concrete the thickness of the slab may be decreased, provided the steel areas are increased sufficiently to give the desired strength.

$$p = \frac{\text{Area of Steel in Tension.}}{\text{Area of Concrete above Steel.}}$$

these values by 4, as each end of the bands is effective, we have 24.7/4 = 6.2 sq. in. as the area of steel in each band. For this may be used twenty ⅝-in. round bars spaced 5 in. centre to centre for both tension and compression steel.

The amount of steel required at centre of rectangular band is 0.17 sq. in. per ft. of width. Placing a ⅝-in. round bar every 10 in. gives more than the necessary area, but ease in placing the steel makes up for the extra amount. The amount of steel required at centre of diagonal band is 0.35 sq. in. per ft. of width. ⅝-in. round bars every 10 in. will thus give necessary amount of steel.

Table 4.—Design of Flat Slabs.

Thickness of Slab, Areas of Steel and Sizes of Column Head are Given for Different Spans and Percentages of Steel. Live Load 300 lb. per sq. ft.

Span between centres of columns in feet.	Ratio of cross-section of steel in tension to concrete below steel. (p)	Ratio of cross-section of steel in compression to concrete below steel in tension. (p')	Distance from bottom of slab to centre of gravity of steel in tension. (d)	Approximate total depth of slab. (t)	Diameter of column head.	*Area of steel over column in tension.	*Area of steel over column in compression.	Minimum area of steel between columns per foot of width of diagonal band.	Minimum area of steel between columns per foot of width of rectangular band.
ft.			in.	in.	ft.	sq. in	sq. in.	sq. in.	sq. in.
12	0.014	0.007	5¼	6½	3.50	9.72	4.86	0.24	0.12
12	0.017	0.017	4½	5¾	4.25	12.27	12.27	0.25	0.11
12	0.022	0.033	3¾	5	5.00	15.56	23.30	0.26	0.10
14	0.014	0.007	6¼	7¾	4.25	14.03	7.02	0.29	0.13
14	0.017	0.017	5¼	6½	5.00	16.84	16.84	0.30	0.12
14	0.022	0.033	4¼	5½	6.00	21.18	31.72	0.31	0.11
16	0.014	0.007	7	8½	5.00	18.48	9.24	0.33	0.15
16	0.017	0.017	6	7½	6.00	23.10	23.10	0.35	0.15
16	0.022	0.033	5	6¼	7.00	29.05	43.50	0.35	0.12
18	0.014	0.007	7¾	9¼	6.00	24.59	12.30	0.39	0.17
18	0.017	0.017	6½	8	7.00	29.18	29.18	0.40	0.16
18	**0.015**	**0.015**	**6¾**	**8¼**	**7.00**	**26.74**	**26.74**	**0.39**	**0.15**
20	0.014	0.007	8¾	10½	7.00	32.32	16.16	0.43	0.19
20	**0.015**	**0.011**	**8½**	**10¼**	**7.00**	**33.65**	**25.36**	**0.43**	**0.18**
22	**0.012**	**0.003**	**10¾**	**12½**	**7.00**	**34.00**	**8.50**	**0.47**	**0.22**
24	**0.010**	**0.000**	**13½**	**15½**	**7.00**	**35.64**	**0.00**	**0.51**	**0.25**

The values printed in black type are figured for a column head 7 ft. in diameter and the thickness of the slab is increased to withstand the shear. (See example.)

* Area of steel over column head = circumference of column head in inches × d × p or p' depending upon whether the steel is in tension or compression. This steel is assumed as distributed over the entire widths of the bands. Thus if a band of steel has 2 sq. in. steel in section, the area, effective, for two bands will be 8 sq. in.

If the reinforcing rods are so bent that more than 60 pounds in shear can be allowed on the concrete the thickness of the slab may be decreased, provided the steel areas are increased sufficiently to give the desired strength.

PUBLIC EXPENDITURE IN MONTREAL.

The plans of City Engineer Janin, which have been submitted to the Board of Control, and which it would seem are likely to be acceptable to the Board and to the City Council, involve the expenditure of upwards of $1,000,000 on street paving in the city of Montreal, this amount being $50,000 to $75,000 greater than last year. Residential streets will be macadamized at an average cost of $12.00 per square foot, the granite rate ruling about the same price. Altogether there are some fifty streets or sections of streets to be paved with approximately 65,000 square yards of macadam and granite, the latter being used on streets where there is heavy traffic. It is understood that well on to $9,000,000 will be spent by the government on buildings in Montreal and on improvements to the Montreal harbor and rivers St. Lawrence and Ottawa. The supplementary estimates include upwards of half a million dollars for expenditure on government buildings in Montreal and other works in the city or in suburbs of the city. In addition to this $6,000,000 has already been passed by statute to the Montreal Harbor Board and $1,658,000 for the deepening of the St. Lawrence, and there is $310,000 to provide for dredging plant for the river from Montreal to Father Point. Improvements to the Lachine Canal amount to $200,000, and a considerable sum will also be expended on the portion of the Ottawa River, known as Back River, which flows past the north side of the Island of Montreal.

PURIFICATION OF WATER BY FILTRATION.*

By R. Winthrop Pratt, M. Am. Soc. C.E.

The filtration of public water supplies for the purpose of removing sediment and other impurities has been practised in Europe, especially in England, for the last 60 or 70 years, or more.

The method used was what is now called the slow sand system, and consisted in passing the water through sand beds at relatively slow rates; and without first using chemicals to produce a coagulation of the impurities. European methods of filtration were proposed for use in this country as early as 1866, and during the few years following were installed in several of our smaller cities. In some cases, where the character of the water supply was similar to that of the English supplies, the filters were successful; but in other cases, where turbid waters were treated, success was not attained.

In 1890, the Massachusetts State Board of Health, at its Lawrence Experiment station began an extended investigation of the principles underlying the purification of water by filtration, and of the nature of the processes involved. Merrimac river water was used in these studies.

Three years later, in 1893, based on the results of the work at the Experiment station, and also following European precedent, a filter was built to purify the entire water supply of the city of Lawrence. This was the first filter in the United States, installed expressly for the purpose of reducing the typhoid fever death rate. Its success is well known—the typhoid death rate having been reduced some 80 per cent. This did much to stimulate interest in filtration in other American cities; and during the next few years the installation of filters of the slow sand type was begun by Albany, Washington, Philadelphia and Pittsburg.

About 1884, there was invented the American or mechanical system of water filtration. The essential features of this method were, and still are, first, the addition of a coagulant to the water before it is applied to the filtering material; second, the passage of the water through the sand layer at a rapid rate; third, provision for cleaning the sand layer in place, by means of a reverse current of water instead of removing the dirty sand, as with the slow sand system.

Mechanical filters were first used principally by paper manufacturers, who required a clear water. Their use as a means of hygienically purifying the water was not generally begun until within the last ten or twelve years. The efficiency of the principles of mechanical filtration for municipal supplies was perhaps first proven during experimental tests at Louisville and Cincinnati, in 1897 and 1898. These cities are representative of a large class in the middle west, which has to use a clay-bearing water, and one that cannot be purified bacterially, or even clarified by the slow sand system. The development of mechanical filtration to its present state of efficiency has been necessary to meet the demands of such cities.

The cost of installing filter plants may range from $10,000 to $40,000 or even $50,000 per 1,000,000 gallons capacity. This unit cost varies with the size of the plant, the character of the water to be treated, the expense necessary to connect with the existing water system, and other local conditions. For example, the cost of installing the raw water pumps would be much less in places along the Great Lakes than it would be on the Ohio river, where the water level fluctuates 50 or 60 feet.

*Paper read before Cleveland Engineering Society.

Studies by the Ohio State Board of Health, of 11 filter plants in Ohio, namely, those at

	Cost per 1,000,000 Gals.
Cincinnati	$49,830
Dennison	26,000
Elyria	10,000
Geneva	13,000
Lorain	12,000
Marietta	10,000
Rocky River	14,000
Upper Sandusky	15,000
Vermillion	8,000
Warren	13,000
Youngstown	13,000

have shown the average cost per 1,000,000 gallons capacity to be about $17,000. Excluding the Cincinnati plant, however, which cost $49,830 per 1,000,000 gallons capacity, the average cost of the remaining ten is only $13,000 per 1,000,000 gallons capacity. The average cost per capita (based on ultimate capacity of plant), excluding Cincinnati, was found to be about $1.50.

Slow sand filters are in general more costly to build, but cheaper to operate than mechanical filters. This statement is made with the assumption, of course, that the slow sand filters are installed only where the water is sufficiently clear to enable them to be operated with reasonable periods of service between cleanings.

Operating costs vary greatly with the quality of the raw water and the character of the treatment. Lake waters drawn from points removed from shore, are cheapest to treat; while muddy river waters are most expensive.

Special treatment to remove color or odor add to the cost; and water softening may increase it two or three times. Under ordinary conditions filtered water may be obtained at a cost of $10 per 1,000,000 gallons, including interest and depreciation charges. This figure will vary from $5 to $20.

With slow sand filters the principal operating cost is the labor and maintenance of equipment used for washing the sand. With mechanical filtration, the cost of chemicals and of labor, which are about equal, constitute the largest items.

In Ohio, it was found that the operating costs, excluding interest charges, ranged from $2.55 per 1,000,000 gallons at Elyria to $12.10 at Warren, with Youngstown second highest at $10.67. This great difference in cost is largely due to the superior quality of Lake Erie water taken from a point fairly remote from pollution, over that of the turbid and polluted Mahoning river.

In considering the cost of maintaining a filter plant, attention should be directed to the comparatively small increase in the cost of supplying filtered water over that of supplying unfiltered water. This increase is rarely more than 25 or 30 per cent., and frequently only 10 or 15 per cent. In any case, the increase should not amount to more than 50 cents to $2 per person per year—a small price to pay for enjoying pure water and all of its benefits.

DISINFECTION OF WATER BY CHEMICALS.*

By Dr. R. G. Perkins.

This term is to be translated more or less literally, as it means merely getting rid of all forms of animal or plant life, which may set up disease or give rise to unpleasant conditions of the water.

Removal of the non-pathogenic varieties was the first of the uses to which chemical disinfection was put, and while at first great things were claimed for the various processes, certain difficulties were found to be present which have modified our actions to a large extent. Of the various chemicals used, the only one which has at present a practical use is copper sulphate, which is used for clearing reservoirs from the fresh water algae which develop in them, especially in the warm weather. In most cases, a strength of about one part of copper sulphate to the million parts of water is sufficient to destroy all the algae, and to leave the water clear after the dead forms have disappeared. It must be considered, however, that it has been found in many cases that the algae return in increased numbers after a short interval, and in others that there are resistant forms which cannot be killed by a dilution which will not be injurious to higher forms of life. The earlier claims that this method would kill pathogenic bacteria in the above dilutions have not been substantiated.

