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The Canadian Engineer

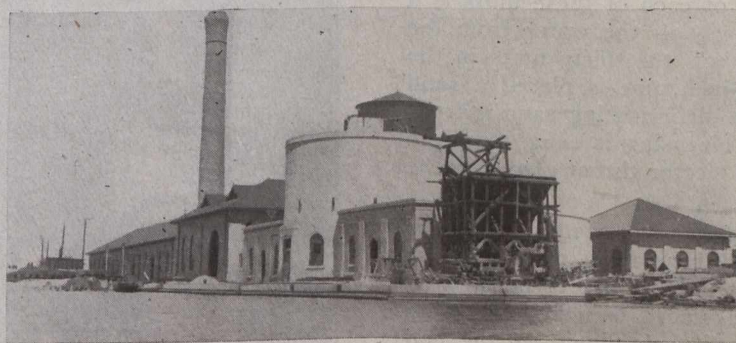
A weekly paper for Canadian civil engineers and contractors

TORONTO'S MECHANICAL FILTRATION PLANT

SIXTY-MILLION-GALLON RANSOME DRIFTING SAND FILTER BUILT AT COST OF OVER MILLION DOLLARS—FIRST MUNICIPAL PLANT OF ITS KIND ON THIS CONTINENT—NO SEDIMENTATION—SAND CONSTANTLY WASHED.

IN *The Canadian Engineer* of April 23rd, 1914, April 8th, 1915, and November 25th, 1915, there were described in a general way some of the details connected with the 60-million-gallon Ransome drifting sand water purification plant for the city of Toronto. As the plant is now practically completed, with the exception of filling the filters with sand, a more up-to-date description is possible.

Fig. 1 shows the general arrangement of the plant as built. Generally speaking, the substructures of the buildings are built of reinforced concrete and the superstructures of a buff pressed brick. The cement was supplied by the Canada Cement Co. On the steel framework forming the roof is placed boarding and on top of this red Spanish tile. The only exception to this form of construction is the coal chemical building which is built almost entirely of reinforced concrete with flat roofs, but having on the western elevation a brick front similar to the other buildings.



General View of Plant—Progress Photograph Taken August 17, 1916.

Fig. 2 shows a longitudinal section of the plant (not drawn to scale) as well as a section through a single filter. The water flows from Lake Ontario through two 72-inch diameter steel intake pipes into the suction well building. At the end of each of these pipes is placed a 72-inch hydraulically operated valve. These two valves are shown in Fig. 9. In the centre of the suction well the water passes through a duplicate set of screens, and after being treated with sulphate of alumina, it is pumped through one or more of three 36-inch diameter suction pipes connected with three 36-million-Imperial-gallons-per-day, low-lift pumps situated in the pumping station building. The plant has a maximum capacity of 72 million Imperial gallons per day and any two of these pumps will give this capacity. From the pumps the water passes through 36-inch check valves, thence through a 36-inch hydraulically operated stop valve, into a 72-inch steel pipe which supplies the filters. On this 72-inch pipe is placed a venturi meter to register the amount of water being filtered. The amount of water passing through this pipe, as registered by the venturi meter, is transmitted to a chemical feed control device situated in the chemical building. This 72-inch pipe is situated in an underground passage connecting the pumping station and the filter house.

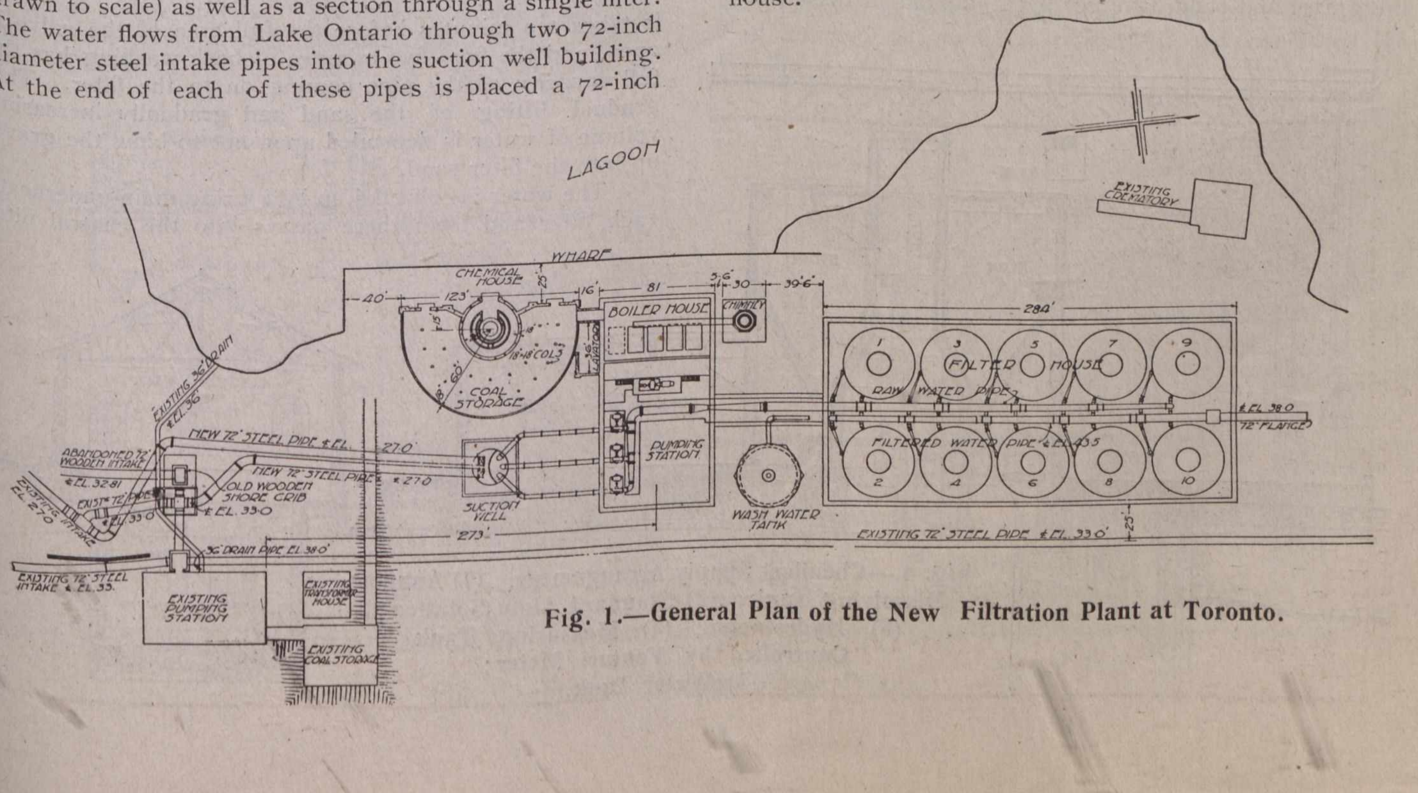


Fig. 1.—General Plan of the New Filtration Plant at Toronto.

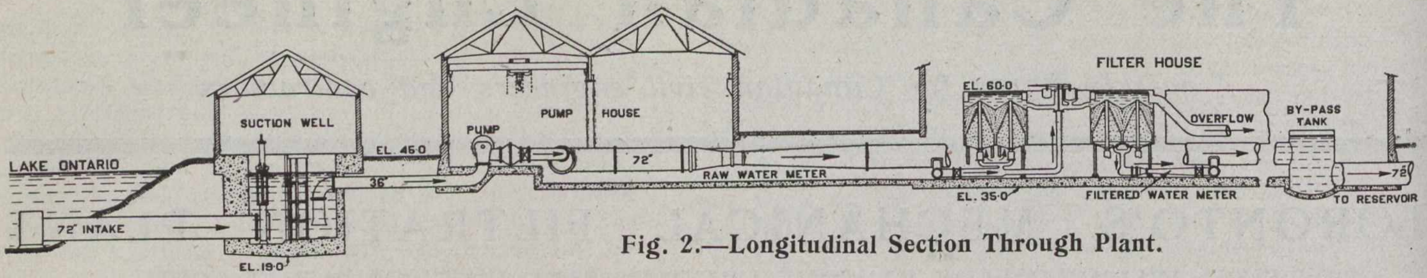


Fig. 2.—Longitudinal Section Through Plant.

The water is distributed from this pipe to each of the ten filters situated in the filter house. Each filter consists of a steel tank 50 feet in diameter and supported by cast iron columns. In the centre of the tank is a circular space 16 feet 8 inches in diameter in which is situated the relief valve apparatus. Each filter is sub-divided into thirty units, twelve in the inner ring and eighteen in the outer ring. These units are separated from each other by steel plates rising about 3 feet above the bottom of the underdrain system. Surrounding each unit is a space 2½ inches wide in which is placed a standard cast iron extractor system. Through the centre of each of these units is a 6-inch wrought iron pipe conveying the water from the raw water ring main to each of the thirty units in the filter. On the line of this 6-inch pipe is placed a sand washer by means of which the dirty drifting sand is freed from its impurities and after cleansing is caught up into the on-going pipe through an ejector throat placed in the sand washer.

The underdrain system consists of a cast iron collector from which radiates 1½-inch sherardized pipes. These 1½-inch pipes are placed 6 inches centre to centre and have a ⅜-inch diameter hole placed 6 inches centre to centre drilled in the bottom of each pipe. At the end of each of these pipes there is a sherardized cap. All of the drilling of holes and threading of these pipes is done before they are sherardized. Concrete is filled into the bottom of each of the units up to within 1 inch of the bottom of these collector pipes. Gravel is then placed around these pipes (to a depth of 9 inches) in three layers of different grades varying from 1¾-inch in diameter down to the size of pea gravel. On top of this is placed the filter sand to a depth of approximately 9 feet. Screens between the gravel and sand have not been adopted as these have been found to give way during backwash and aggravate the difficulty they were intended to remove.

The back-washing of these filters is to be done entirely with water and the apparatus will be automatically controlled so that the period of back-washing extends over 15 minutes. The control valve is fixed in such a way that it takes ten minutes before the full area of the valve is open, and the final five minutes of back-washing has the full capacity of the pipe coming on to the filter. This gradual lifting of the sand and gradually increasing volume of water is depended upon not to blow the gravel up into the filter sand.

The water is collected up into a ring main underneath each filter and from there passes into the central filter

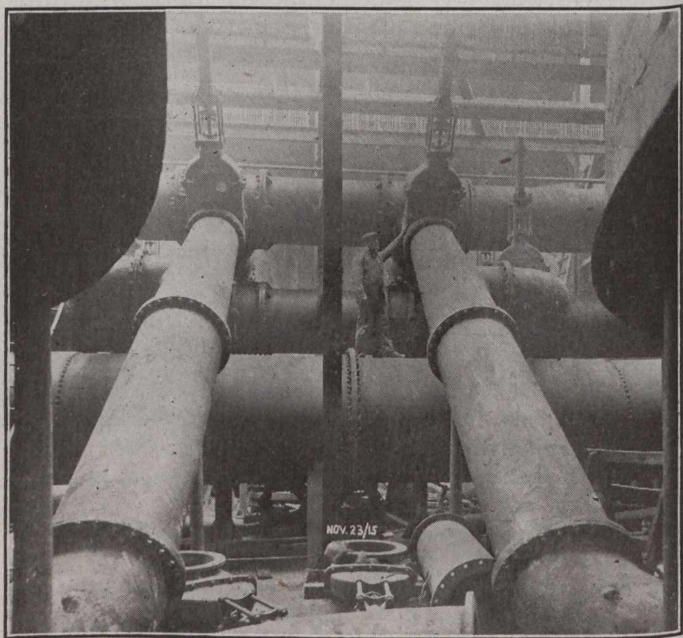


Fig. 3.—View Between Two Filters, Looking Towards Central Gallery.

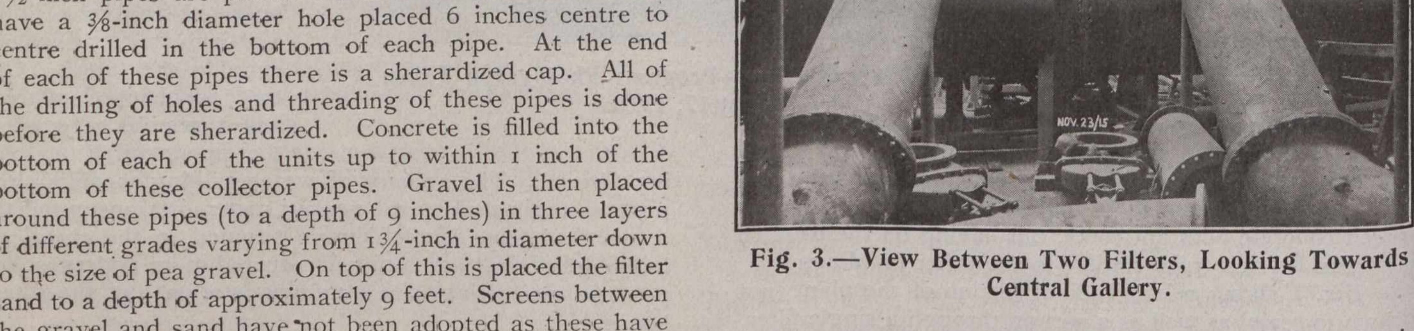


Fig. 4.—Chemical Supply Arrangement. (1) Annular Dissolving Tank; (2) Standard Alum Solution; (3) Hydrometer; (4) Measuring Tank Controlled by Venturi Meter; (5) Water Tank.

water main which collects the water from all ten filters. This central main tapers from 48 inches to 72 inches in diameter and at the north end of the filter house is connected to a by-pass tank from which the water flows by gravity to the reservoir attached to the existing slow-sand filtration plant. From the reservoir it flows through steel mains to the tunnel shaft at Hanlan's Point where it enters the tunnel constructed underneath the bay. Arrangements have also been made whereby the filtered water can be bypassed direct to the city without flowing through the storage reservoir.

Pumping Station.—The pumping station and boiler house are under one roof 75 ft. x 142 ft., with a division wall separating the boiler room from the pumping station. The boiler house contains four dry-back return tubular boilers of 300 h.p. each, capable of being run at 200 per cent. overload. The boilers are hand-fired, but automatic dampers regulate the draft and the steam pressure. They were built by the International Engineering Works. Connected with the boilers is a buff-colored radial brick chimney, 7 feet inside diameter and 120 feet above the level of the grate bar, built by the Custodis Canadian Chimney Co.

