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DESIGN OF A STRUCTURAL STEEL PLANT

THE HANDLING OF EQUIPMENT AND MATERIAL—LIGHTING AND POWER FACILITIES—COMPRESSED AIR AS A POWER TRANSMITTER—WATER SUPPLY AND DRAINAGE

By E. H. DARLING, M.E.*

(Continued from last issue, page 818.)

Handling Machinery and Industrial Tracks.—Next to the selecting of the machinery there is no one feature about a structural steel plant that should receive more careful consideration than the handling equipment. The cost of handling is the largest item in the labor account, and the capacity of the plant depends a great deal on the speed with which material is fed to and taken away from the various machines. Even after every unnecessary motion is eliminated, there is a great deal of handling to do to each piece and the weight, length and flexibility of most of them call for care and special appliances.

In the ordinary run of work it is seldom that a piece of material from the steel mills will exceed three tons in weight. The stock yard crane, however, should have at least ten tons capacity as it is usually desirable to lift several pieces at one draft. Only one crane, having a ninety-foot span, travelling the full width of the lot, will be needed at first. At some future time another crane and runway may be added, which will not only increase the handling capacity, but will double the area of the stock yard.

This yard crane will unload material from the cars and sort it. As it is required in the shop, it will be put on small trucks which run on narrow-gauge tracks from one end of the shop to the other. Inside the building the hoists on the bottom chords of the trusses afford a means by which the material may be taken off the trucks and transferred to any point across the shop. At each end of the building, however, on account of the great deal of handling that takes place, at these points, it is advisable to have travelling cranes of about sixty-foot span—a 10-ton crane at the stock yard end and a 15-ton crane at the shipping end. These cranes will also be found of great service in transferring material from one aisle to another.

At the punches, longitudinal trolley beams with trolleys and chain hoists are necessary to hold the work as it is fed through the machine. These trolley beams must be suspended below the trusses and have openings for the trolleys on the trusses to pass through. Special travellers and jib cranes can be arranged to suit the need of any particular machine.

In that part of the girder shop where the girders are assembled and handled, it will be necessary to have two travelling cranes of thirty-ton capacity. Travelling jib cranes for carrying riveting machines can be arranged to run along the east side underneath the over-head cranes. In the structural shop the riveters will have 3-ton travelling cranes with fifteen-foot span carried on runways suspended from the roof trusses.

Three- and five-ton air hoists will be required wherever much lifting is to be done, provided the head room is sufficient for the hoist. For holding work at machines, however, a chain block is better, as air hoists are not steady enough. Wherever possible, material will be laid on horses or skids, so as to save raising and lowering more than necessary. If much of it has to be done at any point, rapid-acting blocks should be used

In course of time it will be found convenient to have a thirty-ton travelling crane with seventy-five-foot span in the yard at the north end of the plant. Under it finished material may be stored and loaded for shipment as required. It can be used for assembling large trusses when it is necessary to put them together at the works before shipping.

All the thirty-ton cranes should have 5-ton auxiliary hoists, or should be provided with change gears, as some cranes are now made. This will save a great deal of time when the crane is used for handling light pieces, the slow motion or main hoist being used only for heavy loads.

The handling equipment under certain conditions should include a 10-ton locomotive crane. Such a machine will be found of great service during construction for unloading and placing building materials, machinery, etc. It will also be a great convenience, if not a necessity, in moving cars, unless unusually good shunting service is available from the railway company. It may be used to good advantage by the erection department for certain work.

All parts of the handling equipment should have a wide margin of strength. Chains, hooks, cables, chain blocks, etc., that are frequently overloaded, soon give trouble and become dangerous. The most serious accidents of a structural steel shop are the result of falling material.

Power and Lighting Systems.—Electric power is usually delivered as two- or three-phase alternating current at a high voltage, to be transformed to suit the requirements of the purchaser. For distribution about the plant a voltage of 220 or 500 volts is usually used. The higher voltage requires less copper in the feeders, but for a structural shop the lower voltage, i.e., 220 volts, is preferable. The presence of so much metal, the rough treatment which wires and conduits are liable to receive, makes it unwise to use a voltage that might be dangerous to workmen.

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The power equipment must include a motor-generator set, as direct current will be required for variable speed motors, such as cranes, reamers, etc. The motor side of this set should be of the synchronous type with sufficient capacity to correct the power factor of the plant. On account of the varying loads on the motors, the power factor is sure to be very low. The capacity of the generator should be well able to take care of the needs of the plant, including the lighting system and the extra travelling cranes which might be added in a year or two. A set with a capacity of 100 kilowatts direct current and a synchronous motor of 125 k.v.a. should give satisfaction.