We are at present more interested in the disinfection of water from the standpoint of removal of the pathogenic forms, especially those of the type of typhoid, Asiatic cholera, dysentery, etc. The essential of a successful disinfection would obviously be the total and constant destruction of all of these organisms by the use of quantities of the chemical which would be so small as to cause no danger per se, or interfere with domestic or commercial uses of the water. There are then certain definite indications for the use of a disinfectant, and even for the period of use and the strength of the chemical. There are in general three sets of circumstances leading to disinfection:

1. Impure water with no immediate prospect of permanent improvement. Here the use should be continued until the establishent of a permanent safe supply.

2. Where there is a water supply which has been made safe by filtration or other means, there should be an emergency apparatus at hand for temporary treatment in case of accident to the plant.

3. Where there is a properly constructed filtration plant treating polluted water, it is now considered best to use a small amount of disinfectant **after** the filtration to protect against any possible errors.

With these points as the essential indications for disinfection, one may consider the choice of an agent. Ozone and chlorine are the chief chemical agents to be considered, since the ultra-violet ray is rather physical than chemical. One may say in passing that the latter is entirely unsuitable for our purposes in Cleveland since it will work only in a clear water, necessitating preliminary filtration.

Ozone and chlorine then are left, and they act by the setting free of molecules of so-called nascent oxygen, which has an oxidizing power of extraordinary strength. When water is treated by these agents, the nascent oxygen attacks all organic matter with great vigor, and inasmuch as the effect is in direct proportion to the exposed surface, it is clear that bacteria, being very finely divided organic matter, will be among the first to be oxidized. There is thus no specific action, but the pathogenic germs share the fate of the inert organic matter. The germs, however, are more or less well equipped to meet harmful influence and it thus happens that a very definite amount is necessary, and that some varieties are more resistant than others. Fortunately the varieties which cause the water-borne diseases are among the least resistant.

Both these methods have been extensively tried, and both have their good and bad points. From the enormous increase of the use of chlorine as against the very slow spread of the use of ozone it is clear that the apparent advantages are on the side of the former. Ozone is procured by the passage of an arc through dry air and then passing this air through the water to be treated. The difficulties are: First—the need of an expensive and more or less complex apparatus; Second—the necessity of dry air, requiring a special drying apparatus in addition to the other; Third—the need of a storage reservoir, as there is no other possibility of reserve; Fourth—that the method is not at all standardized.

The main advantage is that the public is so pleased at the idea of the use of life-giving oxygen that it offers no objection to the use of the chemical, though this in greater strengths is a definite poison.

The objections to the use of chlorine, leaving out for the present those without foundation, are: First—the introduction of a chemical with a disagreeable odor, taste and associations; Second—the use of a chemical which is known to have corrosive and bleaching powers.

The advantages of chlorine are the cheapness and simplicity of the process which are not approached by any other method, the standardization, the fact that even where a power mixing plant is used, hand mixing could be readily resorted to, so that there is no danger of an interruption of the dosing.

Neither process affects the turbidity, the hardness or the general appearance of the water.

It is the opinion of most sanitariums that ozone is still in the experimental stage and that chlorine is a disinfectant which has practically revolutionized the water problem. In the United States alone there are over two hundred places which are using the method, and there is a very large and increasing number abroad.

One may use chlorine in the form of gas under pressure and there are special apparatuses on the market for the dosage. One may make the gas by electrolysis of salt water, or may use the commercial chloride of lime, also known as bleaching powder, which is made by the saturation of lime with the chlorine formed in the process of manufacture of caustic soda by the aforesaid electrolytic method. For practical purposes the chloride of lime has been found most useful, though there are certain definite advantages in the electrolytic chlorine.

Whatever the method by which the active agent is obtained, it is always the same, and is spoken of as available chlorine. Moreover, the active strength is also the same, as established by a large amount of experimental work, and as a result of this work one may say that a proportion of one part of available chlorine to one million parts of water will destroy all the germs of water-borne diseases. As the result depends on the action on organic matter as such it is clear that the amount of organic matter normally present in the water will have a bearing on the proper dosage, and that waters with a great variation in the organic content, as is true of our water here, will require a greater factor of safety than others.

*Paper read before Cleveland Engineering Society.

The fact of perhaps greatest importance is that there is apparently a critical point in dosage, at which satisfactory results will be obtained, but below which it is not safe to go. With the Cleveland water it was found experimentally, for instance, that 0.6 to 1,000,000 was adequate but that 0.5 was not. Moreover it is also true that a marked excess over this point is of no value as the total efficiency has already been obtained. Continuance of the experiments indicated that 0.7 allowed the necessary factor of safety, except under extraordinary conditions, when it will be advisable to make a temporary increase.

When the chlorine is put into the water where there is chance for aeration, as at the entrance to a reservoir, there is a very rapid action, and a very rapid disappearance of smell and taste, but where the circumstances are as in Cleveland, with the actual place of intake inaccessible during a large part of the year, this ideal method cannot be used. Accordingly it is necessary to put the chemical into the pump well, where there is an interval of less than five minutes before it goes under pressure. The killing effect has been satisfactory at this time, but the taste persists for a time dependent mainly on the temperature of the water, lasting longer in cold water, ordinarily from 30 minutes to an hour, while the odor persists practically until the water is released from pressure at the tap. The amount of odor will decrease with the increase of time from the intake and at distant points will be only appreciable by keen senses, while at nearer points it may be readily smelt, for instance, at the time of the morning bath. The actual disappearance is rapid, tests showing that when samples are taken at once and after five minutes there is already a decrease of nearly 50 per cent., and when the water reaches the consumer there is present less than one part in ten million, so high a dilution that to scientific men it is hardly necessary to point out the absence of danger.

Wherever the method has been tried, it has proved successful in reducing the water-borne diseases, and this has been notably the case in Cleveland, where at the time of introduction of the process, there were all the weather and water conditions suitable for the development of a serious epidemic, which, however, failed to appear. The typhoid rate in December has been the lowest for many years, though the general water conditions have been very unfavorable. In fine, the results of chemical treatment with chlorine have been found here and elsewhere to reduce typhoid to a very large extent and to reduce the pollution of the water as indicated by the daily tests at the city laboratory, which have been carried on since 1904, while there has been absolutely no positive evidence of the slightest ill results to persons who drink the water. The objections are in the main sentimental, and at times hysterical, but all the proof lies on one side of the case.

Note.—Cost of process. Apparatus for small communities pumping 200,000 to 500,000 gallons a day may be established for less than $25. Where there is a reservoir, very large quantities may be treated at a very low cost, and the only real expense lies in the establishment of the large tanks and the power mixer advisable for large communities. The cost of the Cleveland plant was $4,143.68.

The cost of the bleach is usually from $20 to $25 a ton, and roughly one-third of this represents the available chlorine. With the weight of a gallon as eight and one-third pounds one may calculate twenty-five pounds of the powder as able to disinfect one million gallons at a strength of one part in a million. From this the daily cost may be readily computed. Tests of the bleach should be frequent to check irregularities. The dosing outfit should be so arranged as to prevent the ingress of any of the sediment and should allow of flexibility in flow in case of changes in pumpage or in the quality of the water.

PURIFICATION BY OZONE.*

By R. M. Leggett.

One of the most convincing arguments in favor of our advanced civiliation lies in the fact that governments, both national and municipal, have taken to themselves the task of guarding the public health.

A sick or dead citizen ceases to be an asset to any community, and in a great many instances becomes a liability. The trend of modern medicine is to prevent disease, to teach people how to keep well, more than to make them well when stricken.

Thus, modern conditions place responsibilities upon cities that did not exist a decade ago. The city governments to-day are responsible, to a great extent, for the health and safety of every citizen. They supply an adequate police force to protect the public in so far as it is possible to do so, they provide asylums for the insane and hospitals for the sick, but so far as public health is concerned, a great many cities lock the stable door after the horse has been stolen. This they do by compelling the citizens to drink water containing sewage pollution and disease producing bacteria. To quote Ellice Hopkins, "It is better to fence the precipice at the top, than to wait with an ambulance at the bottom."

The majority of American citizens have learned by very bitter experience that it is costly to provide for their inhabitants a polluted drinking water.

Very rapid strides have been made by sanitary engineers in the last ten years, and their labors have resulted in placing at the disposal of cities various devices having as their object the purification of water.

Water purification embraces two principal acts, first, the removal of matter in suspension; second, the destruction of matter in solution.

Suspended matter comprises:

First—The grosses particles, such as clay, sand, leaves and parts of dead fish, sewage, etc.

Second—Micro-organisms.

Third—Bacteria.

The soluble content is composed of the organic compounds due to animal and vegetable decomposition, and mineral contamination from factories, and natural conditions of soil and rock.

In all problems of water purification, we have first to deal with that which causes disease, and after that, with those contents that cause unpleasant but harmless odors, colors and tastes.

The water to be treated by ozone must usually first be passed through a rapid roughing filter. This simply acts as a strainer, removing the grosser matter in suspension. Particles of sewage, dead leaves and organic matter absorb so much ozone, that if present in the water to be treated, reduce the efficiency of the system, unless first removed in this way.

(To be continued.)

*Paper read before Cleveland Engineering Society.

Metallurgical Comment

T. R. LOUDON, B.A.Sc.

Correspondence and Discussion Invited

DROSS MELTING BY ELECTRICITY.

A new form of electric furnace for the melting of drosses, scrap metal and cyanide precipitates is described in the Brass World, January, 1912. This furnace is the invention of Raymond S. Wile, of the Pittsburg Electric Furnace Company, and is a combination of the arc and resistance furnaces. Four carbon electrodes are used, two passing up through the bottom of the furnace and the other two down through the top. When melting is to be begun, the furnace is partly filled with broken glass and the carbon electrodes arranged so that they touch. After the current is turned on they are drawn apart and an arc is formed, which soon melts the glass in its neighborhood. As the glass melts it becomes a conductor of the electric current, where before melting it was a non-conducor. The electrodes are now drawn farther apart so that the current passes through the molten glass and finally the whole charge becomes fluid, the glass being kept liquid by the resistance offered by it to the passage of the current.