Toronto Hydro-Electric power is used for pumping. As a stand-by and for use during the peak load, a 1,200-kilowatt generator has been installed, gear-driven by a De Laval steam turbine. The three pumps supplying water to the filters operate against a total lift of 32 feet. The delivery of these pumps will be automatically maintained by the level of the water in the filters by hydraulically operated valves working through a pilot valve device. All of these pumps were supplied by the Turbine Equipment Co. and were De Laval pumps. In the pumping station seven smaller pumps have been installed for use as drainage pumps, hydraulic-power pumps and back-wash water-tank pumps. Provision has also been made for moving into this building some of the pumps from the existing slow-sand filtration plant. The switchboard has been constructed by the Canadian Westinghouse Co. Two 12-ton Hepburn travelling cranes have been installed for handling the machinery

Toronto Filter Plant Facts in Tabloid

Cost, approximately, $1,066,282
Normal Rate of Filtration, 60 million imperial gallons per 24 hours.
Maximum Rate of Filtration, 30 million imperial gallons in 10 hours.
Capital cost per million gallons normal capacity, $17,771.
Plan area of filters, 17,450 sq. ft.
Normal Rate of Filtration per sq. ft. filter area, 143 gals. per hr.
Number of Filters, 10.
Units in each Filter, 30.
Diameter of each Filter, 50 ft.
Depth of Filter tanks, 14 ft.
Loss of head in sand, 10.5 ft.
Loss of head in washers, 3.5 ft.
Average depth of sand in Filters, 9 ft.
Total sand in each Filter, 600 cu. yds.
Drifting sand in each Filter, about 300 cu. yds.
Weight of each Filter including sand and water, 1,550 tons.
Operating pressure on control valves, 700 lbs. per sq. in., hydraulic.
Plant area, 2.4 acres.
Guaranteed efficiency, 90 to 98%.
Contract awarded, May, 1914.
Probable date of completion, November, 1916.

Intake.—Two 72-inch steel pipes, running parallel 21 feet below water level, form the intake, the construction of which was difficult owing to the very liquid sand encountered and the close proximity of existing works. Each pipe connected to a valve chamber of the existing city intake. It was necessary to lay the intake pipe close underneath the two pipes carrying the existing water supply. Obstacles such as an abandoned wooden stave pipe, crib work, old concrete pipes and logs were encountered. The length of 95 feet from the south, working northwards, was piled with Lackawanna steel sheet piling on both sides, and the new pipes laid and concreted under water by divers. The northmost half of the intake was sheeted in a similar manner, but in this case the water was pumped out and the pipes laid and concreted in the dry.

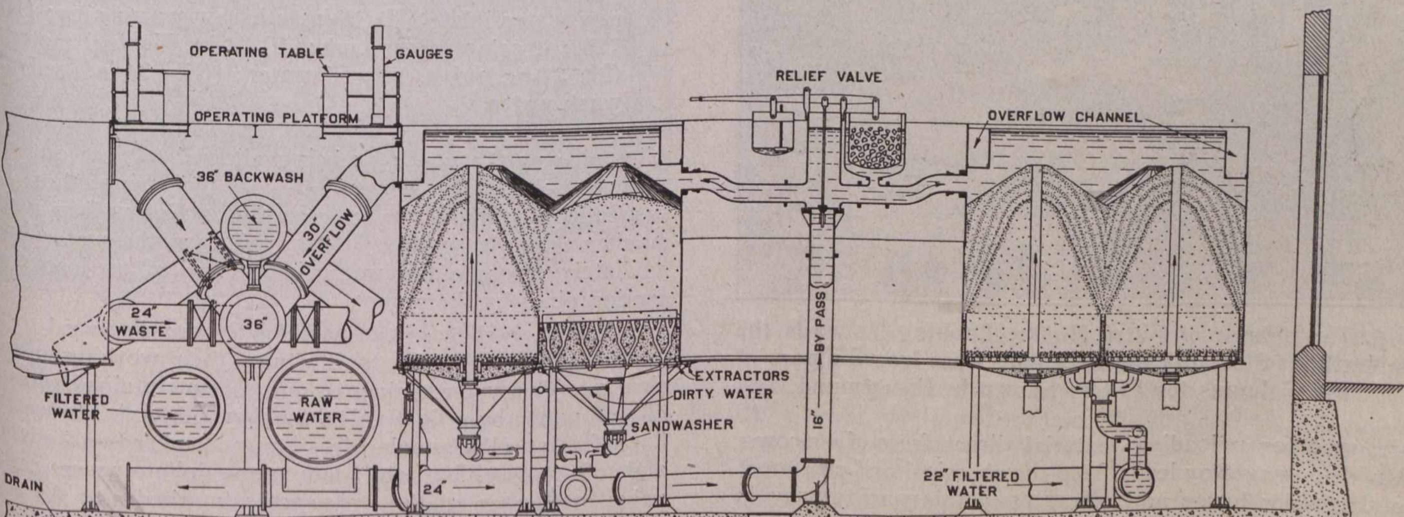


Fig. 5.—Section Through Single Filter.

Chemical House and Coal Storage.—The chemical house and coal storage is shown in Fig. 1 and in cross-section in Fig. 4. Fig. 12 gives an interior view of the coal storage portion of this building. Storage for 1,500 tons of coal and 800 tons of aluminum sulphate, as well as a general store, has been provided. The chemical house consists of circular building or tower 40 feet in diameter,

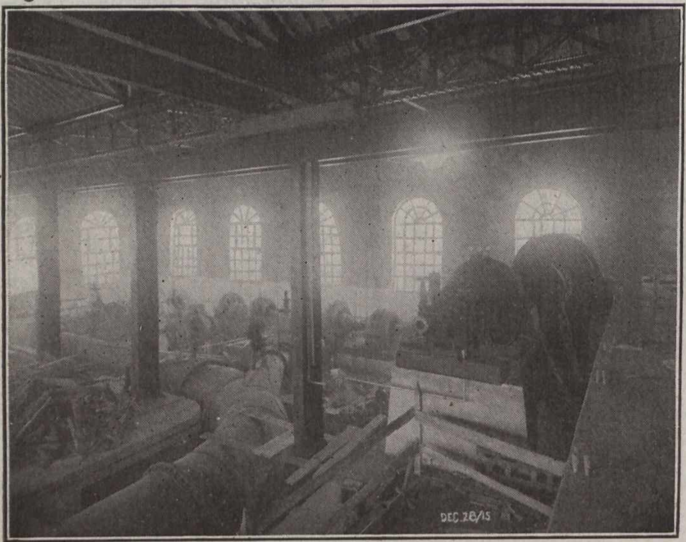


Fig. 6.—Interior of Pumping Station, Showing Machinery Nearly Completed.

through the centre of which is a crane turret mounted with an electrically operated revolving four-ton crane with a boom that reaches 60 feet.

Around two-thirds of the circumference of the chemical building is a coal store, but this is not of such great height, as can be noted from Fig. 4. The building has a straight face parallel to the wharf and is conveniently

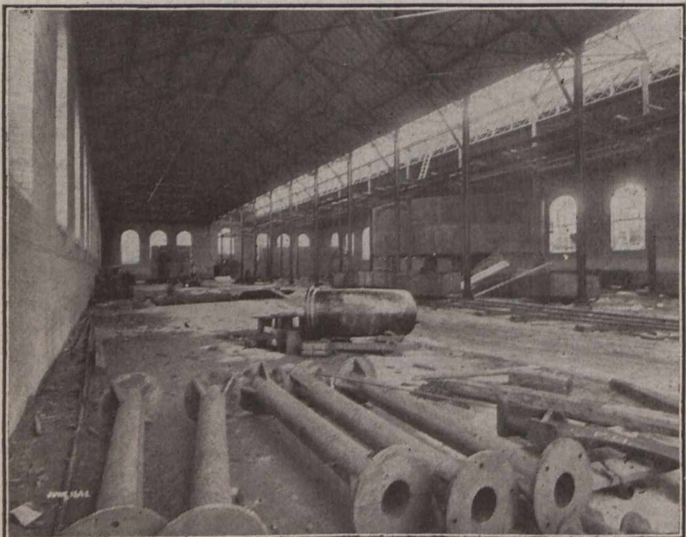


Fig. 7.—Interior of Filter House, Looking Towards the North, at Start of Tank Erection. Cast Iron Supporting Columns for Filters Shown in Foreground.

arranged for unloading material direct from the scows. A wide passageway leads from the chemical and coal store to the boiler house and offices, and this passageway is provided with a fireproof door. In Fig. 12 can be noticed pipes coming out at the bottom of the reinforced concrete columns. These pipes extend up through the centre of each column and project through the roof. By this means the temperature of the coal at any point can be ascertained, and any point can be flooded with water if necessary to stop spontaneous combustion, by flooding the roof.

Chemical Feed.—The arrangements for the supply of sulphate of alumina, or filter alum, to the water before filtration are novel in many respects. The underlying idea is to allow the dry chemical to feed automatically down from the store through a number of control doors into a tray at mid-level in a dissolving channel maintained full of water. This arrangement is shown in Fig. 4. The solution formed may be of any strength in excess of 5 per cent. and this solution is fed from the bottom of the dissolving channel into a dilution tank in which it is automatically diluted down to the standard 5 per cent. by a hydrometer-like arrangement. From this tank the standard solution is fed into a measuring tank controlled by the 72-inch raw-water meter in the pumping station, through a combined electric and hydraulic relay. From the bottom of the measuring tank the solution gravitates through lead pipes to the suction well and is there dis-

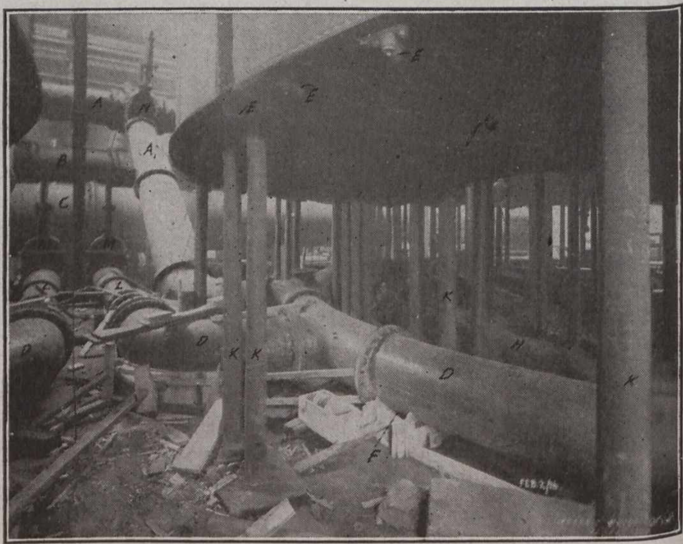


Fig. 8.—Piping in Filter House, Looking Toward Central Gallery. (A) 36-in. c.i. back-wash pipe; (A_1) Branch from A; (B) 36-in. c.i. waste pipe; (C) Steel raw water pipe; (D) 22-in. c.i. filtered water pipe; (E) External extractor; (F) Concrete form work; (G) 6-in. raw water inlet; (H) 16-in. c.i. raw water pipe; (K) 120 c.i. columns per tank; (L) 24-in. Venturi meter; (M) 24-in. valve, filtered water; (N) 24-in. valve, wash water.

tributed over the water by being allowed to flow out of ½-inch holes in a circular 2-inch pipe ring that is suspended just above the water in the suction well in such manner that the solution is sprayed upon the water immediately prior to the water being sucked up into the suction pipes by the pump.

In Fig. 4 some of the parts have been displaced to a certain extent in order to illustrate their working more clearly. The water tank (marked 5) is maintained full of filtered water by a float valve. From this tank the water flows freely to the annular dissolving chamber (marked 1), and, after dissolving, the aluminum sulphate passes to a valve at the top of the hydrometer (marked 3). At the same time, water also goes from Tank 5 to a valve on the bottom of the hydrometer. The hydrometer is poised in the solution between the two valves; thus any vertical movement of the hydrometer opens one valve and closes

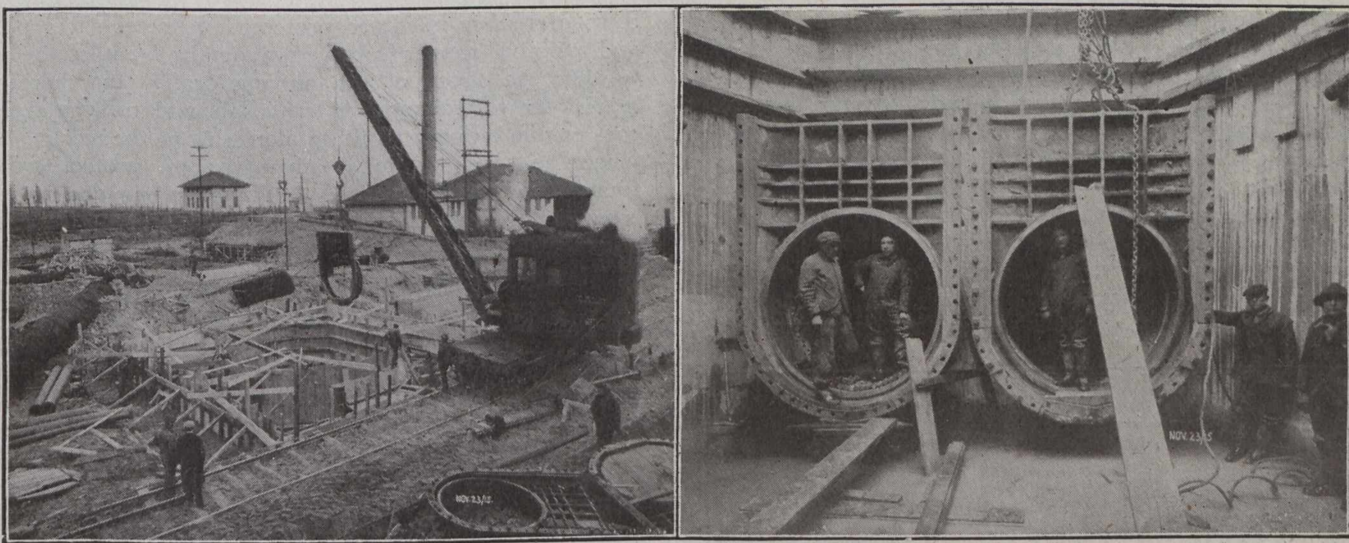


Fig. 9.—Views of Suction Well. (Left) Showing Framework and Lowering of Portion of 72-in. Gate Valve; (Right) Interior of Well, Showing First Half of the 72-in. Gate Valves in Place.

the other. It will let in strong solutions at the top and water at the bottom until balance is obtained, and then the hydrometer just floats in a solution containing 5 per cent. of aluminum sulphate. Any change from this strength causes the hydrometer to move, closing one valve and opening the other. It should be noted that a 5 per cent. solution of aluminum sulphate is about 2½ per cent. heavier than water, and it is upon this fact that

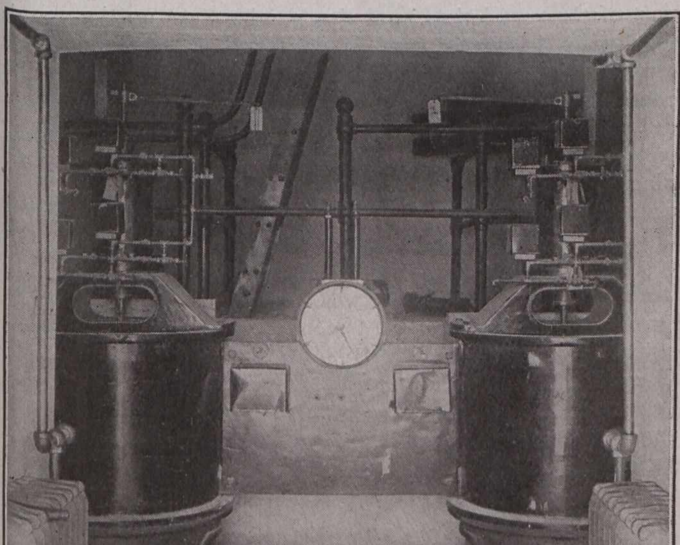


Fig. 10.—Chemical Feed Device.

the apparatus depends, not only from the point of view of supply of energy to move the hydrometer, but also to mix the diluting water with the solution already in chamber 2. The heavier liquid put in at the top tends to sink to the bottom, and, on the other hand, the lighter liquid fed in at the bottom tends to rise to the top; thus, inside the chamber, too, the liquid is kept in circulation. Above the hydrometer is a beam arrangement with knife edges which provides the means for permanent adjustment and also to work with any desired density of solution, a scale with divisions for each 1/10 grain of aluminum sulphate per gallon of raw water being provided for this purpose. By simply moving a weight along the beam any desired amount of aluminum sulphate may be added to the water. The solution passes from the measuring tank (marked 4), controlled by venturi meter, to the suction well, as previously described. For every rate of water passing through the raw water meter there is a corresponding position for the hydraulic piston and gauging slot in tank 4. The chemical feed apparatus is all in duplicate to avoid possible interruption to plant operation.