The high voltage current will be brought down the tower at the end of the power house to the transformers, and from thence the low voltage current will be taken in conduits to the bus-bars of the switchboard. A separate switchboard will be needed for the direct current system. From the switchboards feeders in conduit will run to the machines in the power house and template shops. For the main shop the feeders will pass up the tower and over head to cross-arms on the trusses of the building. A separate system, each on its own switch, should be provided for the different departments, so that any one can be cut out without interrupting the others. There should be three sets of A.C. feeders, one for each aisle of the shop, with room on the cross-arms for the additional aisles to be added later. There should be two pairs of D.C. feeders, one for the north cranes and one for the south cranes. If separate switches are provided at convenient points for cutting out each crane, it will hardly be necessary to have separate feeders for the other D.C. machines in the shop. There will only be one or two of these machines other than the reamers.

All wires above the bottom chord of the trusses will be carried on cross-arms bolted to the steel work, but wires below this level must be put in metal conduits. The starting switches for each machine should be as near the machine as possible. For the portable reamers a series of outlets must be provided on the columns about every forty feet down the shop so that the reamers can be connected up by means of a plug and a flexible chord wherever needed. Each outlet and, in fact, every branch circuit, must have a separate cut-out. In this and in all other particulars the rules of the fire underwriters must be followed, and every precaution taken to prevent short circuits and injury to the workmen.

For general illumination modern D.C. flaming arc 110-volt lights give as suitable and as economical a light as any. One light in every other bay arranged alternately on the right and left-hand side of the centre of each aisle will be sufficient for general illumination, while they may be spaced closer over the laying-out skids and the assemblers. As the power circuit is 220 volts, it will be necessary to connect two lights in series. Each pair must have a cut-out and every four lights should be controlled by a two-pole switch.

Sixteen-candle-power incandescent lights must be provided for each machine. These must be on good lamp chord and protected by wire cages having wooden handles. The power for these lights may be obtained by tapping the circuit that supplies the machine.

For the template shop the best illumination can be obtained by means of 100-watt tungsten lights suspended from the roof, three in each twenty-foot bay. Along the walls, over tables, or near machines, 16-candle-power carbon lights on drop chords will be used to give special illumination where needed.

Compressed Air Systems.—The transmission of power by means of compressed air is a very expensive method, but it is so convenient to handle, and can be adapted to so many uses, that it would be impossible to get along without it. A pressure of 90 to 100 lbs. per square inch is usually used for operating pneumatic riveters, hammers, reamers and hoists. The plant can easily be supplied by a 700-foot-per-minute, two-stage compressor. When the demand gets beyond this, it will be advisable to add a 1,400-foot machine to the equipment and the piping, etc., should be installed at the outset with this object in view. By having two machines of different capacity, the varying demand for air can be supplied a great deal more economically than by one large compressor.

The compressor will be belt-driven by a 125-h.p. induction motor. It should have an automatic throttling device which will cut off the supply of free air completely when the pressure in the system reaches its maximum. Such a governor can be adjusted to regulate the pressure within three pounds. This small variation need not be considered, as the method is much more economical in power than if a regulator were used which would permit just enough air in the intake to maintain the pressure constant. It causes great fluxations in the power used, however, as the compressor runs light when the intake is cut off.

In order to keep the pressure in the distribution system as constant as possible, and to relieve it of shocks, it is necessary to have a storage tank near the compressor. This tank will also act as a cooler, and in it will collect a great deal of the moisture that would otherwise pass into the distribution pipes. A large second-hand fire-tube boiler can be converted into a splendid storage tank. It should be set in a vertical position so as to allow a natural circulation of air through the tubes. The inlet should be near the top and the outlet about eighteen inches from the bottom. A convenient place for this tank is in a corner of the boiler-room. From it the air main can be taken underground to the centre of the main shop, and from thence by three vertical branches to the roof trusses, one branch each for the air hoists in the girder shop and structural aisles and one branch with drop pipes down every other column of the centre row, having outlets for the riveting machines, reamers, etc.

All horizontal pipes should be given a slight slope downward in the direction of the flow of air so that any moisture that is carried past the storage tank will not obstruct the flow. At the tank and at all low points in the system blow-off valves must be provided to the drains, and these should be opened at regular intervals. Care in this particular and abundantly large pipes will do away with all trouble from frost in winter. It will not pay to provide special means to re-heat the air before using, and it is not convenient to arrange a satisfactory indirect method.

A low pressure system—about twenty pounds per square inch—will be required for the oil forges. The blower, which will be driven by a small motor, can be supported between the trusses. The distribution system, which will be made of galvanized iron pipes, will be carried over head and down columns near the rivet forges. Ultimately a separate blower will be required for the rivet-making plant and the blacksmith shop, but for the present the one machine will do.