When all of the glass is in a molten condition, the metal or dross to be melted is charged directly on top of it. The initial heat of the glass melts the metal, and then, on account of its great specific gravity and the fluid condition of the glass, it sinks to the bottom of the furnace where it is completely protected from oxidation. After several months the glass becomes more or less impure and must be tapped off and replaced, but broken bottles form a cheap mixture for refilling it. The furnace is lined with chrome brick, as that is found to be the best resisting material for such work. A furnace with a capacity of 1,000 lb. of brass will pour about one ton of metal per hour and, if run continuously, consumes about 68 kw. in doing so. If the current is not run continuously, and electric current costs 2c. per kilowatt-hour, it has been found that the current cost for melting 1,000 lb. of brass is about $1.36. This is somewhat higher than the cost of melting with oil or coke, but the waste in melting is less and is said to more than compensate for the extra power cost.

STRENGTH OF ROLLED ZINC.

When it was proposed recently that zinc be used for the hangers of electric cables the fact was brought out that data on the strength of American zinc were lacking, and tests were made by the Materials Testing Laboratory of the University of Illinois on this subject. Thin zinc plates were found to have an ultimate tensile strength of about 24,000 lb. per sq. in. The modulus of elasticity was found to average 11,500,000 lbs. per sq. in. Under the action of punches and shearing tools, zinc plates developed about 40 per cent. of the shearing resistance of mild steel and required the expenditure of about 30 per cent. of the energy required for plates of mild steel of the same thickness. No clearly defined elastic limit of yield point was found for cast or for rolled zinc. Zinc plates was found to break under pull with much less stretching than steel, but a zinc cylinder could be flattened without cracking. The result of tests of American zinc showed that its strength does not differ from that shown by European laboratories for foreign spelter. The results of these tests are published in Bull. 62 of the Engineering Experiment Station of the University of Illinois.

NEW COPPER ALLOY.

A copper alloy with the hardness of steel and great tensile strength is claimed by a French metallurgist. It is made by melting together one pound each of chromium and aluminum and adding 22 pounds of copper, 5 of nickel and 4 of zinc, with intervals of half an hour or an hour between the successive additions to the fused mixture. By varying the proportions of chromium and copper the alloy can be given a considerable range of properties, with adaptation to many uses.

WATER POWERS IN UNITED STATES.

On March 14th Herbert Knox Smith, United States commissioner of corporations, submitted to President Taft a report on the concentration of control over water power by large interests in important localities. The report recommends that the government should preserve title to the remaining power sites and develop them to prevent their possible monopolization by public utility companies. They should be developed at once, not only to conserve the fuel supply of the country, but also because they are rapidly passing into private control. The public can either develop and operate these sites, selling the energy at market rates, or lease the sites at a rental. Mr. Smith says that the water power developed and practically capable of development of this kind probably does not exceed 25,000,000 h.p. The total developed water power to-day is about 6,000,000 h.p. The total stationary power used in the United States, steam, water and gas, is probably more than 30,000,000 h.p. The enquiry showed that there was concentration of water powers in three distinct phases: first, there was concentration of control in each important locality; second, large interests influenced some of these local concerns, and finally, there was a growing relationship among large interests.

In California six corporations, of which the most important is the Pacific Gas & Electric Company, with 118,343 h.p., together control 375,000 h.p., which is over 80 per cent. of all developed water power in the State. In Washington two companies control 210,000 h.p., or about 70 per cent. of all developed water power. In South Carolina the Southern Power Company owns about 101,000 h.p., or 75 per cent. of the total development, with 73,000 h.p. undeveloped. In the southern peninsula of Michigan the Commonwealth Power & Light Company controls 52,000 h.p., or 73 per cent. of the whole commercial development, together with probably 71,000 h.p. more undeveloped. Practically similar conditions are reported to exist in Montana, Colorado and Georgia and at Niagara Falls.

More important than this local concentration are the operations of ten large groups of interests which possess control or influence over 1,821,000 h.p., about 60 per cent. of the water power already developed, together with 1,449,000 h.p. undeveloped. The General Electric interests are said to control or influence 939,000 h.p. of developed water power in eighteen States and 640,000 h.p. of undeveloped resources, a total of over 1,500,000 h.p. Next are the Stone & Webster interests with 278,000 h.p,. chiefly in connection with public service concerns. They exercise control over fifty-five to sixty companies, largely through management rather than through ownership. Eight of these companies have water power.

The other groups are the Hydraulic Power Company of Niagara Falls, 144,000 h.p.; the Pacific Gas & Electric Company, with over 118,000 h.p. developed and the dominating factor in a large portion of California; the group known as the Clark-Foote-Hodenpyl-Hardy interests, 104,000 h.p., largely dominating the water-power situation in Michigan and also active in Maine and Oregon; the Southern Power Company, 101,000 h.p. in South Carolina, as previously noted; the S. Morgan Smith interests (Georgia), 76,000 h.p.; the Brady interests (Tennessee), 70,000 h.p.; the United Missouri River Power Company, 65,000 h.p., which, with the Butte Electric Power Company (General Electric group), practically dominates the power situation in Montana, and the Telluride Power Company (Colorado, Idaho and Utah), 56,000 h.p. The last-named nine interests also include under their influence 887,000 h.p. of energy as yet undeveloped.

The two greatest of the General Electric and the Stone & Webster groups have directors in a number of the same corporations. They and the S. Morgan Smith, Westinghouse and Brady interests are similarly connected.

OIL-DRIVEN TRAMS.

The Financial Times of February 23rd last gives an account of the recent developments in the use of oil fuel, and devotes particular attention to the recent trials of a petrol electric coach on the Great Western Railway of England.

The car, which was built for experimental purposes, weighs only 14 tons. The power is supplied by a 40 h.p. Maudslay petrol engine, which drives a dynamo, which in turn, transmits power to two electric motors on the axles of the rail car.

Notwithstanding the light weight of the vehicle, it accommodates 44 passengers, and this in itself is one great advantage of the petrol electric system, the weight of the car, engine, dynamo, etc., per passenger working out to only 700 pounds, as compared with about 1,500 pounds for the steam rail cars in use on the Great Western Railway.

A further advantage is that the fuel is contained in a very small area, the petrol tank, which is carried underneath the experimental car, holding sufficient petrol for between 200 and 250 miles running.

The car is divided into three compartments:—

(1) Containing petrol engine, dynamo and controller.

(2) Passenger compartment.

(3) Conductor's compartment, also containing electrical controller and brake control, the car being driven from either end, according to requirements.

Only one man is required at the driving end, the conductor riding at the opposite end and attending to the engine if required, he also being in a position to stop the car in case of emergency.

It is believed that the new system should prove, for the above reasons alone, in the case of small cars, considerably more economical than steam power, and with these advantages the further development of certain sections of the line which have hitherto not presented the likelihood of paying loads should be possible.

If the series of tests is satisfactory the Great Western Railway Company can hardly fail to reap the reward of their enterprise, as they are the largest users of rail motor cars in the United Kingdom.

ENGINEERING NOTES.

Montreal, P.Q.—The municipal engineer has taken objections to the plans of the Canadian Northern Railway for the construction of an underground tunnel on the grounds that he fears the excavations will damage the city reservoir.

Ottawa, Ont.—Engineers of the Public Works Department of the Federal Government are preparing to make a test in order to ascertain just how much the tower of the Victoria Museum has settled since the erection of the building. An effort is also to be made to ascertain the real cause of the sinking of the middle portion of the structure, if possible, and what means can be taken to prevent it in the future. During the past few months there has been no noticeable settlement, although it is feared that with the approach of spring matters may be different.

Vancouver, B.C.—The Vancouver Shipmaster's Association have disapproved of the plans for the Second Narrows bridge. They claim that with a strong tide running a slight delay in the opening of the draw would mean disaster for the marine interests and possibly for the bridge structure. The bridge has been designed in such a manner that the draw may be opened in three minutes. A design carrying the floor level higher than the one planned would please the shipping men.

PERSONAL.

Mr. R. C. St. John has been appointed to the position of engineer of maintenance of way for the Canadian Pacific Railway for Western Canada.

Mr. J. C. Holden has been appointed to the position of division engineer of the Canadian Pacific Railway for the Province of Manitoba.

Mr. C. H. Fox has been appointed to the position of assistant division engineer of the Canadian Pacific Railway for the Province of Manitoba.

MEETINGS.

Mr. G. R. Conway, chief engineer of the British Columbia Electric Railway, gave an illustrated lecture before the company section of the National Electric Light Association in Vancouver. He took as his subject "Famous Tunnels Under Rivers."

FAMOUS TUNNELS UNDER RIVERS.

During the course of an address given before the members of the company section of the National Electric Light Association in Vancouver recently, Mr. G. R. Conway, chief engineer of the British Columbia Electric Railway, stated that the teredo, a worm-like animal which perforates submerged woodwork, suggested the plan on which all subaqueous tunnel work is carried out. Marc Brunel in 1818 had his attention drawn to an old ship timber which had been bored by the teredo, and this led to an examination of the animal by the engineer. He found that the animal was armed with a pair of strong shelly valves, to which, with the foot used as a fulcrum, a rotary motion was given by powerful muscles, the wood being penetrated as by an auger. Brunel then invented his tunnel shield, which was a machine of iron forming auger-like cells for the workers, which was pressed forward with a rotary motion by hydraulic force, displacing the material for the tunnel. In this space, as the shield moved onward, was placed a steel tube, which was later lined with brickwork. This method, based on the teredo action, the lecturer said, formed the foundation of all subaqueous tunnel work, even to the present day.

The tunnel under the Thames was started by Brunel in 1825, but not completed until 1842. During the progress of this work Lord Dundonald outlined an improvement in the methods involving the use of compressed air and air locks. Lord Dundonald's system was first used in the sinking of shafts at Chalons, France, in 1839 and in 1851 was employed in England on the sinking of the foundations for a bridge over the Medway at Rochester.

Views and explanations were then given of various great tunnel works, showing the advance of methods as the use of compressed air was improved, mechanical excavators employed, etc. These descriptions included the Blackwall tunnel, 27 feet in diameter, on which a shield weighing 200 tons was advanced 25 feet per week; the Baker Street and Waterloo tunnels under the Thames, each of 12 feet diameter, on which 29½-ton shields were used; the great River Dee tunnel, where a 400-ton shield was employed, and the tunnels of the Pennsylvania Railway at New York, where the North and East rivers are being conquered to provide adequate access to the city. This latter work was said to involve the construction of over six miles of tunnel of a diameter of 23 feet, on which four shields, each weighing 200 tons, were employed.