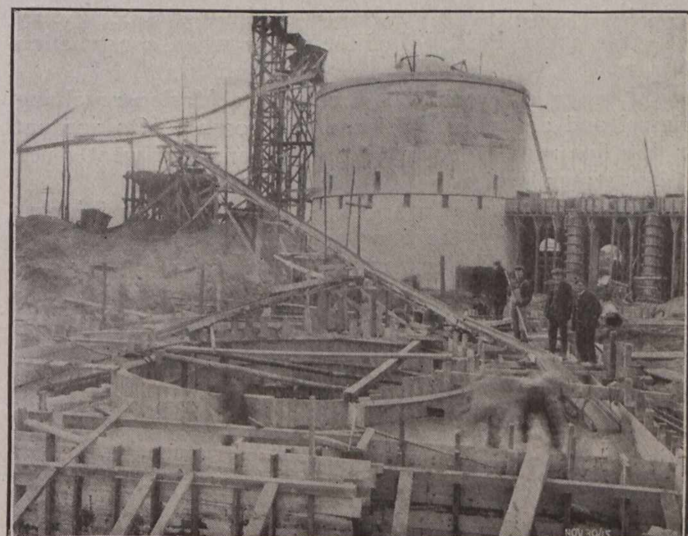


Fig. 11.—Concrete Work Under Way for Suction Well. Portion of Chemical Store Building in Background.

Filter House.—The filters are ten in number, placed in two rows equally spaced on either side of a central gallery. This central gallery provides a space in which all the main supply pipes are laid and on top there is a gangway which carries the operating tables for working and indicating the hydraulic gate valves that control the filters. This platform also carries the various meters, indicating and recording apparatus and gauges necessary for the control of the plant. Each filter is 50 feet in diameter and contains 30 sand cones or units, eighteen in the outer circle and twelve in the inner circle.

The filters and intake pipe were constructed by the Thor Iron Works, ; the cast iron pipe was supplied by Canada Iron Foundries, Limited; valves and operating tables, Glenfield & Kennedy, Limited; venturi meters, Builders' Iron Foundry; structural steel, Dominion Bridge Co.; steel sash, A. B. Ormsby & Co.; skylight, Henry Hope & Sons.

The filter house is the largest building of the plant, being 277 ft. x 123 ft. The bottom of the floor is 9 feet below high-water mark, and is within 25 feet of the lagoon at Toronto Island, which made excavation work difficult. In fact, the whole island is a water-logged sand bar, the highest point on the site of the works being only 4½ feet above the level of the water when construction began.

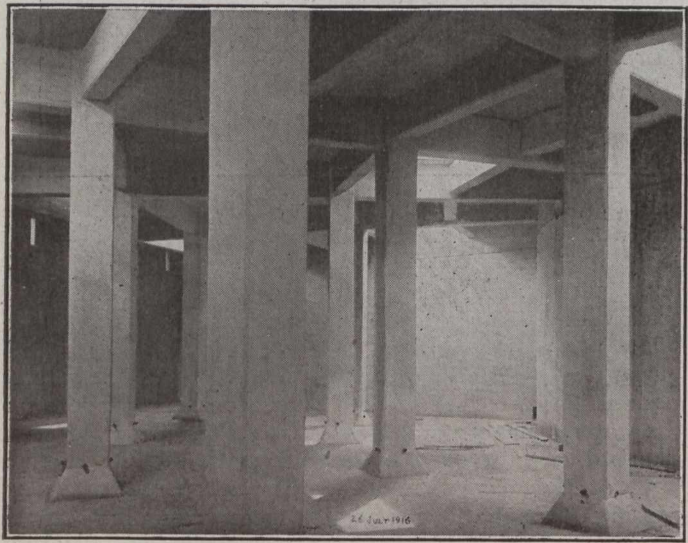


Fig. 12.—Interior of Coal Storage Portion of Coal-Chemical Building.

Excavation work was done with a Marion revolving shovel and an Industrial locomotive crane. On account of the fine running sand, all excavations that went much below water level were difficult and expensive.

A concrete foundation slab, or raft, 2 feet 6 inches thick was laid for the filter house.

Wash-back Water Tank.—The wash-back water tank is of steel and has a capacity of 200,000 Imperial gallons of sterilized, filtered water at a level of 60 feet above the ground, or 45 feet above the surface level of the water in the filters. The area of each filter to be washed is such that the maximum rate of discharge from this tank amounts to 31.4 million Imperial gallons per day, and for this purpose a 36-inch outlet pipe has been provided. Half of the water is discharged at a gradually increasing rate in ten minutes and the remainder at the maximum rate in five minutes, and this tank will probably be emptied about once a day. It is anticipated that on the average each filter will be back-washed once in ten days. A steam connection is provided to the tank to prevent freezing in winter time. The tank was constructed by the Canadian Chicago Bridge and Iron Works. The backwashing is accomplished by reversing the flow through the collector system when the loss of head in the filter becomes so high that the normal rate of filtration cannot be obtained.

Wharf.—The only access to the plant is by water and a wharf has been built along the western side of the plant. A typical section of the wharf is shown in Fig. 4. A concrete wall rests on two lines of timber piles and a further row of piles placed inland has provided foundation for the building wall. The face of the wall and the front rows of timber piles are protected by steel sheet piling and a timber runner is placed along the front of the wall to take the shock of the moving craft. In this way loaded scows transporting materials and railway freight cars can be brought right up alongside of the works. The wharf has the additional advantage of protecting the foundations of the various buildings along the western front of the plant. The sub-contractor who built the wharf was David Arnot, Toronto.

Sand-washing System.—In order better to illustrate the sand-washing arrangement, a typical section through the axis of a single unit gravity filter is illustrated in Fig. 13, while the actual details of one of the sand washers of the Toronto plant are shown in Fig. 14. The filter sand consists of two portions of precisely the same material with no physical boundary between them other than that produced by causing the upper portion slowly and almost imperceptibly to drift over the lower portion and across the paths of the filtering water. The sand has a maximum size of 1.2 mm., 60 per cent. less than .7 mm. and 10 per cent. less than 3.5 mm., and is rounded, water-worn, hard material. Around the periphery of the filter is a passage or system of ports down which the drifting sand passes.

The raw water which has previously been coagulated enters the filter partly by a standpipe at the centre of the unit and partly through a by-pass entering above the sand in the filter.

Within the sand washer the raw water pipe is provided with a restriction in every way similar to the tube of a venturi meter, and the drifting sand collected in the sand washer is inducted into the raw water at the narrowest part of the restriction, and this sand passes up the standpipe with the water, and is delivered with it above the top of the sand pyramid there, forming a volcano-like cone which continually drifts away and is continually being replaced, leaving a rounded topped object of stationary sand resting upon the collecting system. This stationary sand accomplishes the final filtration. The effective area of this stationary sand is more than twice the plan area of the unit and economizes the plan area of the filters. While probing the sand in a filter when in operation, the drifting sand will be found to be spongy and buoyant, whereas the surface of the stationary sand is found to be very hard packed and cannot be readily penetrated.

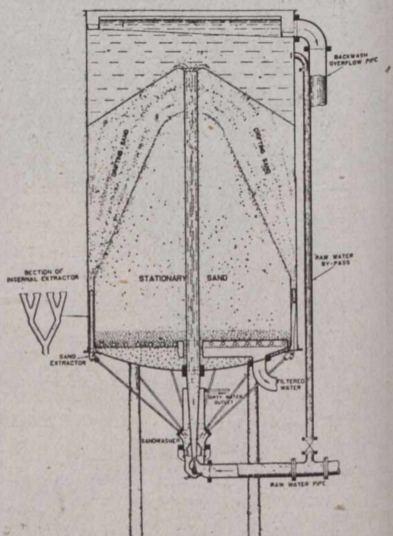


Fig. 13.—Section Through Single Filter, Showing Piping to Sand-washer. Each Filter in the Toronto Plant is Composed of 30 Such Separate Units.

The drifting sand passes down around the boundary of the stationary sand to a slot at an elevation of 2 feet 2 inches above the surface of the underdrain gravel, and ultimately passes through converging ports to a system of outlets or extractors and thence by pipes to the sand washer, in which the sand falls to the bottom through a current of raw water and is picked up by the inductor and the dirty

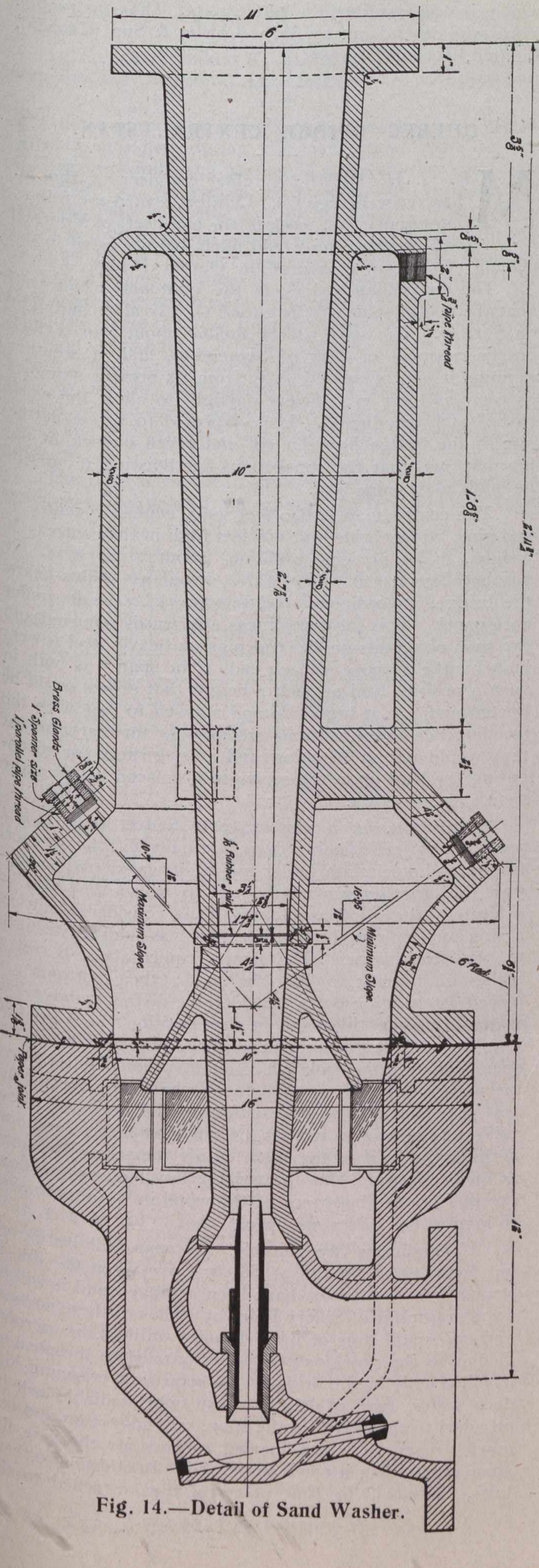


Fig. 14.—Detail of Sand Washer.

water passes upwards and out at the top. The sand extractors are of such a form that the sand over a short distance is made to move vertically against gravity in order to keep it out of the piping system except when the inductor on the sand washer is in full operation. That is to say, the sand moves only when there is an abundance of running water to carry it forward.

The form of the throat is such that the sand enters the high velocity water at the bottom of the sand washer and at the centre of the stream and should, therefore, touch the sides of the pipe only at a high level where the pipe is much enlarged and not until after the sand and water have been reduced in velocity. In this way the sand scouring is reduced to the minimum. The loss of head on the inductor amounts to about 3 feet 6 inches, but a by-pass is provided so that this may be varied either at

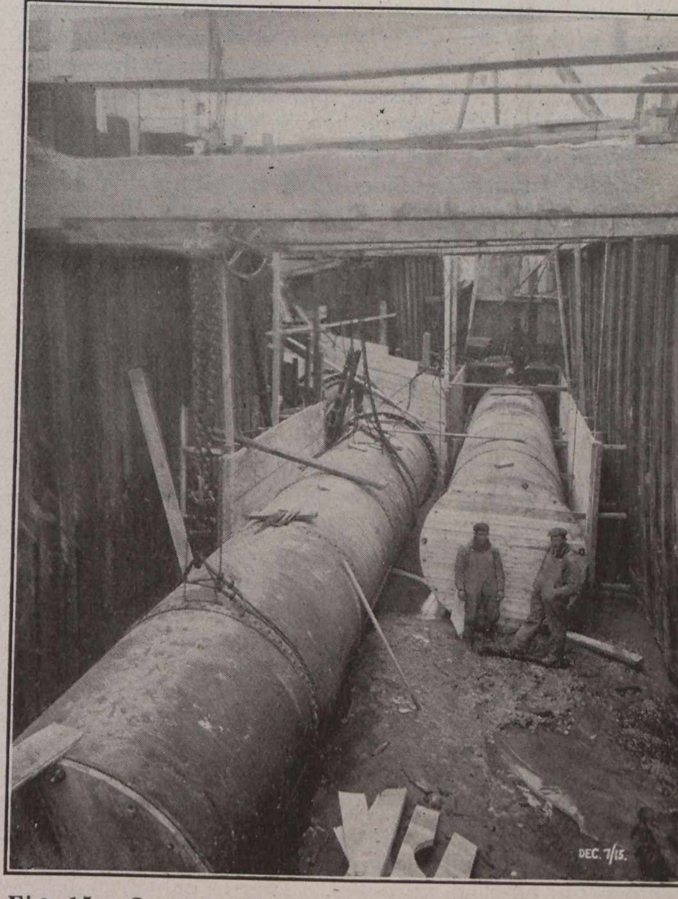


Fig. 15.—Southern End of Intake Pipe Trench, Showing Two 72-in. Pipes.

will or automatically in such a way that the induction will suit the amount of impurities and of the coagulents in the water, it being understood that the greater the proportion of the total raw water passing through the inductor, the greater will be the rate of drifting of the sand. If the sand drifts too slowly, then the bed will choke up and the loss of head will go up and ultimately put the filter prematurely out of business. On the other hand, by drifting the sand too fast unnecessary labor is put upon the apparatus and the larger proportion of the coagulant penetrates right through the drifting sand to the stationary sand underneath. Provision is made, as shown in Fig. 5, for adjusting the proper rate of drifting by use of a 16-inch by-pass, so that an adjustable amount of the raw water goes to the filter direct instead of passing through the sand washer. Thus, if the raw water is comparatively clear, most of it goes to the filter through the raw water by-pass, whereas, if the turbidity is extremely high, the raw water by-pass is closed by means of the relief valve shown in Fig. 5, and the whole of the water is sent through the sand washers, thus creating in the sand washer a greater induction, which causes the drifting sand to operate at its maximum rate. The relief valve is controlled by the operator from the gallery.