Water Supply System.—Apart from the amount of water required for drinking, sanitary purposes and fire protection, it will only be used for the water-cooler of the compressor, and in the boiler of the heating plant. A 6-inch pipe will supply enough for several fire streams if the pressure is good. The source of supply will probably be a public main on the street to the north of the property. The best place to bring in the private main is along the west boundary. Here it will be always accessible and not likely to be covered up with materials, etc., and furthermore, in case of a break it cannot do much damage to tracks or foundations. Where the first branch in the main occurs a manhole should be built and a valve placed on both lines leading away from it. In fact it will be found of great convenience to have plenty of valves in the system so that any one section may be cut out with the least possible interference with the rest of the system. It is most important that the supply for the water-cooler on the air compressor be as independent as possible, for the lack of a little water here will practically stop the operation of the plant.

Hydrants should be placed at convenient points, but not too near the buildings. By having them near the tracks they may be used for supplying the locomotive crane. An automatic sprinkler system should be installed in the template shop.

The ends of all branches should be arranged with plugs or caps so as to permit of being extended as the plant grows, and tees should be put in at points wherever there is the slightest possibility that a branch might be needed in the future.

Sewers and Drains.—The drainage system and its arrangement will depend entirely upon local conditions and the amount of fall obtainable. With a minimum grade of ⅛ inch in one foot for a twelve-inch glazed tile sewer it will require three such to properly drain the plant as first constructed. Assuming that they empty into a trunk sewer on the street and that they are to be four feet deep at the manhole in the stock yard, the trunk sewer will have to be at least thirteen feet deep where the drains enter into it. If the depth be a little more than this, something might be saved in cost by running one twenty-four-inch sewer about three hundred feet into the property and connecting the twelve-inch sewers to it. The question of sewers, however, depends so entirely on local conditions that nothing in the way of a definite design can be worked out at this stage. In general, however, it may be said that in addition to providing for carrying off the rain water from the buildings and the sewage, the surface water that may collect on the site must be taken care of. Special care should be taken to keep the sub-grade of the tracks well drained. All pits for machinery and other low spots should be connected with the sewers as well as all drain-offs and drips from water tops, steam pipes, etc. Sewers other than tile drains should not run near foundations if it can be avoided. In case such arrangement is found necessary, then the foundations must be carried down below the level of the sewer. Manholes with catch basins should be built at all junctions of the large sewers.

Fuel Oil System.—Where light fuel oil of a uniform grade and at reasonable price is readily obtainable, its use in riveting heating forges and other furnaces is well worth considering. The rapidity with which a furnace can be heated, the ease in obtaining a uniform temperature, and the absence of the dirt incidental to the use of coal and coke, are all points in its favor. Only satisfactory results can be obtained, however, from a correctly designed system, and while for a small plant the first installation will be expensive, it may be easily extended in the future at very little cost.

The great secret of success with fuel oil is clean oil of a uniform grade, and large distribution pipes. For storage purposes two 12,000-gallon iron tanks will be required. These are to be buried in blue clay near the tracks at least thirty feet from other buildings, so that a tank car may be unloaded into them by gravity. The tanks should have one end exposed in a pit or concrete cellar roofed in to protect it from the weather. This pit should be large enough to contain a small electric pump which will be required to maintain a sufficient pressure in the distribution system. The first tank serves as a receiving and settling tank. The second tank is connected with the first by a pipe so as to draw off the oil a foot or two from the bottom of the first. It will be necessary to drain the sediment out of the settling tank at regular intervals.

The distribution system should not be made of less than 1¼-inch pipe and should form a closed circuit or duplicate system, having a return pipe or overflow back to the second tank. By this means the oil is kept circulating at all times, and congestion from any cause is prevented. If trouble should occur at any point, that section may be cut out by means of valves and the rest of the system need not be interrupted.

For keeping the oil from congealing in winter, steam coils should be put in the storage tanks and the distribution pipes should be laid in iron casing through which steam may be blown.

Heating System.—The question of heating structural steel plants deserves special consideration in each particular case. It is a question that is involved in the choice of a location. To heat brick buildings of ordinary type is not necessarily a very difficult problem. The office can be heated by means of steam coils in the usual way. For the template shop, compressor room and machine shop a hot air system with fan will give satisfactory results if properly designed. This system is cheaper to install than steam coils and interferes less with the arrangement of the benches, machines, etc.

The heating of the main building is a more difficult problem. The volume of air to be heated is so great, uncontrolled by partitions, the conductivity of the corrugated iron and glass which forms the walls is so high, and the large doors have to be opened so frequently, that the cost of a plant that will give satisfactory results is almost prohibitory, to say nothing of the cost of operating it. Then, again, the capital invested in a heating plant lies idle a large part of the year. In fact, in Southern Ontario severe weather seldom lasts more than a few days at a time at intervals during the winter months. Under such conditions a heating plant is not necessary as "salamanders" or open fires burning coke or charcoal can be placed around at convenient points. The cost of such fires, even with the time lost by the workmen in keeping warm added to it, will not equal the interest on a heating plant and the cost of operation.