COMING MEETINGS.

CANADIAN INSTITUTE.—198 College Street, Toronto. Saturday Evening Lectures, 8 p.m. April 13th.—"Lantern Experiments on Reaction in Non-homogeneous Systems," by Prof. Kenrick, Toronto University. April 20th—"Chemical Interpretations of Vital Phenomena," illustrated. Prof. Leathes, Toronto University.

ONTARIO MUNICIPAL ASSOCIATION.—Annual convention will be held in the City Hall, Toronto, on June 18th and 19th, 1912. Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ont.

THE CLEVELAND ENGINEERING SOCIETY.—Regular Meeting, Tuesday, April 9th, 1912. Chamber of Commerce Bldg., Cleveland, Ohio. Symposium on the Elimination of Grade Crossings. F. W. Ballard, Secretary.

ENGINEERING SOCIETIES.

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

VICTORIA BRANCH—Chairman, F. C. Gamble; Secretary-Treasurer, R. W. Macintyre.

QUEBEC BRANCH—Chairman, P. E. Parent; Secretary, S. S. Oliver. Meetings held twice a month at room 40, City Hall.

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

MANITOBA BRANCH—Secretary E. Brydone Jack. Meets every first and third Friday of each month, October to April, in University of Manitoba, Winnipeg.

VANCOUVER BRANCH—Chairman, Geo. H. Webster: Secretary, H. K. Dutcher, 319 Pender Street West, Vancouver. Meets in Engineering Department, University.

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

MUNICIPAL ASSOCIATIONS

ONTARIO MUNICIPAL ASSOCIATION.—President, Chas. Hopewell, Mayor, Ottawa; Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ontario.

UNION OF ALBERTA MUNICIPALITIES.—President, H. H. Gaetz, Red Deer, Alta.; Secretary-Treasurer, John T. Hall, Medicine Hat, Alta.

THE UNION OF CANADIAN MUNICIPALTIES.—President, W. Sanford Evans, Mayor of Winnipeg; Hon. Secretary-Treasurer, W. D. Lighthall, K.C., Ex-Mayor of Westmount.

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

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

UNION OF SASKATCHEWAN MUNICIPALITIES.—President, Mayor Bec, Lemberg; Secretary, Mr. Heal, Moose Jaw.

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

CANADIAN TECHNICAL SOCIETIES

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

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

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

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

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

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

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

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

CANADIAN ELECTRICAL ASSOCIATION.—President, N. W. Ryerson, Niagara Falls; Secretary, T. S. Young, Canadian Electrical News, Toronto.

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

CANADIAN GAS ASSOCIATION.—President, Arthur Hewit, General Manager Consumers' Gas Company, Toronto; J. Keillor, Secretary-Treasurer, Hamilton, Ont.

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

CANADIAN MINING INSTITUTE.—Windsor Hotel, Montreal. President, Dr. A. E. Barlow, Montreal; Secretary. H. Mortimer Lamb, Windsor Hotel, Montreal.

CANADIAN PEAT SOCIETY.—President, J. McWilliam, M.D., London, Ont.; Secretary-Treasurer, Arthur J. Forward, B.A., 22 Castle Building, Ottawa, Ont.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—President, Dr. Charles A. Hodgetts, Ottawa; General Secretary, Major Lorne Drum, Ottawa.

CANADIAN RAILWAY CLUB.—President, A. A. Goodchild; Secretary, James Powell, P.O. Box 7, St. Lambert, near Montreal, P.Q.

CANADIAN STREET RAILWAY ASSOCIATION.—President, D. McDonald, Manager, Montreal Street Railway; Secretary, Acton Burrows, 70 Bond Street, Toronto.

CANADIAN SOCIETY OF FOREST ENGINEERS.—President, Dr. Fernow, Toronto.; Secretary, F. W. H. Jacombe, Department of the Interior, Ottawa.

CENTRAL RAILWAY AND ENGINEERING CLUB.—Toronto, President G. Baldwin; Secretary, C. L. Worth, 409 Union Station. Meets third Tuesday each month except June, July and August.

DOMINION LAND SURVEYORS.—President, Mr. R. A. Belanger, Ottawa; Secretary-Treasurer, E. M. Dennis, Dept. of the Interior, Ottawa.

EDMONTON ENGINEERING SOCIETY.—President, J. Chalmers; Secretary, B. F. Mitchell, City Engineer's Office, Edmonton, Alberta.

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, J. E. Ritchie; Corresponding Secretary, C. V. Ross.

ENGINEERS' CLUB OF MONTREAL.—Secretary, C. M. Strange, 9 Beaver Hall Square, Montreal.

ENGINEERS' CLUB OF TORONTO.—96 King Street West. President, Willis Chipman; Secretary, R. B. Wolsey. Meeting every Thursday evening during the fall and winter months.

INSTITUTION OF ELECTRICAL ENGINEERS.—President, Dr. G. Kapp; Secretary, P. F. Rowell, Victoria Embankment, London, W.C.; Hon. Secretary-Treasurer for Canada, Lawford Grant, Power Building, Montreal, Que.

INSTITUTION OF MINING AND METALLURGY.—President, Edgar Taylor; Secretary, C. McDermid, London, England. Canadian members of Council:—Prof. F. D. Adams, J. B. Porter, H. E. T. Haultain and W. H. Miller and Messrs W. H. Trewartha-James and J. B. Tyrrell.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—Secretary R. C. Harris, City Hall, Toronto.

MANITOBA LAND SURVEYORS.—President, George McPhillips; Secretary-Treasurer, C. G. Chataway, Winnipeg, Man.

NOVA SCOTIA MINING SOCIETY.—President, T. J. Brown, Sydney Mines, C. B.; Secretary, A. A. Hayward.

NOVA SCOTIA SOCIETY OF ENGINEERS, HALIFAX.—President, J. N. MacKenzie; Secretary, A. R. McCleave, Assistant Road Commissioner's Office, Halifax, N.S.

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, Major. T. L. Kennedy; Hon. Secretary-Treasurer, J. E. Farewell, Whitby; Secretary-Treasurer, G. S. Henry, Oriole.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, T. B. Speight, Toronto; Secretary, Killaly Gamble, 703 Temple Building, Toronto.

THE PEAT ASSOCIATION OF CANADA.—Secretary, Wm. J. W. Booth, New Drawer, 2263, Main P.O., Montreal.

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Secretary, J. E. Ganier, No. 5. Beaver Hall Square, Montreal.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—President, F. S. Baker, F.R.I.B.A., Toronto, Ont.; Hon. Secretary, Alcide Chausse, No. 5. Beaver Hall Square, Montreal, Que.

ROYAL ASTRONOMICAL SOCIETY.—President, Prof. Louis B. Stewart, Toronto; Secretary, J. R. Collins, Toronto.

SOCIETY OF CHEMICAL INDUSTRY.—Dr. A. McGill, Ottawa, President; Alfred Burton, Toronto, Secretary.

UNDERGRADUATE SOCIETY OF APPLIED SCIENCE, McGILL UNIVERSITY.—President, J. P. McRae; Secretary, H. F. Cole.

WESTERN CANADA IRRIGATION ASSOCIATION.—President, Wm Pierce, Calgary; Secretary-Treasurer, John T. Hall, Brandon, Man.

WESTERN CANADA RAILWAY CLUB.—President, R. R. Nield; Secretary, W. H. Rosevear, 115 Phœnix Block, Winnipeg, Man. Second Monday, except June, July and August, at Winnipeg.

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand and projected, contracts awarded, changes in staffs, etc. Printed forms for the purpose will be furnished upon application.

PLANS AND SPECIFICATIONS ON FILE.

The following Plans (P.) and Specifications (S.) are on file for reference only unless otherwise noted at the office of The Canadian Engineer, 62 Church Street, Toronto:—

Bids close		Noted in issue of
4-8	Paving, Port Arthur, Ont. ....(S.)	3-21
4-11	Grading, sanitary sewers, cement walks, etc., Lethbridge, Alta........(P. & S.)	3-14
4-15	Cement sidewalks, Battleford, Sask. ..(P. & S.)	4-4
4-30	Tunnel sewer, Edmonton, Alta. ....(S.)	4-4

(Battleford and Lethbridge plans and specifications are on file at The Canadian Engineer Office, 820 Union Bank Building, Winnipeg.)

TENDERS PENDING.

In Addition to Those in this Issue.

Further information may be had from the issues of The Canadian Engineer referred to.

Place of Work.	Tenders Close.	Issue of.	Page.
Calgary, Alta., concrete structures	May 1.	Mar. 28.	70
Calgary, Alta., designs for aqueduct	May 1.	Feb. 22.	70
Calgary, Alta., steel highway bridges	Apr. 15.	Mar. 14.	68
Dorion, Ont., water pipe	Apr. 3.	Mar. 28.	59
Fredericton, N.B., culvert, McKenzie Hollow	Apr. 3.	Feb. 7.	89
Goderich, Ont., extension to breakwater and dredging ..	Apr. 15.	Mar. 21.	70
Hamilton, Ont., concrete poles.	Apr. 19.	Mar. 28.	59
Hamilton, Ont., water works extension	Apr. 10.	Mar. 28.	72
Holland Island, B.C., lighthouse	Apr. 20.	Mar. 21.	60
Lethbridge, Alta., grading, sanitary sewers, etc.	Apr. 11.	Mar. 14.	70
Lion's Head, Ont., extension wharf	Apr. 16.	Mar. 28.	60
London, Ont., cast iron pipe......		Mar. 28.	72
Medicine Hat, Alta., church	Apr. 12.	Mar. 28.	59
Moose Jaw, Sask., water-tube boilers, etc.	Apr. 17.	Mar. 28.	59
Moose Jaw, Sask., supply of coal	Apr. 13.	Mar. 21.	59
Ottawa, Ont., machinery for yard dipper dredge	Apr. 9.	Mar. 28.	60
Ottawa, Ont., coal	Apr. 10.	Mar. 28.	60
Ottawa, Ont., alterations to fuel testing building	Apr. 9.	Mar. 21.	60
Point Atkinson, B.C., concrete tower, etc.	Apr. 20.	Mar. 21.	60
Point Grey, B.C., plans for university	July 31.	Feb. 7.	60
Port Arthur, Ont., paving	Apr. 8.	Mar. 14.	68
Saskatoon, Sask., pavement ..	Apr. 5.	Mar. 14.	68
Sarnia, Ont., wharf and dredging basin	Apr. 18.	Mar. 28.	60
St. John Harbor, N.B., dredging	Apr. 9.	Mar. 28.	60
St. Boniface, Man., sewer	Apr. 15.	Mar. 28.	60
St. Jerome, Que., hydro-electric installation		Feb. 7.	68
Sudbury, Ont., sewers, etc.	Apr. 17.	Mar. 21.	60
Toronto, Ont., storm overflow sewer, Garrison Creek	Apr. 9.	Mar. 21.	72
Toronto, Ont., dredging	Apr. 3.	Mar. 28.	70
Toronto, Ont., concrete walks ..	Apr. 19.	Mar. 28.	60
Vernon, B.C., C. I. manholes, frames, etc.	Apr. 8.	Mar. 28.	60
Westmount, Que., cement, sand, etc.	Apr. 3.	Mar. 28.	60
Winnipeg, Man., machine shop..	Apr. 18.	Mar. 28.	60

TENDERS.