Suction Well.—The only excavation work that required caisson work was the suction well, which was carried down to 25 feet below high water. An iron cutting edge was built on the site and the concrete forms erected over it. The concrete was poured in sections 7 feet high. When two sections had been poured, the caisson was sunk by taking the sand out of the interior by means of a clamshell. No trouble was experienced until within five feet of its final position, when fine running sand flowed in so fast that the material could not be removed. Operations were suspended until a pipe trench was run close enough to draw the water away and reduce the upward pressure on the caisson. A sump was sunk in the centre of the bottom of the caisson and drains of gravel were built radially into this sump, the whole being covered with light sheet iron, and then concreted into place.

Sand.—In all about 6,000 cubic yards of filter sand are required. This material is being secured at the York Sand and Gravel Co.'s pit on Kingston Road, and the separating of the materials and washing of the sand is carried out at a plant specially erected for this purpose at the pit by the verMehr and Cowlin companies. Considerable difficulty has been experienced in the preparation of this sand, due to lack of water for the purpose of washing and segregating the material. Wells and ponds in the neighborhood of the pit were relied upon for the water supply, and due to the extremely dry summer the supply has been such that the plant could be operated only part of the time.

From a storage bin holding 100 cubic yards of material, the sand and gravel is fed by a belt to a screening arrangement which eliminates all gravel that is too big. From this gravel is obtained the 800 cubic yards necessary for placing around the underdrain system. The material which passes through the main screen is conveyed by water to a series of eight screens about 1 foot in diameter, where the sand that is too coarse is eliminated and the smaller sand drops into the screening tank. From this screening tank the sand is then conveyed to a separator box where the material that is too fine is driven off by water, finally leaving the sand which is satisfactory for filtering purposes. This is conveyed into a storage bin and from there it is grabbed into railroad cars and shipped to the plant.

Plant.—The location of the work was out of the ordinary, involving not only difficulty in foundations but also considerable difficulty in transportation of supplies and men. In the summer all supplies were towed across on scows, and in winter were hauled over the ice. There were periods, however, when both methods were impossible, owing to loose or thin ice, and then long lake hauls were necessary to reach the work. On this account carpenter shops, machine shops, blacksmith shops, etc., were built at the work.

The light and power for the construction plant were both electrical, and the lines were both carried on the same poles. Toronto Hydro-Electric System power was used, with steam stand-by on account of the pumps.

Acknowledgment.—*The Canadian Engineer* is indebted for the above information to Mr. William Gore, consulting engineer, and to Mr. William Storrie, chief engineer, of the John ver Mehr Engineering Co., Toronto, which concern designed the whole plant. The construction work was carried out by Wm. Cowlin & Son (Canada), Limited, Toronto.

QUEBEC BRIDGE CENTRAL SPAN.

Mr. G. H. DUGGAN, chief engineer of the St. Lawrence Bridge Co., Limited, issued the following circular last week to the engineers of Montreal and vicinity who would likely be interested in the placing of the centre span of the Quebec Bridge:—

The controlling valves in the pontoons which will float the centre span will be closed shortly after midnight on Sunday. The span will be floated about four o'clock on the morning of 11th of September, and, if weather permits, it will be moved away from its present supports as early as there is sufficient daylight to allow the work to be safely conducted. It is expected to arrive at the site of the bridge between six and seven o'clock in the morning and that the connections for hoisting it up will be made about nine a.m.

The centre span is 640 feet long, centre to centre of end pins, 88 feet wide and 110 feet high in the centre. It weighs, in its present condition, about 5,100 tons. It has been erected at Sillery Cove, about 3½ miles below the bridge, on ordinary steel false-work, a bent under each panel. This false-work was afterwards removed and the span now rests on the end pins on heavy steel towers built for the purpose at each end. The span was built in such a position and at such a height that scows could be floated under it at high tide and allowed to rest with the receding tide on foundations prepared for them at a height that would permit blocking and steel girders for distributing the load upon the scows to be placed between the span and the scows.

The scows, six in number, each 165 feet long, 32 feet wide and 11 feet 6 inches deep, are built with heavy steel frames and steel plate girder bulkheads calculated to support the large concentrated loads to which they will be subjected—the wooden planking being considered only as a skin to keep out the water and not as adding strength to the framework. The scows require about 8 feet 2 inches of draught to float the span; their bottoms are placed at elevation 83, a considerable distance above low water at spring tides and in this position the high tide rises about 2 feet above the decks, although when the span is floating the deck will be about 3 feet 4 inches above the water level. Each of the scows has six valves in the bottom which can be operated from the deck and these valves are now open so that the tide may flow in and out, keeping the level of the water inside the scows the same as on the outside, thus preventing any tendency to float except from the buoyancy of the wood in the timber skin so long as the valves are open.

If conditions are suitable, the span will be moved out from its anchorage at Sillery Cove when the tide is strong flood. Anchors have been arranged and it will be swung out clear of Sillery Point by means of these anchors and two small tugs of light draught until it is perpendicular to the shore or practically parallel to the position it will occupy in the bridge. As soon as it is swung into deep water, two of the largest tugs available will be attached to the centre of the span, one up-stream and one down-stream, to act as floating anchors for checking the span and holding it when so desired. In addition to these tugs, there will be four powerful tugs attached to the

(Continued on page 219.)

TIME TESTS OF CONCRETE.*

By Franklin R. McMillan, C.E.,
Asst. Professor Structural Engineering, Univ. of Minnesota.

It is the purpose of this paper to present a summary of data collected during the past three years at the Experimental Engineering Laboratory of the University of Minnesota concerning the behavior of concrete when subjected to long time tests. The results of these investigations should be of interest to engineers in regard to the character and amount of the time changes as well as their relation to the theory and practice of reinforced concrete design. Naturally the question arises as to the cause of these time changes and the possibility of their elimination. This, however, must be left to future investigations for no attempt was made in these tests to discover the reasons for this behavior, it being desired first to know something of the movements themselves and how generally they may be expected in ordinary practice.

The tests have been conducted largely on laboratory specimens, because of the greater facility and accuracy

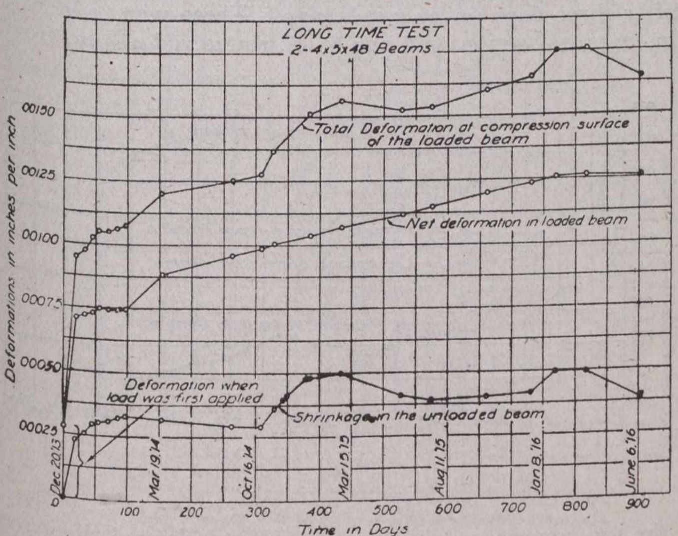


Plate 1.

with which the results may be obtained, but such observations as have been made on a few buildings in service warrant the conclusion that the results from the laboratory specimens are applicable to the ordinary reinforced concrete building construction. The laboratory specimens, which include small beams, as well as large-sized slabs, have all been made and treated with perhaps somewhat greater care than the average building receives, but no greater than should be had nor than would be possible with little or no change in the customary specifications.

The measurements of deformation have been made by the Berry Strain Gauge in the hands of skilled observers. The experimental details, such as selection of standards of reference, elimination of temperature and instrumental errors, etc., which in tests extending over a period of years are troublesome features, have been given careful consideration and it is believed that, especially in the later tests, the results leave little to be desired in these particulars.

In presenting these results, it will be better, except for a brief statement as to the character of the changes observed, to consider the individual tests separately with a discussion of the important features as they are brought out. Only such description as is necessary to a proper understanding of the results will be indulged in.

These studies resulted from an effort to explain the continued sag in a floor panel of a reinforced concrete building under a test load held in place for several weeks. In the very earliest work done it was recognized that the continued movement arose from two sources, one a direct result of the loading and the other entirely independent of it. That movement due to the load has been termed in former publications the time yield to distinguish it from the other movement which is purely shrinkage or volumetric change. Both of these act to produce a shortening of the compression fibres of a beam or slab, which of itself would account for a very large part of the progressive sag frequently noted. This action is probably accompanied by a gradual extension or breaking of those fibres in tension which have not already broken; but as this effect is one contemplated in our usual assumptions, and one that probably is accomplished, if at all, much sooner than that due to time yield and shrinkage, it need not be considered in these discussions.

The term "time yield" has been used in preference to

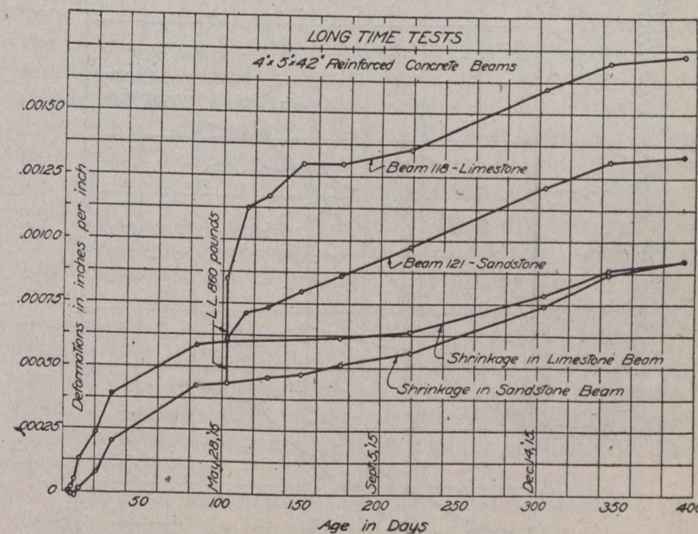


Plate 2.

the term "flow," used by other writers, as it has not been shown that the movement is a flow in the strict meaning of the word. It is of no significance structurally, at least for the purpose of this discussion, whether the movement be a flow or a gradual yielding accompanied by no increase in dimensions laterally, for this paper is concerned only with deformation in the direction of stress.

Test of Two 4-in. x 5-in. x 48-in. Beams.—One of the earliest tests made in the prosecution of these studies will be given first as it shows very clearly the relative effect of the two elements of this time deformation of beams and slabs under load. In Plate 1 are given the results of measurements extending over a period of two and one-half years of the deformations in two small reinforced concrete beams.

In the test of these beams, one was allowed to remain flat on a platform, while the other was tested on a 42-inch span with a centre load of 860 pounds. Since the beams were of the same make-up and kept side by side during the entire period of curing and test, the shrinkage of the loaded beam may be taken the same as that shown for the unloaded beam. This has been done in drawing the curve marked *net deformation* for the loaded beam, which is

*Read before the Engineers' Club of St. Louis.

obtained by subtracting from the total measured deformations at the compression surface the amount of this shrinkage. That is, the ordinates of the net deformation curve are equal to those for the total deformation, less those for the shrinkage curve.

From these curves it can be seen readily how the two elements affect the total deformation, thus the variable shrinkage produces the fluctuations observed in the total while the time yield continues at approximately a constant rate. The curve of net deformation shows a flattening out for the last three months. Whether or not this means that the time yield has ceased cannot be said until further time has elapsed.

The significance of the ratio of the total deformation to that obtained when the load was first applied about seven to one, and of the fact that the deformation has steadily increased for a period of two and one-half years, should not be lost sight of. As these beams were 33 days old, before measurements for shrinkage had begun, and cured open to air except for a single wetting when first

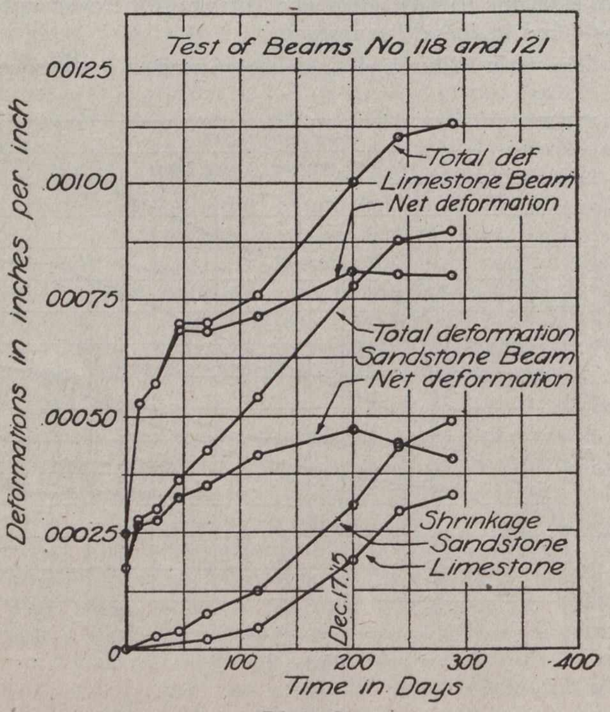


Plate 3.

cast, it is likely that not more than 50 or 60 per cent. of the total shrinkage is shown. That this is true will appear from some of the tests to follow.

The fluctuations in the shrinkage curve and their relation to the seasonal change can be seen very plainly here. It will be noted that a rapid increase in the total measured shrinkage begins each fall at about the time the steam heat is turned on in the building and this is followed by a swelling which begins with that period in the spring when the heat is turned off and when the building is more open to the moist outside air. In this same way may be explained the fluctuations seen in the other laboratory specimens given here and also in the deflections of the wooden horses supporting the $5\frac{1}{2}$-in. x 30-in. x 12-ft. beam shown on Plate 12. It will, therefore, not be necessary to refer to them again.