If care is taken to make a corrugated iron building air-tight, it will be found to be much warmer than such a building is usually expected to be. Large glass areas, such as are becoming so common in manufacturing buildings, if in a south wall, will produce the same warming effect which takes place in a greenhouse. This will add very materially to the warmth of a building on bright days, but it must be counteracted in summer time by good ventilation and circulation of air. Ribbed glass must also be used to diffuse the light.

Erection Equipment.—The equipment required for erecting steel work is merely to be mentioned here to call attention to it as being an item not to be overlooked. Such equipment depreciates so rapidly and the requirements vary so much with every contract, that a large part of the cost of it should be charged up to the work on which it is first used. This should be taken into consideration in making up the estimate for a piece of work. Special equipment, such as travellers, derrick cars, etc., can safely be left for consideration when the time comes to take contracts that require their use.

Order of Procedure in Construction.—When sufficient capital is immediately available the owners will very probably want the plant ready for full operation just as soon as possible, even if it costs more to rush the work. If, on the other hand, only a portion of the necessary money is to be had at once and it is desired to start manufacturing in a small way at first, then the procedure will be somewhat different.

If at all practicable, it will be best to arrange so that the actual work of manufacturing will begin in the spring or early summer. It will be easier to hold a new organization together during the summer and get them in working order than it will be in the winter. Construction should be started in the early fall so that the water service sewers, tracks and all foundations for buildings may be finished, and the power house and template shop closed in, before cold weather stops the outside work. During the winter the electrical equipment and the compressed air plant can be installed and the template shop fitted up for work. The structural steel for the main building can be erected and the orders placed for the rest of the machinery for delivery in early spring. Orders for raw material should also be put in so that it may be on hand when the time comes to start work.

As soon as the weather permits, the foundations for the machinery may be built and the main building completed. Then, as fast as the machines arrive they may be set up and made ready for operation. In the meantime the template shop has prepared templates and the raw material has been marked for punching; thus gradually the different departments are organized. By the end of May or even earlier, shipments of finished material are being made.

If the above plan of construction is followed, it will be necessary to have another company fabricate the steelwork for the power house and the main building. Or, if desired, only one aisle of the main building may be thus arranged for and the rest of the steel work, including crane, runways and bridges, can be manufactured at a reasonable cost on the spot. This, however, would mean some delay in the completion of the buildings.

THE INFLUENCE OF SILICON ON THE CORROSION OF CAST IRON.*

***By J. Newton Friend and C. W. Marshall (Worcester).**

Owing to its relatively low melting point, the ease with which objects may be cast from it, and their extreme hardness when completed, cast iron is now being used for commercial purposes in ever-increasing quantities. It is eminently desirable, therefore, in view of the serious nature of the corroding influences to which articles are exposed, to determine what the influence of varying constituents may be on the corrodibility of cast iron, and to learn what particular compositions offer the maximum resistance to corrosion.

Hitherto but little work has been done in this connection, which affords a wide field for research, inasmuch as the chemical composition of cast iron and the physical conditions at the time of experiment, admit of enormous variation. The problems are in consequence proportionately complicated, and a vast amount of work remains to be done before generalizations of any real value can be made. In the present paper the authors give the results of a study of the influence of silicon upon the corrodibility of cast iron.

For many years chemists have recognized that the presence of alloyed silicon tends to retard the corrosion of iron. Thus Mallett† more than seventy years ago was aware that cast iron rich in silicon is less readily attacked by acids, and Jouve‡ has recently proved that alloys of silicon and iron containing 20 per cent. of the former element are remarkably resistant to acid attack. But alloys such as these are not cast iron, and their utility is greatly restricted by the difficulty of working them on account of the peculiar properties imparted to them by the silicon.

The authors have therefore confined their attention to the influence of corrodibility exerted by a silicon content varying from 1.24 to 2.28 per cent. They would gladly have extended this series had it been possible, but the advantage of studying this particular range is twofold:—(1) It covers many of the various silicon contents usually met with in commercial cast irons and the results are not therefore of purely scientific interest. (2) The silicon is never so great as to interfere with the nature of the carbon content.