Battleford, Sask.—Tenders for the construction of a building for the Battleford High School Board, will be accepted up to April 6th, 1912. Plans and specifications at the office of Robert S. Byers, Architect, Saskatoon, or W. C. Soole, Secretary-Treasurer, Battleford.

Battleford, Sask.—Tenders for laying approximately 150,000 sq. ft. of cement sidewalk, with crossings and curbing, will be received by H. C. Adams, secretary-treasurer of the town of Battleford, up to noon of April 15th, 1912. Wm. Kitson, Town Engineer. (See advt. in Canadian Engineer).

North Battleford, Sask.—Tenders will be received by the Secretary-Treasurer as follows:—

(1) Until Monday, April 22nd, 1912, for constructing 180,000 sq. ft. of concrete walks.

(2) Until Tuesday, April 30th, 1912, for labor laying water mains and sewers. Also construction of power house.

(3) Monday, April 15th, 1912, for furnishing and erecting boiler; furnishing and erecting 750 h.p. steam engine and accessories; furnishing and erecting 500 k.w. generator and equipment. Plans and specifications may be seen at the office of the engineers, Toronto and Winnipeg, and at the Town Hall, North Battleford, on and after the following dates:—(1) April 3rd, 1912; (2) April 10th, 1912; (3) April 17th, 1912. J. Griese, Esq., Mayor; H. W. Dixon, Esq., secretary-treasurer; Messrs. Chipman & Power, engineers.

Carleton Place, Ont.—Tenders will be called for shortly for water supply, sewerage and sewage disposal works. Albert E. Crain, Mayor.

Edmonton, Alta.—Tenders will be received by the City Commissioners until April 30th, 1912, for the construction of a reinforced concrete tunnel sewer. Specifications and forms of tender may be obtained at the office of the City Enginer, Edmonton; also at the office of The Canadian Engineer. (See advt. in Canadian Engineer). A. J. Latornell, City Engineer.

Kentville, N.S.—Tenders will be received until April 15, 1912, for the erection of a brick and reinforced cement academy building for the town of Kentville, N.S. Plans and specifications at the town office, Kentville, or at the office of the Architect. J. Carroll, Town Clerk, Kentville. Leslie R. Fairn, Architect, Aylesford, N.S.

London, Ont.—Tenders will be received until May 1st, 1912, at the office of the City Clerk, for a modern 75-foot aerial hook and ladder truck, the apparatus to be delivered f.o.b., Central Fire Station, London, Ont., on or before August 1st, 1912. Tenders will also be received for bids on the old aerial truck, now in service, at the same time and date. W .D. I. Wright, Chairman No. 3 Committee. John Aitken, Chief, Fire Department.

Moose Jaw, Sask.—Tenders will be received up to noon of April 1-th, 1912, for the delivery of sewer pipe and specials f.o.b. cars, Moose Jaw. City Commissioners. (See advt. in Canadian Engineer).

Moose Jaw, Sask.—Tenders for cast-iron pipe and specials will be received by the City Commissioners up to noon of Monday April 15th, 1912. (See Advt. in Canadian Engineer).

Moose Jaw, Sask.—Tenders for the supply and delivery of about 700 barrels of Portland cement, will be received by the City Commissioners, Moose Jaw, up to noon of April 9th, 1912.

Ottawa, Ont.—Tenders will be received until April 18th, 1912, for the construction of a reinforced concrete sewer at St. Boniface, Man. (See advt. in Canadian Engineer).

Ottawa, Ont.—Tenders will be received until noon of April 20th, 1912, for supplying and delivering the steam coal required for the fog alarm stations in the New Brunswick Agency during a period of one, two or three years at the option of the Department. Specifications, etc., can be obtained from the Marine Department at Ottawa, and from the agent of this Department at St. John, N.B. Alex. Johnston, Deputy-Minister of Marine and Fisheries, Department of Marine and Fisheries, Ottawa.

Ottawa, Ont.—Tenders will be received until May 1st, 1912, for the erection of additions and for certain alterations at the Mount Elgin Industrial School, Muncey, Ont. Plans and specifications may be seen at the office of the Principal, Muncey, and at the office of the Indian Agent, Dekaware, at the post offices, London, St. Thomas, and Hamilton, and at the office of J. T. Sing, C.E., Confederation Life Building, Toronto. J. D. McLean, Assistant Deputy and Secretary, Department of Indian Affairs, Ottawa.

Ottawa, Ont.—Tenders for the erection of a teacher's residence and a school-house on the Little Pines Reserve, Sask., will be received by J. D. McLean, Assistant-Deputy and Secretary, Department of Indian Affairs, Ottawa, up to noon of May 6th, 1912. Plans and specifications at the offices of the Indian Agent, Battleford; the Indian Agent, Duck Lake, and W. J. Chisholm, Inspector of Indian Agencies, Prince Albert; and the Indian Office, Winnipeg.

Penticton, B.C.—Tenders will be received until April 18th, 1912, for the erection of a concrete and steel power station, including all materials except as specified. Plans and specifications may be seen at the office of F. H. Latimer, Consulting Engineer, Engineer for the Municipality, Penticton, B.C., to whom all tenders may be addressed, and at the office of Mather, Yuill & Co., Consulting Electrical Engineers, 429 Pender Street, Vancouver, B.C.

Port Arthur, Ont.—Tenders will be received up to noon of April 15th, 1912, for the supplying and installation of a 50 box fire alarm system, with the necessary central station equipment. J. J. Hackney, Commissioner Utilities. (See Advertisement in Canadian Engineer.)

Prince Albert, Sask.—The time for opening tenders for Contract 12G for 2,400 lin. ft. of concrete outfall sewer disposal works, has been extended to noon, Monday, April 15th, 1912. C. O. Davidson, Secretary-Treasurer, Prince Albert. (See advt. in Canadian Engineer).

Regina, Sask.—Tenders will be received until noon of Friday April 12th, 1912, for the excavation of about three miles of trenching for and the laying therein of 6-inch to 15-inch vitrified pipes, construction of manholes, etc., for water collecting lines at the source of supply in the Boggy Creek Watershed near Regina. Plans, etc., may be had from R. O. Wynne Roberts, Consulting Engineer, P. O. Box 65, Regina. (See Advt. in Canadian Engineer).

Saskatoon, Sask.—Tenders will be received until noon, April 6th, 1912, for supplying cast-iron sidewalk gratings. All information may be obtained on application to Geo. T. Clark, City Engineer, Saskatoon.

Toronto, Ont.—Tenders will be received up to noon of Wednesday, April 10th, 1912, for the erection of the new entrance at Dufferin Street to the Exhibition Grounds, and also the erection of a combined fire hall and police station on the Exhibition Grounds. Specifications and plans may be seen and full information obtained at the office of George W. Gouinlock, Architect, Temple Building, Toronto. G. R. Geary, Mayor, Chairman Board of Control, City Hall, Toronto.

Toronto, Ont.—Tenders will be received until noon April 9th, 1912, for one 36-inch check valve for the waterworks department. Specifications may be seen and forms of tender obtained at the office of the City Engineer, Toronto. G. R. Geary (Mayor), Chairman of the Board of Control, City Hall, Toronto. (See Advt. in Canadian Engineer.)

Toronto, Ont.—Tenders will be received at the office of Symons & Rae, until noon, April 22nd, 1912, for all trades required in the erection of St. Alban's Cathedral, Toronto. Drawings, etc., may be obtained at the office of Symons & Rae, Superintending Architects, 15 Toronto Street. Cram, Goodhue & Ferguson, Architects, Boston and New York.

Winnipeg, Man.—Tenders will be received until April 9th, 1912, for the supply of a 50-h.p. gasoline traction engine, to be delivered f.o.b., city yards, on or before May 15th, 1912. Specifications, etc., at the office of the City Engineer, 223 James Avenue. M. Peterson, Secretary, Board of Control Office, Winnipeg.

Winnipeg, Man.—Tenders are wanted for evaporating and bottling plant, at Little Lake, Manitou. Must be built before the first of May. Morrel's Manitou Mineral, Limited, Winnipeg.

CONTRACTS AWARDED.

Brampton, Ont.—Concrete reservoir; Mr. John Patterson; $3,600, and 30c. cubic yard for excavation. Tenders for pumps and meters have not yet been awarded.

Calgary, Alta.—A contract has been let at Edmonton for the construction of a sandstone brick plant to cost $100,000.

Chesley, Ont.—Public building; Messrs. Gilpin Bros., Wiarton, Ont.

Grand Falls, N.B.—Post Office and Customs interior fittings; the J. T. Schell Co., Alexandria, Ont.

Lockport, Man.—Approaches to bridge, Red River; the Brown Construction Co., Ltd., Winnipeg, Man.

Municipality of Surrey, B.C.—Erection of dams and excavation work; Messrs. M. P. Cotton & Co., Vancouver, B.C., $85,924, without gates.

New Liskeard, Ont.—Wharf; Mr. C. L. McCool, Fort William, Que.

Ottawa, Ont.—The contracts awarded for the Kent Street school alterations are as follows:—Carpenter and brick work, Taylor and Lackey, $9,113; galvanized iron work, Architectural Sheet Metal Company, $1,056; heating and plumbing, McKinley and Northwood, $3,373; painting and glazing, W. J. Carson, $925; fans, etc., Canadian Sirocco Company, Limited, $595; plastering, T. Brethour and Company, $400.

Port Arthur, Ont.—Office building for Alberta Land Co.; Mr. J. L. McRae; brick, two stories, 90-ft. x 110-ft.; cost, $62,000; Messrs. Hood & Scotte, architects.

Prince Albert, Sask.—Mr. Wm. Osemun, of Kinistino, has closed a contract with the C.N.R. for the grading of fifty miles of railway from Prince Albert towards Hudson Bay.