The curve of deflection of this beam is shown on Plate 4 along with two beams from the test which follows. The interesting features of this curve are the fluctuations with the seasonal changes in the moisture content of the air, and the relation of the total deflection at the end of two and one-half years to that measured when the load was first applied.

In description of these beams it is sufficient to say that they were 4 in. x 5 in. in cross-section reinforced with two 5/16 in. round rods with centres $4\frac{1}{4}$ in. from the compression face. They were cast from a 1 : 2 : 4 mixture of a standard grade of Portland cement, an average grade of sand and a crushed limestone of pea size. The load was applied at the age of 33 days. On the usual assumptions the load applied gives calculated stresses of 650 and 15,000 pounds per square inch in the concrete and steel respectively.

Additional Tests of Small Beams.—On Plate 2 are shown the results of measurements on beams of two different aggregates. These are given as they show the results of shrinkage measurements from the time the beams were but three days old until the load was applied, together with the results of load deformation, time yield and additional shrinkage for the remaining period of the test. Some explanation of the difference in behavior of the two aggregates may be necessary; this will be given after considering the general question under discussion.

In this set three beams were made up from each aggregate in a 1 : 2 : 4 mixture and cured open to the air after three days under wet burlap. These were 4 in. x 5 in. in cross-section with one ⅜ in. round rod $4\frac{1}{2}$ in. from

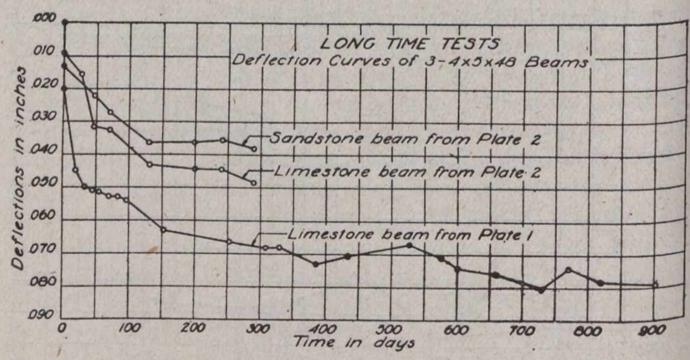


Plate 4.

the top surface. One from each set was loaded when 103 days old with 860 pounds at the centre of a 42-inch span, and measurements taken of the maximum deformation at the compression surface. The results are shown in Plate 2. Results of deflection measurements are shown on Plate 4.

In the curves of Plate 2 the portions from zero to the 103rd day, when two of the beams were loaded, were obtained by measurements of shrinkage on the beams to be loaded. From this point on the shrinkage was determined from measurements on the two beams of each set not under load.

The measurements of the maximum compression in the concrete beginning with the time of application of the load are added to the total shrinkage up to that time to obtain the total deformation shown in the upper curves. To reduce these to the same basis as the beams described under the previous test Plate 3 has been prepared. This shows the total deformation at the compression surface beginning with the day that the load was applied and includes that due to the application of the load and all subsequent deformation from both time yield and shrinkage. Likewise the shrinkage curves shown represent that beginning from the date of loading. These curves are simply the curves from Plate 2 with the shrinkage for the 103 days preceding the loading omitted for convenience of comparison. They are plotted to the same scale at Plate 1 and with zero of time at the time of loading, that is, at the 103rd day. The net deformation curves, as in Plate 1, show the difference between the total and the shrinkage.

The same general behavior as noted in the first beam can be seen in these two. The difference in the amount of total deformation between the limestone of this set and that of the previous test for the same period under load can be accounted for by two considerations. First, the limestone used in beam 118 was a coarser and better graded sample and one that in many comparative tests has given concrete of higher strength than the pea size used in the first beam. Second, these beams were 103 days old when loaded as against 33 days in the first beam. The difference between the sandstone and the limestone will be referred to later.

The difference between the shrinkage as shown on Plates 1 and 3 is seen to be due to the difference in age of the specimens at the time the loads were applied. In the case of the first test what had happened before the 33rd day is not known and can only be estimated from the results of other tests. The shrinkage shown for the first 103 days of this second set of beams represents in a

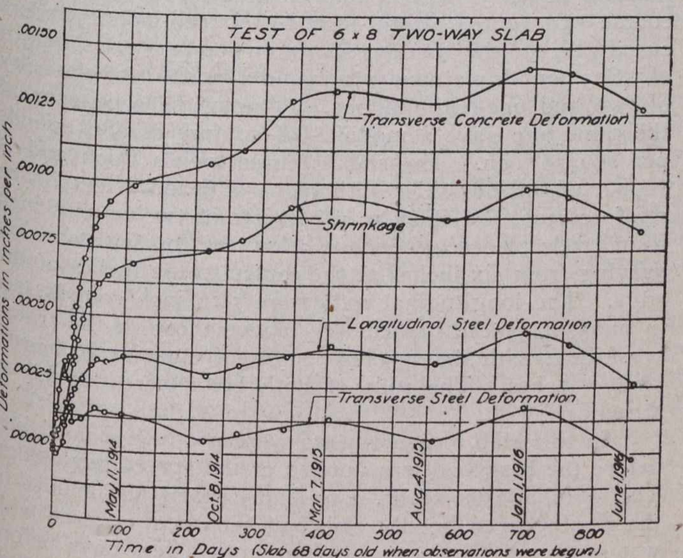


Plate 5.

general way what has been obtained from quite a large series of other tests, both as to the total amount shown and the rate at which it develops. In these other tests, which need not be given here, a number of variables were introduced such as variation in the mixture, in the amount of water used, in the time of mixing, in the density, etc., and while each change produced a consistent change in the shrinkage these were so slight when compared to the total shrinkage that it may be said that for all variations within the limits of ordinary practice the difference in total shrinkage is negligible. Even a difference in curing conditions, contrary to the general belief, does not affect the total shrinkage. The results of tests covering this point are quite conclusive and indicate that keeping the concrete wet serves only to retard the shrinkage; the same total amount may be expected once the specimen has dried out, this in spite of the fact that the strength of the concrete may be materially increased.

Now, from Plate 2 it is seen that in the first 30 or 40 days in a drying atmosphere, about one-half as much shrinkage occurred as was shown in the first 8 or 9 months. In some other tests more than two-thirds of the shrinkage shown in the first 6 or 8 months has occurred in the first 40 days. Also, from both Plates 1 and 2 it will be observed that even after nine months considerable shrinkage occurred. The total amount of shrinkage should be noted, the maximum shown on Plate 2 being .0009 inch per inch, or more than 1 inch per 100 feet, and that from Plate 1 being .0005 inch per inch, or 0.6 inch per 100 feet with the shrinkage in the first 33 days not included.

In regard to the difference between the two aggregates used in these two sets of beams, this is of more than passing interest, inasmuch as the sandstone is one that engineers of Twin Cities have quite generally condemned. It is a fine-grained, loosely compacted sandstone obtained from the Kettle River quarries at Sandstone, Minnesota. In spite of the general feeling against this rock as a concrete aggregate, which is based largely on its appearance of being somewhat soft and friable, and porous, it has been shown by a large number of exhaustive tests to give a very excellent concrete of high strength. This undoubtedly accounts for the lower deformation shown by beam 121 for the direct application of the load as well as for the time yield. The difference in the time yield is seen to be very considerable.

The results of shrinkage measurements on these two aggregates are of interest in showing an effect which the writer has used to partially explain the high strength shown by concrete made from this sandstone. Owing to the porous nature of the rock the excess of water used in mixing is absorbed with the result that the strength is increased, partly because the excess of water has been disposed of and partly because it has been stored up where it is available during the curing period, thus producing an ideal condition for hardening.

If this explanation is correct, then the shrinkage in the sandstone beam should be retarded in comparison with that of the limestone, just as the curing under external moisture retards the shrinkage as explained in a previous paragraph. It is seen from the curves of Plate 2 that the shrinkage in the sandstone beam is considerably retarded, yet with the same final total amount at the end of the year. Since the external conditions were identical, this seems to support the plausibility of the above explanation.

The data presented in these two simple tests can completely explain the phenomenon of the progressive sag frequently noted in reinforced concrete floors. This does not mean that other items such as poor materials, errors in design and erection, freezing, or premature removal of the forms, do not enter into many cases; for all too often one or more of these defects are present. It does mean, however, that a continually increasing sag may, and usually will, result even though the imperfections of design and construction are avoided.

It will be seen at once that the shortening of the compression fibres unless accompanied by a corresponding shortening on the tension side, must result in an increase in deflection. On the tension side there is probably a similar time yield within the limit of extensibility of the concrete but this has very little effect except to throw more and more stress into the steel, which being perfectly elastic within the working limits, governs the behavior in tension. The shrinkage on the tension side, if the concrete remained uncracked, would be resisted by the steel just as the column rods aid in resisting shortening from external load; and if thoroughly cracked each section would shrink independently with very little effect on the total length. Thus the continued shortening at the top is accompanied by little or no shortening at the bottom and the slab or beam must deflect just as a timber warps from unequal drying. The curves in Plate 4 representing the deflections in the beams of these tests illustrate very well the progressive sag.

That slabs and beams in buildings in service do show sags increasing from year to year has been verified in a large number of instances. That some are more noticeable than others may be accounted for, neglecting the factors of inaccuracies in design and construction which may frequently be present, by the differences in thickness, the differences in strengths of the concrete and the relative loadings. The effect of the thickness or depth largely accounts for the fact that slabs sag considerably more than beams; for which the same unit deformation at the top and little or no change at the bottom the angular movement between sections originally parallel, and hence the deflection, is less the greater the depth.

In regard to the effect of strength of concrete and relative loading it may be stated that from some tests not quoted here the time yield seems to be a function of the ratio of the unit stress to the untimate strength of the concrete. Thus, with a unit stress of 650 pounds per square inch the time yield would be much greater in a concrete of ultimate strength of 1,800 pounds than in one with an ultimate strength of 2,500 or more. If such dif-

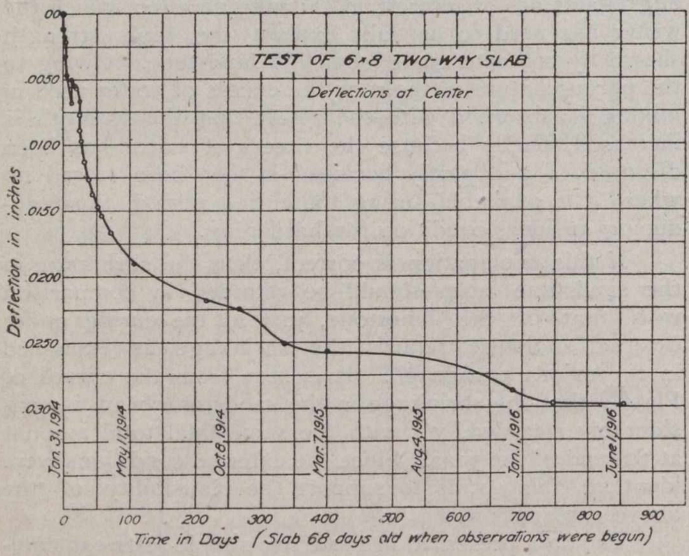


Plate 6.

ferences in concrete as represented by these ultimate strengths exists in different structures, then varying degrees of sag may be expected from this cause. That such differences do occur in structures built under the same specifications seems to be probable. They result from the use of different aggregates, consistencies and methods of curing, as well as from the seasonal differences at the time of construction, both as to temperature and humidity. In regard to the relative loading, some buildings practically never receive their full load while others may be loaded almost continuously, and frequently with an excess over that for which the floor was designed. This would produce a difference in the ratio of actual stress to ultimate strength that might account for a considerable difference in yield even in buildings of about the same grade of concrete. The notoriously high compressive stresses around the column heads of some of the earlier flat slab designs may account for a large part of the sag noted in many examples of this type of construction.

In addition to offering an explanation of the continued sag in reinforced concrete floors, a study of the data from these two simple tests raises the two important questions concerning the probable initial stresses in the steel of beams, slabs and columns due to shrinkage, and the probable final stress in reinforced columns due to both shrinkage and time yield. Theoretical calculations based on the data of the first two tests presented are of little value in predicting these stresses because of various factors which it is impossible to estimate, such as: the modulus of elasticity of the concrete and its variation through the early hardening period, the rate at which a perfect bond between the steel and concrete is developed, and the ability of the concrete to accommodate itself to the strained condition during the early hardening period. For these reasons these questions will be left to the discussion of the tests which follow in which special effort was made to obtain data bearing on the points raised.

Test of 6-ft. x 8-ft. Two-Way Slab.—Some of the results of the test of this slab extending over a period of one year were published in the Engineering News for March 11, 1915, and in Bulletin No. 3, Engineering Series, University of Minnesota, "Shrinkage of Time Effects in Reinforced Concrete." The results are brought up to date and given here for they bring out very clearly the features of continued sag and initial stresses in the reinforcement.

This slab was cast in November, 1913, from a 1:2:4 mixture using a crushed limestone of pea size for the coarse aggregate. Eight-inch by sixteen-inch cylinders cured with the slab 72 days showed a compressive strength of 1,825 pounds per square inch and a modulus of elasticity of two and one-half millions. Transverse specimens at the same age gave a modulus of rupture of 380 pounds per square inch. The slab is three inches thick and is supported on four sides with spans of 6 and 8 feet. The reinforcement the short way consists of twelve 5/16 inch round rods placed 2⅝ inches below the top with spacing varying from six inches at the centre to ten inches at the edge. The longitudinal rods were 5/16 inch rounds, six in number, placed immediately above those in the transverse belt, with the spacing varying from nine inches to twelve inches. The rods of both belts were hooked at the ends.

In this slab measurements were not begun until just before the first load was applied at the age of ten weeks. The shrinkage, however, is probably nearly all included in the results given, for the slab had been kept covered with wet sand and the forms in place until a few days before loading. A load of 50 pounds per square foot was first applied; this was increased to 100 three days later, which, except for one removal and reapplication soon after, has been continuously in place to the present time. Calculated on the basis of the recommendations of the Joint Committee the load of 100 pounds per square foot gives stresses of 650 pounds per square inch in the concrete and 16,000 in the steel. These assumptions are undoubtedly very conservative, which accounts for the fact that the concrete is still holding in tension after two and one-half years.

The data it is desired to show from this test is given in Plates 5 and 6. In plate 5 are shown the results of measurements of shrinkage and of stresses in the steel of both belts, as well as the maximum concrete deformations. It will be observed that except at the first application of the load and for a very short time thereafter the steel stresses are all compressions. The transverse belt, it will be noted, shows considerable less compression than the longitudinal. This is to be expected, for in addition to the greater tendency toward tension in the short way steel from bending, the effect of its higher percentage and greater distance from the unrestrained surface in resisting shrinkage would be considerable. The greatest compressions in the transverse belt are 4,500 pounds per square inch after 80 days under load, about the same amount at 400 days, and about 5,000 at 700 days. In the longitudinal steel a maximum value of 13,600 pounds per square inch is obtained on the 700th day. The fluctuations in these curves show the same seasonal variations noted in the previous tests.