The latter is a most important point, and one to which we hope it may be possible to give further attention at a later date. As is well known, the presence of silicon tends to throw out the carbon as graphite, thereby rendering the metal porous and more liable to corrosion. Consequently, unless particular care be taken to keep the carbon in the same condition, both physically and chemically, the influence of the silicon per se upon the corrodibility of the metal must be affected by the proportion of graphitic carbon, and the results rendered misleading. The various cast irons used in this research were especially prepared for the authors by Messrs. Green and Company, of Wakefield, and they have pleasure in acknowledging their indebtedness to the manager, Mr. W. B. Greener, for his kindness. The irons were cut into blocks measuring 4.8 x 1.1 x 1.5 cubic centimetres, and, after rubbing with emery paper, were tested in this form. The authors wish also to thank Mr. A. E. Page, chemist to Messrs. Green and Company, for kindly analysing the metals for them. The results of these analyses were as in Table I.:—

TABLE I.

Percentage of Composition.

Cast iron No.	Silicon.	Graphite.	Combined carbon.	Manganese.	Sulphur.	Phosphorus.
1 . . .	1.24	2.70	0.65	0.63	0.096	0.99
2 . . .	1.29	2.65	0.68	0.75	0.093	1.05
3 . . .	1.45	2.55	0.65	0.89	0.082	1.04
4 . . .	1.55	2.70	0.67	0.86	0.079	1.02
5 . . .	1.72	2.75	0.61	0.75	0.085	1.06
6 . . .	2.04	2.60	0.51	0.86	0.115	1.09
7 . . .	2.28	2.75	0.55	0.69	0.076	1.04

It will be observed that, with the exception of the silicon, the other elements are present in the cast iron in remarkably uniform proportions. The corrosion of the samples containing the lowest quantity of silicon (No. 1) is in all the accompanying series taken as 100, the corrodibilities of the other samples being expressed accordingly.

I.—Tap Water Tests.—The samples of iron were laid on sheets of paraffin wax in glass beakers containing 500 cubic centimetres of tap water. After seventeen weeks the irons were removed, carefully scraped free from rust, rinsed in alcohol, and dried in a steam oven. They were then weighed, the loss in weight being taken as a measure of the corrosion (see Table II.).

*Paper read before the Iron and Steel Institute, May 1st, 1913.

†British Association Reports, 1838, p. 277.

‡Journal of the Iron and Steel Institute, 1908, No. III., p. 310.

TABLE II.—Corrosion of Cast Iron in Tap Water (17 Weeks' Exposure).

Cast iron No.	Silicon. Per cent.	Original weight. Grammes.	Loss in weight. Grammes.	Corrosion factor.
1	1.24	57.0494	0.4040	100
2	1.29	57.3176	0.3276	81
3	1.45	57.6996	0.4098	101
4	1.55	54.5786	0.4028	100
5	1.72	56.9500	0.3980	99
6	2.04	59.4522	0.3846	95
7	2.28	57.6416	0.3554	88

II.—Salt Water Tests.—These experiments were carried out in a precisely similar manner to the preceding ones, save that the liquid corrosive medium was 3 per cent. salt solution (see Table III.).

TABLE III.—Corrosion of Cast Iron in 3 per cent. Sodium Chloride Solution (13 Weeks' Exposure).

Cast iron No.	Silicon. Per cent.	Original weight. Grammes.	Loss in weight. Grammes.	Corrosion factor.
1	1.24	57.0036	0.3134	100
2	1.29	57.3356	0.2882	92
3	1.45	57.6354	0.2974	95
4	1.55	54.9200	0.3112	99
5	1.72	57.2766	0.3182	101
6	2.04	58.5736	0.3172	101
7	2.28	58.5102	0.2758	88

III.—Alternate Wet and Dry Tests.—These experiments were carried out in a precisely similar manner to those detailed in connection with nickel and chromium steels.* The results were as in Table IV.

TABLE IV.—Corrosion of Cast Iron exposed to Alternate Wet and Dry (15 Weeks' Exposure).

Cast iron No.	Silicon. Per cent.	Original weight. Grammes.	Loss in weight. Grammes.	Corrosion factor.
1	1.24	56.0926	1.0442	100
2	1.29	56.6978	1.2116	110
3	1.45	58.2680	1.0780	103
4	1.55	55.4664	1.0424	100
5	1.72	57.2854	1.0370	99
6	2.04	58.5464	1.0738	103
7	2.28	57.5996	1.0996	105

IV.—Sulphuric Acid Tests (0.05 per cent.).—These experiments were carried out in a precisely similar manner to those with tap water, the corroding liquid in this case being 0.05 per cent. sulphuric acid—that is, 0.5 gramme of acid in 1,000 grammes of solution with water. The acid was renewed every fourteen days. The results were as in Table V.

TABLE V.—Corrosion of Cast Iron in 0.05 per cent. Sulphuric Acid (13 Weeks' Exposure).