Stewart, B.C.—Extension to wharf, Portland Canal; W. G. Gillett, 429 Pender St. W., Vancouver, B.C.

Toronto, Ont.—Tenders on the construction of the Connaught Public School, amounting to $96,798, have been awarded as follows:—Masonry, Bayliss & Sons, $53,200; terra-cotta, Robert Bennett, $6,608; carpentry, William Williamson, $22,545; plastering, George White, $5,294; painting, J. R. Robinson, $2,630; roofing and tinsmithing, W. E. Dillon & Company, $2,021; iron stairs, Canadian Ornamental & Iron Company, $4,500. The total estimated cost of the Connaught School is $115,000, and work on which tenders are yet to be received are plumbing, heating, ventilation and wiring. The tender of the cabinet work in the manual training department of Brown School was awarded to the Beverley Wood and Specialty Company for $488.

Vancouver, B.C.—Messrs. Robertson, Godson & Co., Ltd., of Vancouver, have received the contract for the supply of water pipe for the proposed extensions to the water works distribution system, during the current year, at a contract price of $66,054. Other bidders and their prices are as follows:—Messrs. Crane Company, $68,643.50; Messrs. Evans, Coleman & Evans, Ltd., $68,443; Messrs. Balfour, Guthrie Co., Ltd., $68,837.50.

Victoria, B.C.—Messrs. Parfitt Bros. have secured the contract for the erection of an important addition to the emergency plant of the British Columbia Electric Company. They will erect a new cement roof and other fire-proof parts.

Welland, Ont.—Mr. Marcus Vanderburg, of Welland, has secured the contract for the extensive factory buildings at Port Robinson for the British-Canadian Canners, Ltd. The company will also build factories at Bowmanville, Cobourg, Merlin and Highgate.

West Toronto, Ont.—The contract for the construction of tar macadam pavement from Humber bridge to Mimico at $10,000 per mile, has been awarded to the McKnight Construction Company.

Weyburn, Sask.—J. H. Simmons, of Winnipeg, has secured the contract for building a freight shed for Canadian Pacific Railway, to cost $25,000. T. Martin, Moose Jaw, Divisional Engineer.

Winnipeg, Man.—Messrs. C. W. Sharpe & Son have signed the contract for the new C.P.R. building at Edmonton to cost $350,000.

RAILWAYS—STEAM AND ELECTRIC.

British Columbia.—Mr. William McNeill, chairman of the directors of the projected Burrard, Westminster, Boundary Railway and Navigation Company, has returned from Ottawa and is reported to have stated that ample capital for the commencement of the project has been secured and that the work will proceed at once if the provincial government show that they are in accordance with the scheme.

Calgary, Alta.—It is reported that the Chicago, Milwaukee and St. Paul Railway Company will construct a line from Butte, Montana, into Canada, and that part of the proposed route has been surveyed, and that it will pass through the Flathead Valley and into Alberta.

London, Ont.—The Water Commissioners have engaged the services of an expert to place a value on the plant and belongings of the London Street Railway with a view to purchase the same at a future date.

LIGHT, HEAT AND POWER.

Gatineau Point, P.Q.—This municipality will construct a new system of electric lighting to cost $25,000. Mr. Lafortune is the mayor of this town.

Hull, P.Q.—The municipal council have stated that the funds available for the present will not permit the erection of a "white way" and if the same is constructed the citizens will have to pay for it themselves. Some members of the city council desire a movement made for aid from the provincial government of Quebec.

Sudbury, Ont.—Considerable damage was done to the plant of the Wahnapitae Power Company by the bursting of a turbine case.

Victoria, B.C.—The emergency power plant of the British Columbia Electric Company will be increased by the addition of about $25,000 worth of new apparatus, and extensions to the building. A new cement and fire-proof roof and other structural alterations will be made.

Victoria, B.C.—The city council have authorized the calling of tenders for the supply of cluster light materials.

GARBAGE, SEWAGE AND WATER.

Brighton, Ont.—The Reeve and Council of Brighton have instructed Mr. T. Aird Murray, of Toronto, to prepare plans for a gravity water supply for the town. The water will be taken from springs located north of the town.

Carleton Place, Ont.—The Board of Water and Sewerage Commissioners have completed an agreement with Mr. T. Aird Murray, of Toronto, to act as consulting and supervising engineer for works of water supply, sewerage and sewage disposal. The town recently passed a by-law for a sum of $150,000 for the above purposes. Tenders will be called for in the course of a month and the work proceeded with this year with as little delay as possible.

Cobourg, Ont.—The Town of Cobourg contemplates extensive additions to its sewerage system. Mr. T. Aird Murray has been engaged by the corporation to prepare plans for a system including sewage disposal for the western section of the town. The Northumberland and Durham Counties have also instructed Mr. Murray to at once prepare plans and specifications for a complete sewage disposal system for the House of Refuge. The work will be let by contract at an early date.

Edmonton, Alta.—The superintendent of the municipal waterworks has expressed his opinion in favor of the purchase of a duplicate of the large steam pump recently installed.

Lethbridge, Alta.—During the construction of the sewage plant it has been found that the estimated cost of $76,500 voted by the ratepayers will not complete the work, and that an additional $17,000 will be required. The total for the plant is made up as follows:—

Hotson, Leader & Goode's contract	$65,000
Roof for filters	7,000
For lifting sewage from No. 2 outlet to sewage plant.	2,000
Hauling 7,000 yards of cinders by city	10,000
Engineering, approximately	9,000
Total.	$93,000

Saskatoon, Sask.—The employees of the city have completed the task of constructing a new intake for the municipal water supply.

Saskatoon, Sask.—The date for opening of tenders for the outfall sewer and disposal work has been postponed until noon of Monday, April 15th. Geo. T. Clark, City Engineer.

Toronto, Ont.—The recommendations of Judge Winchester, who has been preparing a report on the water supply system of this city, include the purchase of Venturi meters to ascertain the loss between reservoir and main pumping station, a steel pipe to replace the cement one now in use, and that the pumping station be enlarged and electrical equipment be installed throughout.

BUILDINGS AND INDUSTRIAL WORKS.

Calgary, Alta.—Work is to be resumed immediately on the new million dollar store building for the Hudson Bay Company and an effort will be made by the contractors to have the building ready for occupation November 1.

Langdon, Alta.—The Canadian Pacific Railway will erect a dam at this point. The project is for the purpose of storing water for the irrigation system throughout the country around this town.

Lethbridge, Alta.—Mr. A. Southard announces that he intends to erect a six story hotel structure in this city. The cost of the undertaking will be about $300,000. The building will contain 200 rooms and be constructed of brick and terra cotta.

Ottawa, Ont.—A new company which will be known as the Gatineau Spa Milling Company, composed of prominent business men of Ottawa and Hull, is in process of formation. The company which is capitalized at $125,000, has acquired quarries situated in the Gatineau Valley. Messrs. Belcourt and Ritchie are engaged in organizing the new industry.

Port Arthur, Ont.—The ratepayers of this city will erect a new municipal hall to cost $100,000. The Central School site has been chosen for the structure.

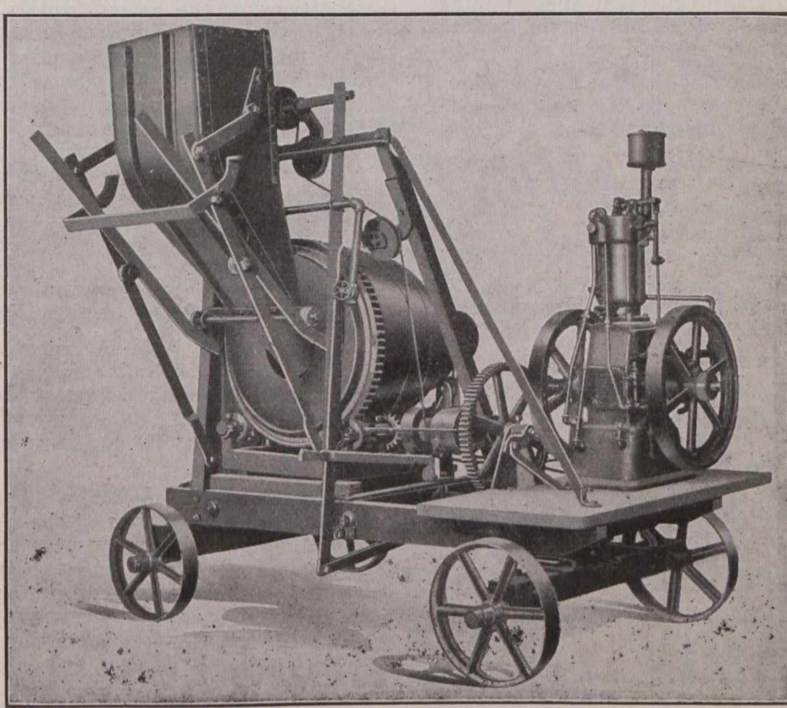
Regina, Alta.—The Security Lumber Company plan to erect lumber yards and sheds in this city. The head office of this concern is in Winnipeg, Man.

Saskatoon, Sask.—An addition to the programme of large buildings for the coming season has been made owing to the announcement of Messrs. S. R. and W. Ross of their intention to erect a seven story structure for office purposes in this city. The building will contain one hundred and forty offices and will be fitted with all modern conveniences for mercantile pursuits.

Saskatoon, Sask.—There is serious talk of the municipal controllers taking definite steps toward the construction of a civic abattoir. Ald. Maclean and Blackstock are the committee that will report on the project.

Saskatoon, Sask.—Messrs. Harrison and Jones, brick manufacturers, England, are about to consider the erection of a brick plant in this city. Mr. Charles R. Hill, Saskatoon, is interested in the matter.

Welland, Ont.—Mr. J. L. Weller, superintending engineer of the Welland Canal, reports that it is the intention to sink large steel tubes underneath the canal at the north end of the aqueduct, from the river above, where the present lock is, to the river below the aqueduct and change, for that distance, the bed of the river, carrying it through these tubes instead of underneath the aqueduct as at present.



BRIDGES, ROADS AND PAVEMENTS.

Brantford, Ont.—The Grand Trunk Railway officials are considering the rebuilding of the bridge over the Grand River at a cost of $50,000. The proposal is to move the easterly abutment eighteen feet farther east and add a span at the west end of 68 feet 6 inches. Also to rebuild the centre part with two trusses and another girder. The old bridge consists of three spans of 100 feet each, having a clear water way of 285 feet. The clear water way of the proposed bridge will be 366 feet. To get this will mean the building of two new abutments, and three piers, the westerly abutment being turned into a pier.