Since the shrinkage had been retarded until but a few days before loading the "initial" compression stress was probably slight, but had loading been postponed for another 80 days the initial stress would have been somewhat higher than that shown for the 80th day on these curves; that is, possibly 6,000 or 7,000 pounds in the transverse and twice as much in the longitudinal steel. That such initial stresses represent the condition in every building cannot be said, for the high strength of the concrete in tension and bond before shrinkage began (having been kept wet for nine weeks), undoubtedly had considerable influence; but that they may occur in many structures is highly probable.

What effect these initial stresses have on the final stress condition in beams and slabs the writer is not prepared to state at this time. It seems probable, however, that once the concrete in tension has become thoroughly cracked the conditions do not differ greatly from those assumed in designing. There is, however, a very large influence on the behavior under the first load which, as will be discussed later, may affect materially the interpretation of test data.

The one conclusion from these results that seems most important is the possibility of high steel stresses in columns or in the compression steel of beams. With a compression from shrinkage alone of from 5,000 to 13,000 pounds per square inch where tension would be expected, it seems quite reasonable to predict steel stresses of from 20,000 to 30,000 pounds where the time yield and shrinkage are acting together.

The deflection curve of Plate 6 shows the same downward tendency even after two and one-half years, as exhibited in the other tests. This shows the effect of shrinkage and time yield in producing the continued sag with the uncertainties of design and construction completely eliminated.

(Continued in next week's issue.)

WEEKLY RAILWAY EARNINGS.

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

Canadian Pacific Railway.

	1916.	1915.	
August 7	$2,985,000	$1,787,000	+ $1,198,000
August 14	2,943,000	1,815,000	+ 1,128,000
August 21	2,860,000	1,956,000	+ 904,000
August 31	4,092,000	2,856,000	+ 1,236,000

Grand Trunk Railway.

August 7	$1,256,376	$ 993,773	+ $ 262,603
August 14	1,236,989	1,004,412	+ 232,577
August 21	1,304,848	1,052,483	+ 252,365
August 31	1,952,163	1,535,213	+ 416,950

Canadian Northern Railway.

August 7	$ 868,000	$ 438,500	+ $ 429,500
August 14	841,500	427,600	+ 413,900
August 21	846,300	465,400	+ 380,900
August 31	1,129,100	652,100	+ 477,000

The Canadian Pacific Railway July's return, the first of the company's current fiscal year, is as below:—

	1916.	1915.	
Gross	$12,247,440	$7,895,375	+ $4,352,064
Expenditure	8,230,348	5,094,972	+ 3,135,376
Net	$4,017,091	$2,800,403	+ $1,216,688

THE LOSSES IN CABLES AT HIGH FREQUENCIES.

Messrs. E. F. Northrup and R. G. Thompson in a paper contributed to the Franklin Institute remark that when current passes through solid metal conductors at the high frequencies employed in wireless telegraphy and telephony the heat-losses are needlessly excessive, and, to diminish these, various types of stranded cable are employed. The authors have investigated if there is any appreciable difference in the losses in cables which depends upon the arrangement, the size, and the insulation of the individual strands which make up a cable, and endeavored to determine what combinations of these various features will give a cable best suited for use at high frequencies under specified conditions. They find that in a cable the strands of which are parallel the loss is appreciably greater than it is in a solid wire having the same cross-section; and, surprising as it may appear, if this same cable is very much twisted, so that the wires lie in concentric spirals, the loss decreases 50 per cent. or more and becomes less than in a solid wire. The tests appear to show that the more the cable is twisted the greater is the reduction in the loss. With the exception of the case just mentioned, the alternating-current resistance of a cable is less than that of a solid wire of the same cross-section. The smaller the individual wires and the better they are stranded or braided and the more perfectly they are insulated from each other, the more nearly does the alternating-current resistance approach the direct-current resistance for a given cable. It is, further, important that individual wires should be stranded or braided so that in passing along the cable an outside wire becomes an inside wire, and then again vice versâ. Well-insulated cable-strands are obtained by using enamelled wire, though good insulation may be partly obtained by thoroughly treating the cable with an insulating varnish. The tests seemed to indicate that the decrease in loss obtained by using enamel-insulated wire in cables would hardly warrant the extra cost of this kind of insulation, particularly in cases where only a portion of the total current which flows is high-frequency current. A case of this character is where the secondary of a high-tension transformer feeds an oscillating circuit, some of the high-frequency oscillating current finding its way into the secondary winding of the transformer.

IRON OUTPUT INCREASED

The production of pig iron in Canada during the first six months of 1916 was 507,750 tons, compared with 366,825 tons in the first half of 1915. This represents an increase of 40 per cent. These figures are gathered from an official compilation of the American Iron and Steel Institute. At the rate of production in the first half of the year it is possible that the output for the full twelve months will exceed the high record established in 1913. The total production of pig iron up to June 30th, this year, compares with 366,825 tons in the first half of 1915, 458,595 tons in the second half, 1,015,118 tons for the full twelve months of the record year of 1913.

Production of steel ingots and castings in Canada, according to the Institute, promises to break all records in 1916. Last year, production was very near the high record of 1,042,503 tons in 1913. The output in 1915 was 912,755 tons, compared with only 743,352 tons in 1914, an increase for the year of approximately 22 per cent.

The Panama Canal, now practically completed, has, so far, cost $400,000,000 and the commission has $16,800,000 more to spend on perfecting details and for permanent equipment, outside of an additional $4,500,000 for fortifications.

THE ALIGNMENT DIAGRAM APPLIED TO THE FLOW OF WATER IN UNIFORM AND COMPOUND MAINS.*

By D. Halton Thomson, M.A.(Cantab.), Assoc.M.I.C.E.

(Concluded from last week's issue.)

Irreducible Compound Mains.—Theoretically, the flow in any network of mains is capable of exact determination; practically, however, when it cannot be completely subdivided into lengths wholly "in series" or wholly "in parallel," trial and error is the best method, and in such cases the carrying power axis facilitates the calculations. When the diameter and length of each component pipe are given, the carrying power of that pipe is known and constant, whatever changes take place in the discharge and loss of head. The flow in each pipe is thus represented by a single index line, such as *qph* in the key diagram, the locus of which is fixed at one point *p*. With their respective points *p* as fulcra, therefore, these index lines have then to be adjusted until the given conditions of discharge and loss of head are fulfilled, as indicated by their intersections on the *q*- and *h*-axis.

Practical Application to a Network of Pipes.—The detailed calculations of a compound main, in which are included the different applications of the alignment diagram described above will now be explained.

The general procedure is to determine by means of *dsl*- and *dpl*- index lines the values of *s* or *p* for each of the component lengths, and to combine these values step by step with the aid of equations (6) and (7) until the carrying power of the whole is obtained. The required diameter and discharge are then determined by *dpl*- and *qph*- index lines respectively, each intersecting the *p*-axis at the value of the carrying power previously calculated. It should be noted that corresponding values of *s* and *p* occur at the same point on the *p*-axis; when, therefore, one of the values has been calculated, the other is obtained from the reading immediately opposite.

Example 9.—Given the compound main shown diagrammatically in Fig. 2 (Plate 2); the diameters and lengths of the component uniform mains are known, and water flows between the points A and B; required—

(1) The diameter of a single uniform main of same length as AB (5.5 miles) equivalent to the compound main;

(2) The rate of discharge assuming a loss of head of 40 ft.

It is convenient to draw up the calculations as shown in the accompanying table. The reference numbers (1) to (10) in the first column correspond to the component mains in Fig. 2. The upper half of the table refers to the determination of *s* or *p* from the known diameters and lengths by means of *dpl* index lines. Thus, for main (1) an index line through $d = 10$ in. and $l = 2$ miles intersects the *s*-scale at 20, and so on. The values omitted in the last two columns are not required. The lower half of the table refers to the combination of the component mains with the aid of equations (6) and (7). Thus, mains (1) and (2) are in series, and equation (6) must be used. Adding together the values of *s* from the upper half, $s = 24$ for the whole is obtained, and since the corresponding value of *p* will be required in a later step, $p = 0.2$ is read off opposite 24 on the *p*-axis and entered in the table. This equivalent main is referred to as (11). Similarly, mains (8), (9), (10) are combined and referred to as (12). Mains (4) and (5) are in parallel, so that equation (7) must be used. Adding together the values of *p* from upper half, $p = 0.42$ for the whole is obtained, and since the corresponding value of *s* will be required in a later step, $s = 6$ is read off opposite 0.42 on the *p*-axis and entered in the table. This equivalent main is referred to as (13), and can now be further combined with main (3), with which it is in series; this is called (14). Mains (11) and (14) are next combined, and so on, until the carrying power (*p*) = 0.32 for the whole system is obtained.

To find the diameter of a single equivalent uniform main of the same length as AB (5.5 miles), draw an index line through (*l*) = 5.5 miles and (*p*) = 0.32; this intersects the *d*-scale at the required diameter (*d*) = 14.5 (say 15) in.

To find the discharge, assuming a loss of head of 40 ft., draw an index line through (*h*) = 40 ft. and (*p*) = .32; this intersects the *q*-scale at the required discharge (*q*) = 1.2 million gallons per twenty-four hours.

Table Showing Method of Calculating the Carrying Power of the Compound Main in Fig. 2.

Reference No.	Diameter. *d*.	Length. *l*.	For Mains in Series. *s*.	For Mains in Parallel. *p*.
	inches.	miles.		
(1)	10	2·0	20	—
(2)	15	3·25	4	—
(3)	12	1·5	6	—
(4)	12	2·5	—	0·31
(5)	8	2·5	—	0·11
(6)	12	0·5	2	—
(7)	12	1·0	4	—
(8)	8	2·25	65	—
(9)	6	2·5	350	—
(10)	8	1·0	30	—

Reference No.	Portion of compound main calculated.	Whether in series or in Parallel.	Equation (6) or (7).	*s*.	*p*.
(11)	(1) (2)	Series.	$s = 20 + 4$	24	0·2
(12)	(8) (9) (10)	Series.	$s = 65 + 350 + 30$	445	0·045
(13)	(4) (5)	Parl.	$p = 0{\cdot}31 + 0{\cdot}11$	6	0·42
(14)	(3) (13)	Series.	$s = 6 + 6$	12	0·28
(15)	(11) (14)	Parl.	$p = 0{\cdot}2 + 0{\cdot}28$	5	0·48
(16)	(15) (6)	Series.	$s = 5 + 12$	7	0·39
(17)	(16) (12)	Parl.	$p = 0{\cdot}39 + 0{\cdot}045$	5·5	0·435
(18)	(17) (7)	Series.	$s = 5{\cdot}5 + 4$	9·5	0·32

Result: The carrying power of the whole compound main is $p=0.32$.

In the ordinary cartesian system, where the variables are referred to two axes at right-angles to one another, it is not possible to represent a formula of more than three variables without making the diagram unduly involved, whereas in Fig. 1, by means of the alignment system, no fewer than six variables are represented in a very simple way. The advantage of the latter in thus dealing with a large number of variables is, therefore, apparent, for by its use alone has the extension to the calculation of compound mains been made possible.

Appendix.—Rules for Construction.—Like the slide-rule, it is not necessary to understand the principles underlying the alignment diagram in order to employ it in actual practice, and the above examples should serve as sufficient instruction for its use. It is proposed, however, to enter upon a brief discussion of these principles in so far as is necessary to explain the rules for construction. For their proof, reference may be made to the publications given below in the bibliography.

Many formulæ in common use are of, or can be transformed to, the general type—

$$u = k\, x^a\, y^b \quad \ldots\ldots\ldots\ldots \quad (8)$$

where u, x, y are variables, and a, b, k are constants, positive or negative. These can be represented by an alignment diagram in which there are three parallel straight lines (one for each variable), and the scales of which are logarithmic—*i.e.*, like those on a slide-rule. Since it is a property of a logarithmic scale that the lengths representing each multiple of 10 are equal—*e.g.*, the distance from 1 to 10 is equal to the distance from 10 to 100—and so on, each of such lengths constitutes a logarithmic unit.

Let N_u, N_x, N_y represent the length of the logarithmic units in terms of any standard length for each of the variables u, x, y, and let these units be called positive when the scales increase upwards, and negative when they increase downwards. Also let B_{ux} B_{xy} be the distances between the axes, as shown in Fig. 3 (Plate 2).

It will be assumed that the units and positions of the x- and y-scales are selected so as to cover the required range of values and to form a compact diagram; two or three trials will probably be necessary before this is achieved. The values of N_x, N_y, and B_{xy} are therefore known, and it is required to determine N_u and B_{ux} to complete the diagram.

Then the rules for construction are—

(I.) For the logarithmic unit of the u-axis—

$$\frac{l}{N_u} = \frac{a}{N_x} + \frac{b}{N_y} \quad \ldots\ldots\ldots\ldots \quad (9)$$

(II.) For the position of the u-axis relatively to the x- and y-axes—

$$B_{ux} = \frac{N_u}{N_y}\, b\, B_{xy} \quad \ldots\ldots\ldots\ldots \quad (10)$$

If B_{ux} is positive, the u-axis lies towards the y-axis; if it is negative, the u-axis lies away from the y-axis.

(III.) For the position of the u-scale on its axis, assume values of x and y in equation (8), and calculate u. Place the u-scale in such a position on its axis that the calculated value is intersected by the index line laid through the assumed values of x and y on their respective scales.

The method may be extended to equations containing four variables of the type—

$$u = x_a\, y^b\, z^c \quad \ldots\ldots\ldots\ldots \quad (11)$$

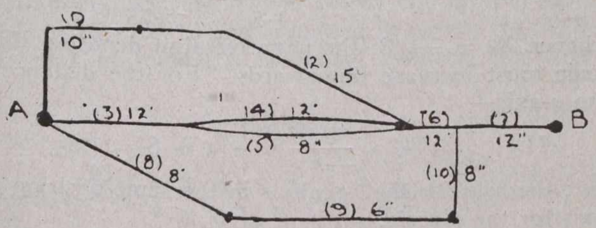


Fig. 2.

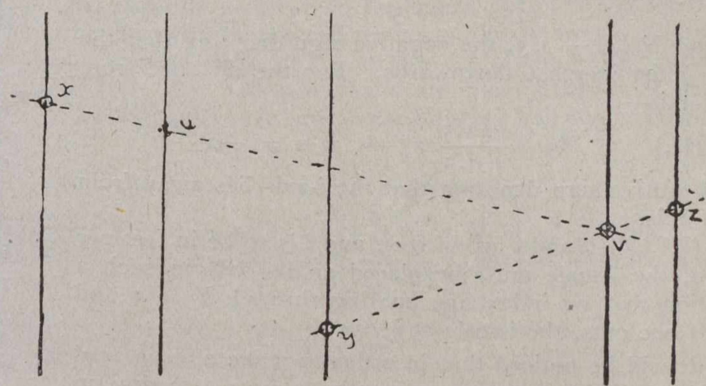


Fig. 4.