Cast iron No.	Silicon. Per cent.	Original weight. Grammes.	Loss in weight. Grammes.	Corrosion factor.
1	1.24	56.6814	0.5962	100
2	1.29	56.3498	0.6258	105
3	1.45	57.8794	0.5938	100
4	1.55	55.9416	0.5826	98
5	1.72	56.9324	0.6192	104
6	2.04	58.4756	0.6182	104
7	2.28	56.8700	0.6000	101

*Journal of the Iron and Steel Institute, 1912, No. I., p. 249 (See Iron and Coal Trades Review, May 10, 1912).

V.—Sulphuric Acid Tests (0.5 per cent.).—These experiments were similar to the preceding, save that stronger acid was employed, which was renewed every fourteen days (see Table VI.).

TABLE VI.—Corrosion of Cast Iron in 0.5 per cent. Sulphuric Acid (13 Weeks' Exposure).

Cast iron No.	Silicon. Per cent.	Original weight. Grammes.	Loss in weight. Grammes.	Corrosion factor.
1	1.24	56.9196	5.4512	100
2	1.29	56.6360	5.4486	100
3	1.45	57.9528	5.3868	99
4	1.55	55.4094	5.4218	99
5	1.72	56.7000	5.5454	102
6	2.04	58.6396	5.7658	106
7	2.28	57.6414	5.7614	106

Discussion of the Results.—For the sake of facilitating the discussion of these results, Table VII. has been drawn up, in which the corrosion factors of the cast irons as obtained in the present research are grouped together.

TABLE VII.

Cast iron No.	Silicon. Per cent.	Corrosion factor in Tap water.	Wet and dry.	Salt water.	0.05 per cent. acid.	Mean factor.	Corrosion factor in 0.5 per cent. acid.
1 . . .	1.24	100	100	100	100	100	100
2 . . .	1.29	81	116	92	105	98	100
3 . . .	1.45	101	103	95	100	100	99
4 . . .	1.55	100	100	99	98	100	99
5 . . .	1.72	99	99	101	104	101	102
6 . . .	2.04	95	103	101	104	101	106
7 . . .	2.28	88	105	88	101	96	106

A study of Table VII. reveals the following interesting facts:—(1) The corrosion factors for the irons in acids and neutral media are almost identical. This is very remarkable in view of the divergence usually observed between the two in the case of steels. (2) All the irons corrode at a uniform rate, although No. 7 shows a slight tendency to corrode less rapidly in neutral solution. Possibly this indicates that if the percentage of silicon were raised still higher, without affecting the proportions of graphitic and combined carbon, a gradual increase in resistance to corrosion would be observed. We may safely conclude, however, that a variation in the percentage of silicon between the limits of 1.2 and 2.3 per cent. has no appreciable influence per se upon the corrodibility of the cast iron. If the relative proportions of graphitic and combined carbon are simultaneously varied with the silicon, a considerable difference in the corrodibility may be expected, and this is a point upon which the authors hope to throw further light at a future date.

PROSPERITY OF THE BRITISH SHIPBUILDING TRADE.

During the early part of this year British shipbuilding firms had in hand the construction of 563 vessels with an aggregate of 2,063,694 tons. This exceeded by 377,000 tons the vessels on hand last year, and makes the highest record in the history of the British shipbuilding trade.

The tonnage of vessels at present under construction in British shipbuilding yards is equal to two-thirds the entire mercantile marine of Germany, and is about double the entire mercantile marine of France.

WELDING BY THE ELECTRIC ARC.

By J. F. Lincoln.

An arc welder is essentially an apparatus for transforming electric current at high voltage to a low voltage work current with heavy amperage. In a paper read before the American Foundrymen's Association recently, Mr. J. F. Lincoln described briefly a number of types of welder that have more or less satisfactorily established a place for themselves in commercial use.

The changing of the current which is necessary for the best application of the arc is first the reduction of the voltage to a value somewhere between 30 and 60 and then some kind of arrangement so that this voltage will be reduced as the current increases. In other words, as the resistance of the arc decreases on account of increasing current, the amount of current that flows must not increase to a point which will burn the weld or give varying results. That is, the welder must have a dropping characteristic so that as the current flow increases the voltage will drop, and drop considerably.

The first types of arc welder were of resistance units, either a water rheostat or grid resistance which placed sufficient resistance in the circuit so as to reduce the voltage to the proper point for use in the arc. This is a very satisfactory method for arc welding and the only disadvantage is that about 65 per cent. of a 110-volt current and 85 per cent. of a 220-volt current is wasted in the resistance. Another bad feature is the fact that it is rather difficult to handle large currents through resistance in a satisfactory manner on account of the burning-out of the resistance units.

Another type consisted of a motor-generator set, the only possible advantage of which over the resistance method being some current saving. There are many devices of this kind which give a satisfactory arc and save some of the current which was lost in the resistance type. With the motor-generator set it is necessary to keep a considerable amount of resistance in circuit in order to act as a ballast, or to limit the amount of current when only a small amount is required.