Gatineau Point, P.Q.—The Provincial Government of Quebec Province have sanctioned the expenditure of $20,000 for the construction of macadamized roads around and in this locality. Mr. Lafortune is the mayor of this town.

Galt, Ont.—A proposal has been made that the present bridge doing service on Main Street of this town be moved below the waterworks and provide an entrance to the industrial section.

Halton County, Ont.—The Halton County Council propose to spend $300,000 on road improvements in their county. This includes the grant recently made by the government.

Kildonan, Man.—The council of this municipality are considering the erection of a bridge to cost $165,000.

Province of Manitoba.—Premier Roblin, during a discussion on the estimates in connection with grants to the various municipalities of the province in aid of roads and bridges, stated that at the present time the government was considering a policy of having a standard road for the province, and also of bringing in a bill at this session defining the position to be taken by the government on the important question of good roads.

Nelson, B.C.—Chief Provincial Engineer Griffiths will advocate that the proposed bridge across the Kootenay River at Nelson be a quarter of a million dollar steel and concrete structure instead of the pile bridge originally planned. A permanent bridge is necessary to meet the rapidly growing requirements of this district.

Saskatoon, Sask.—This municipality will purchase six new road sprinklers during the coming spring. Geo. T. Clark, city engineer.

South Vancouver, B.C.—The municipal council will consider a new by-law dealing with the collection and handling of the civic garbage. It is proposed to fill certain ravines and gullies around the city with the refuse.

St. John, N.B.—The Provincial Government has announced that an agreement has been reached with the St. John Railway Company with regard to the erection of a bridge, to cost $335,000.

FIRES.

Lindsay, Ont.—Fire destroyed the plant and premises of the Hood Knitting Company.

Oshawa, Ont.—The car barns of the Oshawa Railway Co. were destroyed by fire on the morning of March 29th last. The loss is placed at $20,000.

Ottawa, Ont.—The plant of the Ottawa Paint Works was destroyed by fire on March 28th, last. Loss estimated at $8,000.

Orillia, Ont.—The sash and door factory of J. R. Eaton and Sons was destroyed by fire on March 27th last.

CURRENT NEWS.

Lethbridge, Alta.—Tenders will be called at an early date for the work of laying and constructing the municipal sanitary sewers, street grading and cement sidewalks.

Calgary, Alta.—The Canada Western Natural Gas, Heat, Light and Power Company will lay their underground mains by means of a mechanical trencher with a capacity of one mile, six feet deep and twenty-two inches wide, per twenty-four hours. The digging pieces or buckets are caused to pass along in rotation, each grasping its capacity of earth or gravel and in turn depositing it on a wooden slide that passes it out to one side. The digging part of the machine, which gets its power from a 24 horsepower gasoline motor, is similar to that of many river dredges.

Frank, Alta.—The Canadian Pacific Railway will confer with the federal authorities for the making of an expert's report on the advisability of blowing up Turtle Mountain at Frank.

Moncton, N.B.—The natural gas piping is now completed in this city the first users of the commodity being Messrs. John Abram and Sons. This firm will use the gas for boiler operations as soon as the necessary appliances are installed.

Montreal, P.Q.—The Shipping Federation and the Montreal Board of Trade have petitioned the federal government that the wrecking plant of the Messrs. George T. Davis and Sons, of Levis, P.Q., be granted an increased subsidy and the plant retained in its present position on the St. Lawrence River for an emergency. There has been some talk of a sale being concluded with the owners and another shipping firm. The proposition will be considered by the cabinet.

Moose Jaw, Sask. — Money by-laws totalling $741,000 have been passed by the ratepayers. They include $95,000 for 11th avenue subway; $225,000 for electric plant extensions; $70,000 for public library; $170,000 for sewer and water extensions; $6,000 for exhibition ground improvements; $16,000 for the paving programme. An option was also given of $15,000 or $10,000 grant for the board of trade campaign, and the former carried. All the by-laws had sweeping majorities.

Quebec, P.Q.—The federal government are preparing plans for an increased wireless telegraph equipment at this point. The present station in the Citadel is only a half-kilowatt one, and it is impossible to get communication with Father Point, or Montreal, without relaying at the stations at Grosse Isle or Three Rivers. The new station will be one of five kilowats, or perhaps ten, so that direct communication will be established with places hundreds of miles distant.

Regina, Sask.—The municipal council are about to appoint a Health Officer for the city.

Vancouver, B.C.—This municipality recently witnessed the working of a new system of fire alarm methods. Representatives of the manufacturers fitted up a working model and invited fire insurance inspectors, electricians and business men to the demonstration. The great point of difference with the systems now in use is that the ordinary civic telephone wires are the main part of the new apparatus. A small signal box is connected with the house instrument in such a method as to not interfere with the workings of the telephone. At the fire station end of the system the usual signal boards are used and should a fire occur in a building a contact button is pressed on the cover of the box, a buzzing sound in the central exchange warns the operator that the attention of the fire station is requested and she connects the telephone in the burning building with the fire station and saves the time of an ordinary call.

Vancouver, B.C.—A report states that a number of British and French financiers have decided to promote a scheme for building a floating dry-dock for Vancouver. The capital for the scheme has already been subscribed, and joint boards have been formed in London and Paris in connection with the project.

Vancouver, B.C.—The mayor of this municipality has decided to make a tour of the city and fix the blame for the condition of the dirty streets and lanes that exist in some portions of the city. As there appears to be some difference as to the share of responsibility held by the health authorities, the police and the fire warden, as well as the Board of Works, the mayor considers that a joint tour will do a great deal to clear the matter up and effect more co-operation.

West Vancouver, B.C.—There has been a movement made to appoint a city engineer for this municipality. Applicants may address the clerk of North Vancouver.

The smelting of metallic ores in Canada during 1911 did not produce the profit that was enjoyed from the same industry in the year 1910. The following list has been com-

piled from the mines branch of the Dominion Government at Ottawa. The ores treated may be classified as follows:

	1910, tons.	1911, tons.
Nickel-copper ores	628,947	610,834
Silver cobalt-nickel-arsenic ores	9,466	8,504
Lead and other ores in lead furnaces	57,549	55,408
Copper-gold-silver ores	1,987,752	1,517,981
Total	2,683,714	2,192,727

The closing down of the Granby smelter in British Columbia, due to the coke shortage, was the principal cause of the falling off in copper-gold ores treated.

The products obtained in Canada from the treatment of these ores include: Refined lead produced at Trail, B.C., and fine gold, fine silver, copper sulphate and antimony produced from the residues of the lead refinery; silver bullion, white arsenic, nickel oxide and cobalt oxide produced in Ontario from the Cobalt district ores.

TRADE ENQUIRIES.

The following were among the enquiries relating to Canadian trade received at the office of the High Commissioner for Canada, 17 Victoria Street, London, S.W., during the week ending March 11th, 1912:—

An English firm of fancy leather dressers are desirous of getting into touch with Canadian importers and users of bookbinding and fancy leathers.

A London firm manufacturing electrotyping machinery and appliances, elevating laying machines, box board printing machines, branding machines, box trimming and nailing machines, stereotyping machinery and appliances, desire to get into touch with Canadian importers.

An East Anglian firm specializing in the manufacture of cement-making plant desire to enter into Canadian business connections.

The following were among the enquiries relating to Canadian trade received at the office of the High Commissioner for Canada, 17 Victoria Street, London, S.W., during the week ending March 18th:—

A Bristol correspondent makes enquiry for the means of Canadian furniture manufacturers open to establish themselves in his city.

A Yorkshire firm manufacturing elevators and conveyers for grain, coal, and all classes of material, as well as complete equipments for colliery surface plants, and specialties connected with automatic stoking and transport appliances, desire to get into touch with users of such machinery, and to appoint suitable representatives in Canada.

A London firm desire to appoint agents in Canada for the sale of their high-class decorative enamels and iron enamels.

A London firm manufacturing annealed tungsten wire lamps for steamships, piers, quays, cotton mills, etc., desire to get into touch with Canadian importers.

A correspondent now in London is proposing to establish in South Africa a general agency for Canadian goods of all descriptions, for which a large market exists, and would like to hear from Canadian manufacturers and produce exporters open to consider propositions.

An Indian firm of manufacturers and general agents desire to get into touch with Canadian manufacturers and produce exporters open to do business in India; also with importers of Indian products.

From the branch for City Trade Enquiries, 73 Basinghall Street, E.C.:

A South of England company manufacturing bungalows and all kinds of portable buildings would like to arrange for their sale in Canada.

A Lancashire manufacturer of belting (leather, cotton, balata, etc.,) would like to be placed in communication with Canadian importers.

A manufacturers' agent in Toronto asks to be placed in touch with United Kingdom manufacturers of bifurcated, tubular and other rivets of all kinds, and also self-feeding automatic machines for attaching same; leather measuring machines and manufacturers of belting, and garter elastic.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA.

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from The Canadian Engineer for small fee.

16135—March 14—Approving changes and alterations in C.P.R. station at Dufferin Bridge, Ottawa, Ont.

16136—March 15—Relieving C.P.R. from erecting and maintaining fences on its Sirdar subdivision, B.C.

16137—March 15—Authorizing C.P.R. (G.B. & S. Ry.) to cross two highways at mileage 82.89 and 82.02.

16138—March 18—Authorizing C.P.R. to reconstruct bridge No. 66.6 on Souris subdivision.

16139—March 18—Authorizing C.P.R. to construct spur track across Montcalm Street, in the city of St. Boniface, Man.

16140—March 18—Authorizing C.P.R. to construct industrial spur for city of Medicine Hat, Alta.

16141—March 18—Permitting C.P.R. to file a new location plan for its Molson St. Boniface branch, said plan to show a width of land that will coincide with arbitration notice filed by the railway company; application of E. B. Chambers and W. G. Phair, Winnipeg, Man.

16142—March 16—Approving revised location of C.N.R. (Swift Current Branch) mileage 78.29 to 124.96, Saskatchewan.

16143—March 16—Relieving G.T.R. from further protection of 2nd highway north of Huntsville, dist. of Muskoka, Ont.

16144—March 19—Further extending until April 1st, 1912, time for installation of interlocker at Nipissing Jct. by G.T.R. crossing C.P.R. and connecting with T. & N.O.

16145—March 20—Directing that Twp. of York shall at all times maintain bridge over Toronto Belt Line Ry. (G.T.R.) east of Yonge St., Toronto, as well as construct same.