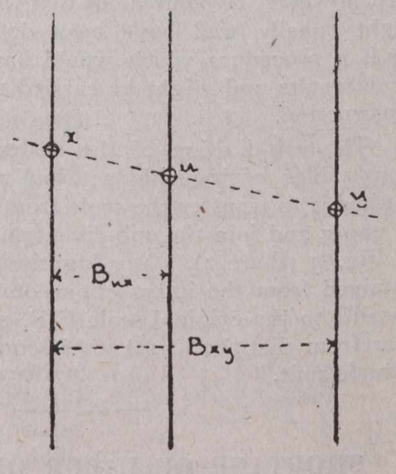


Fig. 3.

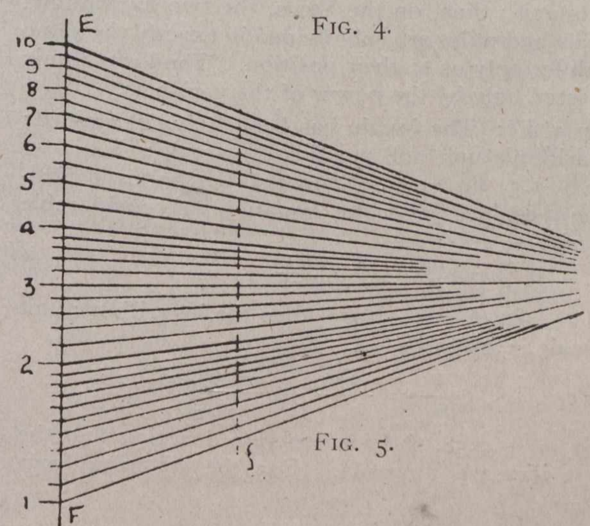


Fig. 5.

Plate II.—Alignment Diagrams for Water Mains.

where z and c are an additional variable and constant respectively. This may be written—

$$u = k\, x^a\, v \quad \ldots\ldots\ldots\ldots \quad (12)$$

where—

$$v = y^b\, z^c \quad \ldots\ldots\ldots\ldots \quad (13)$$

Equations (12) and (13) are evidently of the same form as equation (8), and can be regarded as two tri-axial alignment diagrams with a common v-axis. When, therefore, in equation (11) the values of any three, say, u, x, y, of the four variables are given, that of the fourth, z, is determined by drawing two index lines, one through x and u, intersecting the common axis at v, the other through v and y, intersecting the z-axis at the required value, as indicated in Fig. 4 (Plate 2). On the same principle the diagram may be extended to formulæ containing more than four variables.

Construction of Pipe-flow Diagram.—Since equations (1) and (2) for flow in pipes are of the same form as the general equations (12) and (13), the rules given above may be applied. For the purpose of construction the variables must be taken in groups of three, the units and positions of the scales of any two being assumed or previously calculated, and those of the third determined therefrom. In Plate 1 the standard length selected is 1 in.

Group $i\ h\ l$: Select logarithmic units and positions of h- and l- scales; $N_h = -.75$, $N_l = -1.5$, $B_{hl} = 2$. Required, the unit and position of the i-scale. To make equation (1) comparable with (8), write—

$$i = h\ l^{-1}$$

whence $a = 1$, $b = -1$; then the logarithmic unit of the i-scale is given by—

$$\text{(I.)} \quad \frac{1}{N_i} = \frac{1}{-.75} + \frac{-1}{-1.5} = -\frac{4}{3} + \frac{2}{3} = -\frac{2}{3}$$

whence $N_i = -1.5$, the negative sign denoting that the scale must increase downwards. For the distance from the i-axis—

$$\text{(II.)} \quad B_{ih} = \frac{-1.5}{-1.5} \times -1 \times 2 = -2$$

the negative sign denoting that the i-axis lies away from the l-axis.

(III.) If h and l are in feet, and i is to be in feet per 1,000, the i-scale must be placed on its axis in such a position that an index line passing through $h = 1$ and $l = 1,000$ cuts, the i-scale at $i = 1$.

It will be noticed that in order to make a scale read in other units it is necessary merely to move it bodily up or down its axis; thus, on the l-axis, the two logarithmic scales of feet and miles are sub-divided in exactly the same way, but differ only as to their position. The logarithmic unit is affected only by the power of the variables.

Group $q\ d\ i$: The i-scale has been fully determined; select logarithmic unit and position of q-scale; $N_q = +1.5$, $N_i = -1.5$, $B_{qi} = 6$. Required, the unit and position of the d-scale. To make equation (1) comparable with (8) write—

$$d = q^{\frac{m}{n}} - i^{\frac{1}{-n}}$$

whence $a = .384$, $b = -.197$; then the logarithmic unit of the d-scale is given by—

$$\text{(I.)} \quad \frac{1}{N_d} = \frac{.384}{1.5} + \frac{-.197}{-1.5}$$

whence $N_d = +2.58$, the positive sign denoting that the scale must increase upwards. For the distance from the q-axis—

$$\text{(II.)} \quad B_{qd} = \frac{2.58}{-1.5} \times -.197 \times 6 = +2.03$$

the positive sign denoting that the d-axis lies towards the i-axis.

(III.) From equation (1) it may be calculated that when $i = 1$ ft. per 1,000 and $d = 12$ in., then $q = .65$ million gallons per twenty-four hours. The scale on the d-axis must be so placed that these three values when plotted on their respective scales lie on a straight line.

Group $q\ p\ h$: The q- and h-scales have been already fully determined; $N_q = +1.5$, $N_h = -.75$, $B_{qh} = 8$. Required, the unit and position of the p-scale. To make equation (2) comparable with (8) write—

$$p = q\ h^{\frac{1}{-m}}$$

whence $a = +1$, $b = -.512$; then the logarithmic unit of the p-scale is given by—

$$\text{(I.)} \quad \frac{1}{N_p} = \frac{1}{1.5} + \frac{-.512}{-.75}$$

whence $N_p = +.74$, the positive sign denoting that the scale must increase upwards. For the distance from the q-axis—

$$\text{(II.)} \quad B_{qp} = \frac{.74}{-.75} \times -.512 \times 8 = 4.05$$

the positive sign denoting that the p-axis lies towards the h-axis.

(III.) Since the unit adopted for carrying power corresponds to a pipe discharging at the rate of 1 cu. ft. per second under a total loss of head of 1 ft., the scale on the p-axis must be so placed that the three points representing these values lie in a straight line.

For the calculation of the s-scale, since $s = \frac{1}{p^m}$ equation (2) must be written in the form—

$$s = q^{-m}h$$

whence $a = -1.95$, $b = +1$; then the logarithmic unit is given by—

$$\text{(I.)} \quad \frac{1}{N_s} = \frac{-1.95}{1.5} + \frac{1}{-.75}$$

whence $N_s = -.38$, the negative sign denoting that the scale must increase downwards. For the distance from the q-axis—

$$\text{(II.)} \quad B_{qs} = \frac{-.38}{-.75} \times +1 \times 8 = 4.05$$

i.e., the axis for the s-scale is in the same position as the axis for the p-scale.

(III.) The position of the s-scale on its axis is determined by the fact that s and p must equal unity at the same point.

This completes the calculations for the diagram; it may, however, be pointed out that the p-axis and its scales might equally well have been determined from group $d\ p\ l$, a procedure which would have led to exactly the same results and might be carried out as a check on the construction.

The sub-division of the scales may be ascertained from tables of logarithms; but a sufficiently accurate method is to transfer the scale from a slide rule to a sheet of paper and join the sub-divisions to a point, as shown in Fig. 5 (Plate 2). Any logarithmic scale can then be obtained from the intersections on a straight line drawn parallel to the original scale E F, and at such a distance therefrom that the length $e\ f$ is equal to the known logarithmic unit.

SHORTAGE OF LABOR ON THE COAST.

(Staff Correspondence.)

Vancouver, September 4th.

Manufacturing industries are beginning to feel the lack of labor. The need of men is felt by all, but the Empire's war is the first consideration. The manager of a lumber mill in Vancouver told *The Canadian Engineer* that unless more men were available they would have to consider the question of closing down of at least part of their operations. The output of logs is being curtailed, and notwithstanding the unprecedented output in June of 120,023,869, and it is expected that July's figures will approximate this, prices of logs have stiffened. Demand is better, too. Shingle manufacturers are affected to a greater degree, and one or two of the large producers have already shut down. Shingle bolts are higher in price than they ever were, and scarce. It is possible that after the salmon fishing season is over a number of Japs will be in the woods getting out bolts.

Shipbuilding plants are affected. At Ocean Falls, where a pulp and paper industry is being started, many men could be taken on, and some have been secured in Seattle. The Empire Pulp and Paper Company has taken over the idle pulp plant at Swanson Bay with the idea of resuming operations, and men will be needed there also.

QUEBEC BRIDGE CENTRAL SPAN.

(Continued from page 210.)

down-stream ends of the scows, two at each end, and one tug on the up-stream end of each set of three scows to assist in moving the span endwise and generally for purposes of manipulation, so that there will be eight tugs in all—five on the down-stream side to hold the span against the current and three on the up-stream side for use as may be required.

It is the intention to check the span several times on the way up to the bridge to determine that it is under perfect control, and to stop it definitely some 200 or 300 feet below the bridge. Light lines will then be run from engines on the suspended span to the mooring frames which are now suspended from the ends of the cantilevers, and the span will be gradually pulled into position against a moderate pull of the tugs working down-stream. As the span nears its position, additional heavy lines will be carried from the mooring frames to the end of the span, these lines being crossed and arranged in such a way that the span may be hauled to an exact position vertically under that it will occupy when in place on the bridge.

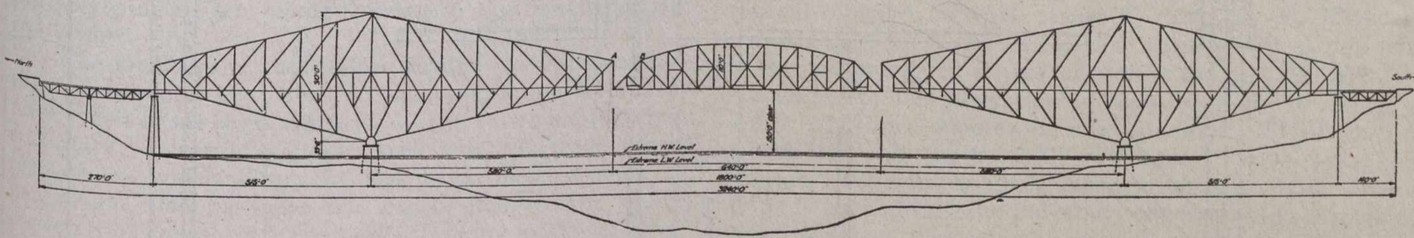
After the span is securely moored in this position, the hoisting chains, made of a series of bar links, by which it is to be raised up will be dropped into position and attached to the span. After the links are secured to the span they will be pulled up by hydraulic power and the span thus lifted to its final position. The eye-bars from which the span is to be finally suspended will be joined about the middle of their length by pins which will be driven when the span is in place. The upper links of these eye-bars are now hanging from the ends of the cantilevers and the lower links are fixed in their final position at the ends of the centre span.

Sketch No. 1 shows the bridge in outline with the centre span in its final position after the above described operations but without the floor system completed or without the redundant member later to be put in for the sake of appearances between the points A and B.

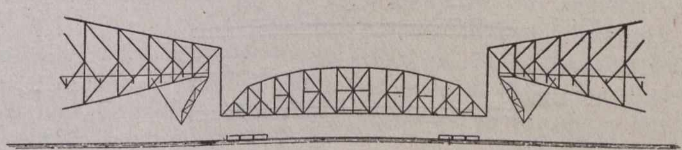
Sketch No. 2 shows the centre span when partly hoisted with the mooring lines released and the mooring frames partly hauled up out of the way.

Sketch No. 3 shows the span moored in position but without the hoisting chains attached to it. These will be hanging down from the lifting girders but are omitted on the sketch to avoid confusion of lines.

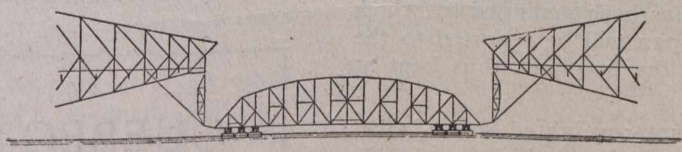
Sketch No. 4 illustrates the arrangement for hoisting the span into place.



SKETCH-1



SKETCH-2



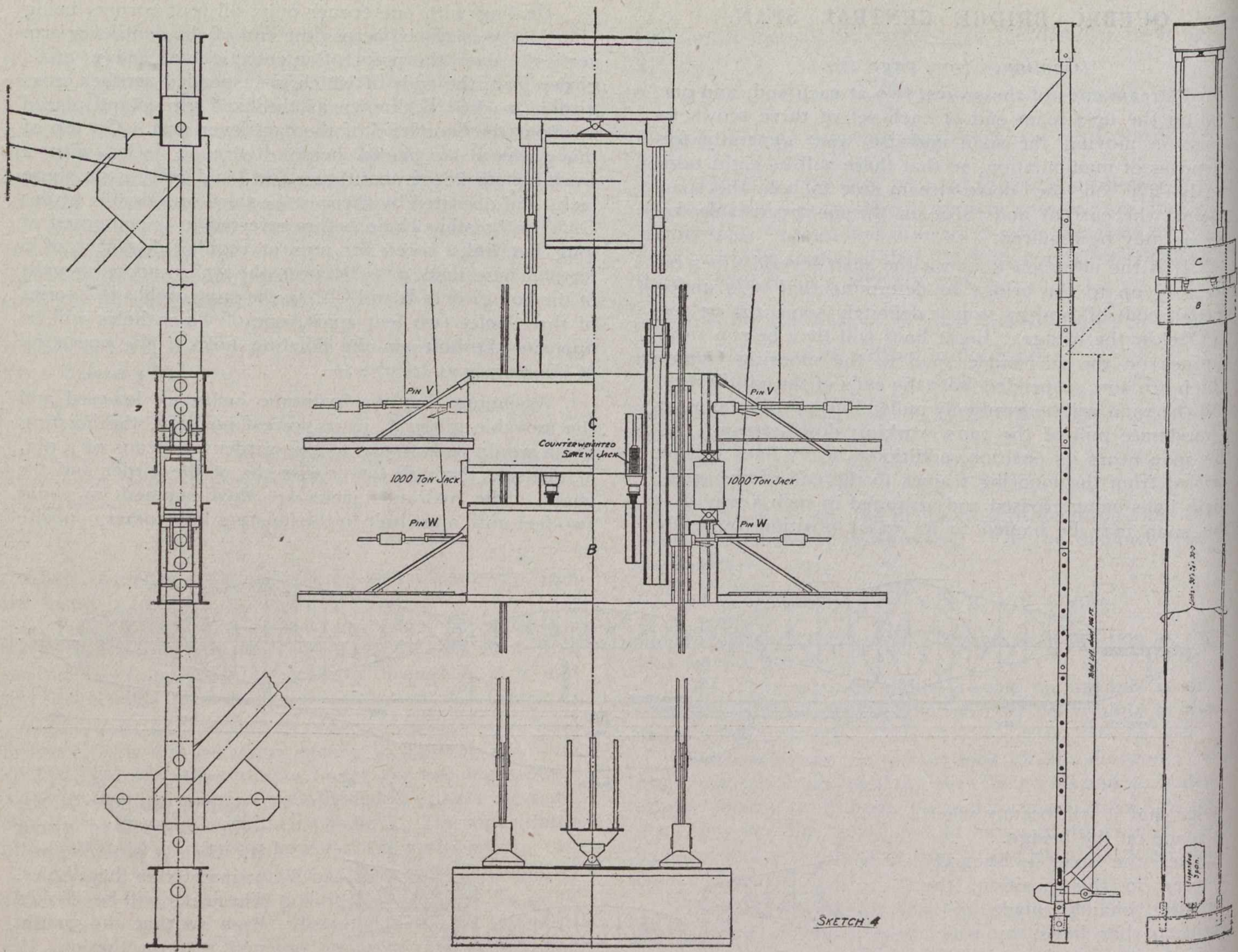
SKETCH-3

Dealing with one corner only, all four corners being alike, there is placed across the end of the cantilever arm vertically over the point of intersection a heavy cross girder from the ends of which is suspended another cross girder, marked B, known as the fixed girder and placed at about the floor level of the cantilever arm. On top of this girder B are placed heavy hydraulic jacks with a working stroke of about two feet, and resting on these jacks and operated by them is the third or movable girder C. The hoisting chain before referred to is composed of long flat links bored for pins at regular distances of 6 feet. These links pass between the webs and cross-webs of the box girders B and C. In the cross-webbs is a series of three holes two feet apart, one of which holes will be opposite the holes in the hoisting links. The operation of hoisting is as follows:—