The usual application of the electric arc in welding is made by forming an arc between a carbon electrode and the piece to be welded. Since the piece which is welded is the positive electrode, practically all the heat of the arc is liberated here, very little being released at the negative carbon electrode. Into this arc is passed the filling metal which rapidly melts off and drops on to the positive electrode, kept at a welding temperature by the arc. In this way a weld which is perfect can be made because both the filler and the piece to be welded can be kept at a temperature at which the metal is fluid; 95 per cent. of all arc welding is done in this way.

There is another application for the electric arc, however, which is used to some extent in certain classes of work where the weld must be made overhead or on the side of a piece into which the molten metal cannot be dropped. For this application an electrode of metal is used, this electrode itself being the filler. As the arc is established the metal electrode slowly melts off, sticking on to the part already heated by the arc.

This metal electrode work is apt to be unsatisfactory unless carefully done, on account of the fact that the metal welded on must be heated to a welding temperature and the point it touches must also be heated to the same temperature.

In a general way, the statement is true that the weld is equally as strong as the original piece, providing that the original piece is of the same quality and kind of metal as the filler used. This statement, however, does not fully comprehend the difficulties in the way of getting a weld which is as strong as the original piece. A steel casting can be repaired by the use of the arc welder and a weld can be made the strength of which will exceed 60,000 lbs., which is as strong as the average steel casting. The strength of the weld is practically constant when properly made and is approximately 60,000 lbs. per sq. in. Whether it is stronger or weaker than the original piece depends on the strength of the section.

In the cutting of steel, the electric arc has another application. It is used extensively for cutting sheets, boiler-plate, etc. This work can be done cheaply and efficiently when compared with punch press, cold saw, or any other method of cutting.

MODERN METHODS IN THE MANUFACTURE OF PORTLAND CEMENT.

By Mr. H. K. G. Bamber,
Assoc. Inst. C.E., F.C.S., M.C.I., Etc.

The subject matter of this paper has had the close attention of the engineering profession during recent years, in view of the important functions which this material exercises in almost all constructional work. More especially is this the case where the engineer has to combat the mighty forces of nature, which are continually acting on such constructions, more particularly in connection with hydraulic and marine work, such as docks, harbors, breakwaters, water reservoirs, etc., where the combination of forces is such that only the most skilful design, coupled with the use of the highest quality of the most suitable material, can insure success.

To the engineering profession is largely due the credit for the improvement in the quality and adaptability of the material which is the subject of our discussion. By collaboration of their varied experiences in the use of Portland cement, aided by the technical knowledge of the manufacturers, improvements have been introducd into manufacturing processes, which have wholly, or almost entirely, removed the defects which existed in the early days of the manufacture.

Specifications have been drafted as the result of the combined experiences of engineers in all branches of the profession, which have gone far to raise the standard of quality, and to insure uniformity of this most important material of construction.

The general principles governing the manufacture of Portland cement are well known to the profession. It will therefore only be necessary to refer shortly to the usual methods of manufacture, devoting the space at our disposal more particularly to those processes upon the proper conduct of which depends the ultimate quality and reliability of the material produced.

Need of Uniformity in Quality.—Portland cement is now being manufactured in all parts of the world from a variety *of raw materials all having as their base some form of calcium carbonate, which, together with suitable argilaceous materials, form the principal ingredients of manufacture. These materials must be perfectly amalgamated and combined chemically in fixed and defiant proportions, the limits of which are not so wide as is generally supposed. Nature

* Notes on a paper delivered to the Canadian Society of Civil Engineers, Vancouver Branch, on May 26th, 1913.

has, in some localities, partially prepared and amalgamated these raw materials, but apparently without any pre-conceived ideas as to the use which such material might ultimately be put, or the stringent requirements of engineers' specifications, with the result that in localities where such partially mixed materials are found, too much reliance is sometimes placed on these ancient natural operations, with the result that cement manufactured therefrom usually has a reputation noted for the variety of its characteristics, and frequently contains one of the principal elements of failure, i.e., want of uniformity. Unless such pseudo-natural raw materials are dealt with on scientific lines, it is preferable that the material operated upon should exist in their elementary condition, having a fixed, definite, and uniform chemical composition, such as pure calcium carbonate, the line in which constitutes the base of the finished material, and clay or shales containing the acid constituents in correct ratio. Given modern machinery for the proper proportioning, amalgamating, and calcining of such materials, and the subsequent reduction, to a fine powder, of the resulting clinkers, a more uniform product can be obtained than by the use of semi-natural materials, where too much reliance is placed upon the reducing and mixing effects of ancient geological operations.