16146—March 19—Authorizing C.P.R. to construct bridge 85.2 on its Portal subdivision, Sask.

16147—March 18—Naming express delivery and collection limits for city of Ottawa, Ont.

16148—March 20—Substituting Plan "A" for plan filed showing diversion C.N.O. Ry. approved by Order 13952, June 14, 1911.

16149—16150—March 20—Authorizing G.T.R. to construct siding for J. Goodwillie & Sons, Welland, Ont., and for J. T. Watson, in the Township of York, on Toronto Belt Line Railway.

16151—March 20—Authorizing town of Claresholm to extend Fourth Ave. across C. & E. Branch of C.P.R.

16152—March 21—Authorizing C.P.R. to reconstruct bridge No. 176.9 over Bow River on Calgary Sub-division.

16153—March 18—Rescinding Order No. 12783 on Jan. 18th, 1911, in complaint Dawson Board of Trade vs. White Pass & Yukon Route.

16154—March 22—Authorizing C.P.R. to construct its Lacombe Easterly Branch across highways from mile 140.31 to 143.61.

16155—March 22—Relieving C.P.R. from further protection at public highway near Griswold, Manitoba.

16156—March 21—Authorizing C.P.R. to construct spur for Vancouver Lumber Co., Ltd., in Townsite of Merritt, B.C.

16157—March 22—Authorizing C.N.O. Ry. to construct spur for Alexander Bruce and Company. Tie Preserving Plant, on Indian Reserve No. 18B in Twp. of McIrvine, Ontario.

16158—March 20—Approving rules of T.H. and B. Ry. for operation of automatic block signals.

16159—March 22—Approving location of Campbellford, Lake Ont. and Western Ry. Co., through town of Oshawa and revised location as previously approved by Order 11947 through Township of East Whitby mileage 29.1 to 34.2.

16160—March 22—Authorizing Montreal and Southern Counties Ry. to construct track from G.T.R. property east of Front St., St. Lambert, P.Q., to connection with Central Vermont Ry., crossing Victoria Ave. by overhead bridge.

16161—March 21—Directing G.T.R. to file special tariff or supplement to existing tariff C.R.C. No. 1686 to take effect not later than 8th April, 1912, establishing a rate of $3.00 per car for switching lumber from docks of F. McGibbon and Sons, of Sarnia, Ont., to storage yard and mill, for storage, sorting or dressing and re-shipment via. G.T.R.

16162—March 21—Authorizing G.T.R. to construct siding to premises of William Laking at Haliburton Sta., County Haliburton, Ont.

16163—March 22—Directing G.T.R. to at once remove shrubs, etc., at crossing of 1st highway east of Waterdown Station, Ontario. Cars of trains not to be left standing within 75 feet of crossing.

16164—March 20—Approving standard plan of Portable Depot of Great Northern Railway Company.

16165—March 25—Naming express delivery and collection limits for city of Hull, Que.

16166—March 22—Authorizing G.T.R. to construct spur into premises of Steel and Radiation, Ltd., St. Catharines, Ont.

16167—March 23—Authorizing Highway Board of Parish of Grand Falls, N.B., to construct highway across C.P.R.

16168—March 23—Approving location of C.P.R. Suffield to Kipp, Alta. Branch from main line near Suffield to mileage 21.

16169—March 13—Authorizing C.P.R. (G.B.&S.Ry.) to construct across Jackson Street, in village of Bethany, Ont.

16170—March 5—Approving location of G.T.P.Ry. station to be erected at Henry House, Alberta.

16171—March 25—Approving Supplement No. 8 to Express Classification for Canada No. 2.

16172—March 25—Granting certificate of correction to G.T.R. B.L. Co. correcting errors in revised plan at Cutknife Branch.

16173—March 25—Slightly amending Order No. 16076 March 5th, 1912, re Boissevain to Lauder Branch of the C.P.R.

16174—March 23—Authorizing city of Saskatoon to carry 20th Street across C.P.R. at Rail Level.

16175—March 25—Amending Order 16064 of March 1st, 1912, re Bridgeburg Bridge by adding clause that Municipality shall at all times and at its own expense maintain bridge, etc.

16176—March 26—Authorizing G.T.R. to construct bridge No. 165 at mileage 32.22 over Clubiness Creek and Bridge No. 166 at mileage 33.91 over Holland River, 11 District Northern Division.

SUPPLEMENTARY ESTIMATES.

The supplementary estimates brought down by the Finance Minister this week total $13,072,526 on consolidated fund and $6,537,512 on capital account, making $19,610,039 altogether. The main estimates were $104,919,304 on consolidated fund and $44,870,372 on capital account, making a total of $149,789,677. Thus the total will be: Consolidated fund, $117,981,831; capital account, $51,407,885; total, $169,389,716. In addition, a "further supplementary estimate" for the year 1911-12 gives $600,000 to the Intercolonial.

The supplementaries contain appropriations of $300,000 for new Dominion buildings in Toronto; $200,000 for Welland Canal construction; $100,000 for French River waterways improvements; $1,500,000 for terminal elevators, and $200,000 for seed grain to settlers on unpatented Western lands.

Chargeable to the Department of Agriculture is a grant of $500,000 to be paid to the provinces for the encouragement of agriculture. It is apportioned on a basis of population as follows:—

Ontario	$175,733
Quebec	139,482
Nova Scotia	34,288
New Brunswick	24,509
Prince Edward Island	6,529
British Columbia	27,334
Manitoba	31,730
Saskatchewan	34,296
Alberta	26,094

There is a grant of $200,000 for seed grain to settlers on unpatented lands in the Prairie Provinces.

The totals for militia are $561,947, among the votes being Stoney Creek monument, $14,000.

Under the head of railways and canals is a grant of $1,000,000 for subsidies to the provinces for improvement of highways. This is in proportion to population, and works out as follows:—

Alberta	$ 52,189.90
British Columbia	54,669.52
Manitoba	63,460.10
New Brunswick	49,019.86
Nova Scotia	60,576.90
Ontario	351,466.64
Prince Edward Island	13,059.70
Quebec	278,964.80
Saskatchewan	68,592.58

Other important grants are: Hudson Bay Railway, railway terminals and elevators, $1,500,000. Welland Ship Canal construction, $200,000.

Under the heading of public buildings capital appear the following votes: Acquiring site and construction of a Dominion Government Building at London, England, $1,000,000; buildings at Ottawa, $917,512.

Under harbors and rivers capital appear: French River waterway improvements, $100,000. Quebec harbor improvements, $1,000,000. Victoria Harbor, Ontario, improvements, $30,000.

Mail subsidies and steamship subventions amount to $204,000, including $105,000 for a service between Canada and West Indies or South America, or both.

There is a vote for $2,100 for gratuity and pension to the mother of Inspector Fitzgerald, who died on the Dawson-McPherson trail.

The National Battlefields Commission gets $114,500; $100,000 for the park at Quebec; $6,000 to repair No. 4 Martello tower, and the rest for administration.

The Farmers Bank enquiry is appropriated $15,000. A similar sum appears for expenses under the Enquiry Act. The monument to Alexander Muir gets $1,000. The Olympic team gets a grant of $15,000. The Child Welfare Exhibition is given $5,000. Under the post-office appears $200,000 for rural mail delivery. Under Trade and Commerce appears a vote of $1,500,000 for acquisition of terminal elevators. The Canada-West Indies Conference at Ottawa is allowed $5,000.

Tenders Called for

TOWN OF BATTLEFORD, SASK.

LAYING CEMENT SIDEWALKS.

Sealed tenders, addressed to the Secretary-Treasurer of the town of Battleford and endorsed "Tender for Cement Sidewalks," will be received up to noon of Monday, April 15th, 1912, for the following:—

Approximately 150,000 sq. ft. of Cement Sidewalk, with crossings and curbing.

A deposit in the amount of $500.00 must accompany each tender, and a bond in the amount of $2,000.00 will be required of the successful bidder. The lowest or any tender not necessarily accepted. Plans and specifications can be obtained from the Town Engineer, or at the office of The Canadian Engineer, 820 Union Bank Building, Winnipeg.

WM. KITSON, Town Engineer.
H. C. ADAMS, Secretary-Treasurer.

Tenders Continued on Pages 72, 74 and 76.

QUEBEC GRANTS RAILWAY SUBSIDIES.

Railway land subsidies amounting to $5,000,000 and printed in the form of resolutions, have been prepared for the consideration of the Quebec House of Assembly. Of the many hundred miles of railway to be subsidized which have been included in the said resolutions, a good part are revoted from the Act of 1908 for the reason that the conditions prescribed at that time have not been fulfilled. Included in the resolutions is a subsidy for the construction of a line to James Bay and for the extension of a line into the Temiskaming district. Hon. Mr. Taschereau, minister of public works, stated that the general idea of the grants of subsidies was to encourage the building of the railroads and for the opening up of new tracts of land in Quebec province.

The subsidy to the James Bay line makes no reference to the name of the railway which is to win the aid from the government. For the first two hundred miles from Montreal a company will be subsidized at the rate of 4,000 acres per mile, that is, for the section from Montreal to the Transcontinental, and 5,000 acres per mile from the latter point to the mouth of the Nottaway River, on James Bay, being a distance of 300 miles.

In but two instances is the clause omitted that the grant is not convertible in money, and these instances are for the costruction of a line from Chaudiere Junction, in Levis county, to Sherbrooke, and for two other short lines, as well as for the construction of a line from Nairn Falls, in Charlevoix county, to Ha-Ha Bay.

The Canadian Pacific Railway Company's shops at Calgary will be built by Messrs. Westinghouse, Church, Kerr & Company, of Pittsburg, U.S.A. It is intended to have the shops in operation December 1st next. The contract includes the design and construction of locomotive, machine, boiler, blacksmith, pattern, coach, freight car repair and paint shops, and foundry, planing mill, power-house, dry-kiln, scrap docks, material bins, storeroom and office buildings. In general the construction will be concrete, steel, brick or hollow tile.

Latest reports from the Rocky Mountain section of the Grand Trunk Pacific Railway show that track has been laid on the various sections as follows—Wolf Creek to Athabasca River, 100 miles; Yellowhead Pass to Tete Jaune Cache, 58.5 miles; Aldermere to Copper River, 38 miles; Copper River to Prince Rupert, 100 miles. Rivetting on the superstructure of the Athabasca River Bridge has been completed, and the deck was commenced on February 26th, so that trains are now able to cross upon it. The round house at Fitzhugh has also been completed.