Assuming that the hydraulic jacks are lowered and the movable girder C in its lowest position, the hoisting chain would be fastened to this girder by means of a pin, V, passing through the cross-webs of the girder and the chain. The hydraulic jacks are then pumped up about two feet until a pin hole in the hoisting link comes opposite a pair of pin holes in the webs of the fixed girder B, when a pin, W, will be inserted in these holes. The jacks will be slacked back so that the weight will rest on the pin W and the pin V may be withdrawn, permitting the movable girder C to be returned to its original position, 2 feet lower. When in this position another pin hole in girder C will be opposite a pin hole in the hoisting links, the pin V will be inserted therein, and the jacks pumped up until the load is relieved from the pin W, which will then be withdrawn and the girder C raised another two feet. In this way the operation will be repeated, raising the span two feet at each movement of the jacks until it is in its final position.

The following data may be of interest to engineers:—

There are two jacks to a corner, 8 in all. The load to be lifted is estimated to be 5,540 tons. The rams of the jacks are 22 inches in diameter and the working pressure 4,000 lbs. The lacks have been tested in position by anchoring the girders B and C together to a pressure of 5,000 lbs. or 25 per cent. overload. The hydraulic pumps operating the jacks, two at each end of the span, are operated by compressed air piped from power houses on shore. There is a separated control valve for each jack at each corner and control valves for each pair of jacks at each end. Multiplying tell-tales are arranged



so that the valve operators at the corners may keep the moving girder C exactly horizontal and the valve operator at the centre of the span may keep the span itself horizontal. A telephone system has been arranged by which each lift at the ends of the span will be reported to the officer in general charge and the two ends thus kept at the same vertical height.

There is a system of counter-weighted screw-jacks, hand-operated, to follow up the hydraulic jacks so that in the event of a packing blowing out or any accident happening to a hydraulic jack, it may be removed and repaired while the bridge is resting on the follow-up screw-jacks. The hoisting chains, two to a corner, are each composed of two bars, 30 inches by 2¼ inches, 30 feet 0 inch long, connected by 12-inch diameter pins. The pins for connecting these links to the girders are also 12-inch diameter. When a full link has come up through the girder C it will be suspended from a purchase on the top strut and the pin connecting it to the link below will be withdrawn, allowing the link to be lowered on to the span. The movable pins for hoisting are suspended from above and counterweighted so that they are easily inserted or withdrawn by two men.

The mooring frames are calculated at erection unit stresses for a force of 300,000 pounds applied at the lower end. The mooring lines, four in number at each end, are 1¼-inch plough steel rope with 9 part ¾ inch wire rope falls leading to engines on the deck. The hoisting tackle, or back-guy for the mooring frame, is a 9 part ⅞ inch wire rope tackle leading to one of the main hoisting engines formerly used on the erection traveller.

QUEBEC BRIDGE SPAN FALLS

Quebec, September 11th.—The central span of the Quebec Bridge fell into the river at 10.45 this morning, when it had been raised only fourteen feet. Nine St. Lawrence Bridge workmen missing. Thought that one of mooring pins failed. Cantilever arms not affected.

The council of the Canadian Society of Civil Engineers has asked all of its members to protest against the employment of alien engineers on Canadian work.

Editorial

LOSS OF QUEBEC BRIDGE SPAN.

After having been raised only fourteen feet, the central span of the Quebec Bridge dropped into the St. Lawrence River last Monday morning, possibly owing to failure of one of the mooring pins.

While the accident is serious from a time and monetary standpoint, fortunately the loss of life was not heavy, according to telegraphic dispatches received at the time of going to press. It is thought that nine St. Lawrence Bridge Co. workmen are missing, but it is possible that this number may be reduced when more complete information is gathered. It is stated that the cantilever arms stand intact and uninjured, so that the accident probably means merely the loss of a million dollars more or less to the St. Lawrence Bridge Co. and possibly nine or ten months' delay in the completion of the bridge.

The members of the Quebec Bridge Commission and the officials and engineers of the contracting company have received the deep sympathy of the entire engineering fraternity; nevertheless, compared with the tremendous size of the undertaking, the loss is no more serious in proportion than has been the loss of many other spans during the course of erection of many other bridges throughout the world. How often have contractors lost smaller spans owing to breakages, stream conditions, or other unforeseen and practically uncontrollable happenings?

The designs for hoisting the span were unquestionably most carefully prepared, checked and re-checked a dozen times; the best American and Canadian bridge engineers were employed on the work; every precaution that could have been taken was, without doubt, observed and with presumably large factors of safety. The accident, whether due to the failure of pins, eye-bars, bracing, or other parts of the equipment, will undoubtedly be found to have been of such a nature as to cast no reflection upon any of the engineers connected with the work.

Mr. Phelps Johnson, Mr. Duggan and the other heads of the St. Lawrence Bridge Co. are made of sterner stuff than to be discouraged or disheartened by this accident, the character of which is not unprecedented in bridge erection. They will undoubtedly build another span and hoist it into place by the same or other means, probably taking even more elaborate precautions.

THE ENGINEER AND THE CHEMIST.

The war has upset many accepted theories, ideas and attitudes in various lines of thought and business. It has perhaps wrought a greater change in the relation of the engineer to the chemist than in other relations, because the European conflict has made such a great demand upon their combined efforts and ability. The sudden demand for materials both military and civil has brought these two great services into closer relation than could have taken place probably in decades in times of peace, and they have accomplished more under the stress and urgency of the situation than was sanguinely expected. Further, the importance of the co-operation between the engineer and the chemist and the results accruing from it cannot be fully appreciated at present. It was the close and correlated organized relation between these professions that was fostered by Germany in pre-war days, and which has enabled the enemy to be so strong. It produced wonderful results in the commercial prosperity of that empire, and to this measure of preparedness can be ascribed in a large measure the powerful resistance of the central empires.

Whilst engineers and chemists did much for our industries, it cannot be stated that they were trained with the view to co-ordinating their work. They were, as a rule, separate and distinct bodies, each with a particular sphere of their own. The war has revealed the weakness of such a condition, and the future will doubtless see a great change in this respect. Prof. F. G. Dounan, F.R.S., recently wrote on this subject with a powerful pen and employed strong argument to show the need for changes in our educational methods in the training of men who have adopted these professions. "Hitherto our chemists and engineers," he states, "have been kept apart with extraordinary disadvantages to both sides." "It is argued that the university chemist is too theoretical and does not understand practical matters." The reason given by Prof. Dounan is that the student is trained in the practice of molecular juggling; that is to say, the practice of the analyses and synthesis of chemical substances in the laboratory. It is exceedingly important that he should be also fully trained in the theory and practice of designing chemical engineering plant, not so much as an engineer, but in conjunction with him.

Whether these remarks apply with equal force to Canadian universities is not material to the contention that each profession should be promoted by the best possible training and that the two should be brought together into more intimate connection so as to achieve the greatest results. There is room to believe that the value of highest scientific attainments in chemistry, engineering and other lines has already been appreciated in Canada, but whether it is as great as might be desired is doubtful. The future of industrial development in Canada is linked closely with the utilization of raw materials by-products and waste materials which are not now fully made use of. The uses of coal and gas in the many processes associated with manufactures merit intense study and research so as to improve the conditions. Electro-chemical processes are bound to produce commodities for the use of man to a great extent that cannot now be anticipated. These offer the engineer and the chemist glorious opportunities. Every ordinary industry can be made to be more efficient by the adoption of more scientific methods. Even the smith at his anvil may do better if the services of science are enlisted. This is what W. H. Cathcart shows in his book on "The Value of Science in the Smithy and Forge." The difference between the old and the coming practice, as the reviewer stated, is that the first was based on rich and prolonged experience—what is often sneered at as the rule of thumb—while the second is positive and precise.

PERSONAL.

W. N. SMITH, mining engineer, has joined the staff of the Canadian Copper Co. at Copper Cliff, Ontario.

F. B. TAPLEY has been appointed an assistant engineer of the Canadian Government Railways with headquarters at Moncton, N.B.

A. L. SMITH, superintendent of the Sudbury division of the Canadian Pacific Railway, has been promoted to the office of superintendent of the London division.

A. J. WADDIE, president and general manager of the Canadian Drawn Steel Co., Hamilton, was struck by a street car on August 22nd and received severe injuries.

D. H. McDOUGALL, general manager of the Dominion Steel Corporation, has been gazetted Honorary Colonel of the 187th Nova Scotia Highland Regiment.

EARL McINTYRE, for 17 years connected with the Republic Iron & Steel Co., Youngstown, Ohio, has resigned to take the position of field engineer for the Canadian Steel Corporation at Ojibway, Ont.

JAMES BALKWILL has been appointed superintendent at St. Thomas of the Michigan Central Railway. Mr. Balkwill is a St. Thomas man and the first Canadian to hold this position since the road was opened more than thirty years ago.

N. B. WALTON, superintendent of the Grand Trunk Pacific at Wainwright, Alta., has moved his headquarters to Edmonton. Before going to Wainwright as superintendent, Mr. Walton was in the general superintendent's office in Winnipeg.

Lieut. K. G. REA, architect, Montreal, has been appointed to the 245th Battalion Canadian Grenadier Guards, now being organized by Lieut.-Col. C. C. Ballantyne, managing director of the Sherwin Williams Company of Canada.

J. H. MUSGRAVE, mining engineer with the British Columbia Department of Mines, is making examinations of prospects for owners. He is now in Nelson, B.C., and will later visit Cultus Creek, Bayonne Camp, and Hall and Lockhart Creeks.

CHARLES PASCOE, former metallurgist for the Canadian Steel Foundries, Limited, and recently connected with the Thomas Davidson Manufacturing Company, Limited, Montreal, as consulting metallurgist, has joined the Snyder Electric Furnace Company, Chicago, as metallurgist in that company's electric furnace research plant, at Clearing, Ill.

L. L. GISBORNE, mechanical engineer, who has been in charge of the civic waterworks department of Ottawa, has resigned from the city's service to accept a position as sales representative of a Toronto manufacturing firm. W. A. MACDONALD, who has been in the city's employ for the past five years, has now been placed in charge.

W. F. B. RUBIDGE, A.M.Can.Soc.C.E., O.L.S., recently resident engineer on the Rosedale section of the Bloor Street Viaduct, Toronto, for the Dominion Bridge Co., Limited, general contractors, has resigned in order to represent George F. Hardy, consulting engineer, New York, on the construction of the dam and power house for the Abitibi Power and Paper Co., Limited, Twin Falls, on the Abitibi River.

O. W. COOK has been appointed manager of the Canadian Cartridge Company, Hamilton. Shortly after the organization of this company Mr. Cook accepted the position of assistant superintendent, rising to be superintendent, then works manager, and now manager of the company. Formerly Mr. Cook was associated with the American Westinghouse Company, spending six years in England with that company during the building of its large electrical plant in Manchester.

OBITUARY.

JOHN NICHOLSON, a very old resident of Victoria, B.C., died recently at the age of 94. Mr. Nicholson came to Canada from Ireland 70 years ago and for a considerable time was engaged in the contracting business. He also held the position of government road superintendent under Sir James Douglas, and later was associated with the firm of McNamee & Company, of Montreal, in the building of the dry dock at Esquimalt.

CANADIAN PUBLIC HEALTH ASSOCIATION.

The 5th Annual Congress of the Canadian Public Health Association will be held in Quebec City on September 13th and 14th, 1916. Wednesday, September 13th, will be devoted to the registration of members, general business meeting, appointment of committees and report of secretary. On the afternoon of that day there will be a session at the city hall and the following papers, which are likely to be of interest to our readers, will be read: "Modern Sanitation in Camps," by Dr. W. S. J. McCullough, Medical Health Officer for Ontario, Toronto, and "Pollution of Drinking Water by Untreated Sewerage," by M. MacH. McCready, chemist, Quebec Provincial Board of Health, Montreal.

Evening Session—Promotion Hall, Laval University, 8 p.m.

Thursday, September 14th, city hall, morning session. Afternoon session, 2 p.m., at which the following papers will be read: "Activated Sludge Treatment of Sewage," by H. W. Clarke, chemist, Lawrence Experiment Station, Boston, Mass.; "Difficulty of Providing Adequate Water Supplies for Small and Large Towns," by Dr. C. R. Paquin, Medical Health Officer, Quebec City.

A convention of the Sanitary Officers' Association of the province will be held at the same time in Quebec, when the following additional subjects which will likely be of interest to sanitary engineers will be discussed: "Refuse Disposal," by Dr. S. Boucher, director of the Montreal Health Department; "Purification of Water Supplies," by T. J. Lafreniere; "Unsanitary Conditions in Workshops," by M. Louis Guyon, Provincial Inspector of Factories.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Toronto Branch will open the winter season by holding a smoker this evening at the rooms of the society, Engineer's Club, 90 King Street West, Toronto, at 8 p.m. G. A. McCarthy, chairman; L. M. Arkley, secretary.

The opening meeting of the season was held last Thursday by the Manitoba Branch, at the University of Manitoba. Frank Lee gave an address on the terminal layout of the C.P.R. at Winnipeg. A. W. Smith, secretary-treasurer.