The manufacture of Portland cement has its origin in Great Britain, where suitable materials are found in the greatest abundance. The advancement of chemical science, however, has enabled materials of different characteristics found in various parts of the world to be brought into use. The author has been engaged in British Columbia on the construction of a cement plant at Bamberton on the Saanich Inlet, Vancouver Island, for the Associated Cement Company (Canada) Limited, a company formed by the Associated Portland Cement Manufacturers, (1900) Limited, of England, to operate upon a practically pure limestone, and a clay shale of very uniform composition. With these materials, and with the aid of the modern plant which has been installed, it is confidently expected that cement will be produced of a quality equal, if not superior, to the cement imported from the United Kingdom, the utmost importance being placed on the great desideratum of all engineers, i.e., uniformity of quality.

While describing, with the aid of lantern slides, the general methods of manufacture usually adopted, particular reference was here made by Mr. Bamber to the special additional processes which have been introduced in the new plant at Saanich Inlet, in order to insure the absolute uniformity of quality, the absence of which in the product of many plants has been the cause of much anxiety and trouble to the constructional engineer.

Uniformity in Setting.—There are many factors which help to produce various unsatisfactory results, but perhaps the feature of most importance in the experience of the engineer, and the one in which uniformity is most desirable, is that of setting time. The difficulties of the engineer are great, if during the construction of some important work he is suddenly confronted by a change in the characteristics of the materials he is using, to counteract which might necessitate a reconsideration of his methods of construction, and it should be the aim of all cement manufacturers to supply as uniform a material as possible; so regulating the various properties of their product to suit the climatic and other existing conditions which have a most important bearing on the setting time of all cement which as a chemical product is rapidly affected by changes in atmospheric conditions. The difficulties which confront the cement manufacturer who, having produced an article, the very first quality of which is subject to variation in many of its characteristics due to such atmospheric changes, is not fully realized, or understood, and it frequently happens when some difficulty arises in connection with construction, due to such causes, the quality of the cement is unjustly impugned. Long experience has taught the prudent manufacturer how to produce cement which is least affected by such changes, and the methods adopted will be shortly described.

The manufacture of Portland cement necessitates three distinct and separate operations. The first process is mechanical, and includes the assembling, proportioning, amalgamating and grinding the raw materials; the second chemical, during which the material prepared by the first process is calcined at a high temperature, bringing about chemical combination of the various ingredients; the third and final process being partly mechanical and partly chemical, in which the clinker resulting from the calcining operation, together with a small percentage of retarder, is reduced to a fine powder. During the latter operation the cement is submitted to a partial process of hydration by means of steam, at a temperature ranging between 220° and 300° F., and after subsequent cooling the cement is ready for immediate use.

Mechanical Process.—It is essential that the raw materials selected are of such physical character as to be easy of reduction, and such chemical composition that the resulting mixture contains the necessary ingredients in proper ratio, one to the other. If so constituted, and thus available for the purpose, the proportions of the mixture are kept constant by means of continuous chemical supervision, the permissible limits of variation in the composition of the raw mixture being very narrow.

This preliminary part of the manufacture may be conducted by one of three methods, the selection depending upon the physical condition of the raw material to be operated upon.

Where the materials are soft, as in the case of chalk, clay and marls, such as are found in England, the wet process is usually adopted, which consists of reducing the materials together to a pulp, or slurry, containing about 40% water. This is easily accomplished in open wash mills, or pug mills, requiring but small expenditure of power.

When one or both of the materials are of a hard or crystaline character, and in some cases with the soft materials already referred to, the dry process is adopted, which consists of evaporating the water from the raw materials as quarried, and grinding them in a dry state to a fine powder, by means of suitable machinery.

The third process, which is suitable for both soft and refractory materials, has been adopted for the works at Bamberton, Saanich Inlet, and consists of a semi-wet process, in which the drying of the raw materials is avoided—the materials being reduced to a thick slurry in mills suitable also for the dry process, but with a small percentage of water, producing a more uniform and reliable product than is possible with the dry process.

In any of the processes it is essential to reduce the raw material to such fineness that at least 95% will pass through a sieve having 32,400 holes per square inch, more particularly where the materials have not been partially mixed by nature.

A great improvement in the quality of the cement is produced by the introduction at this stage of the manufacture, of such storage capacity and machinery that large quantities of this prepared slurry can be kept in reserve, and continuously mixed, thus correcting any irregularities that may have occurred in the composition of the material during the first mixing and grinding operations. By this means a product of absolutely correct and uniform composition is presented to the kiln for calcination, and it will be readily understood that, although the cement industry as a whole has not until recently thought it necessary to provide such intermediate storage of prepared raw material, how important it is, before the material is submitted to an expensive chemical process of calculation, in which the desired results are so adversely affected by any irregularity, either in the material or the temperature at which the operation is conducted, that this correcting process should be installed. It is not possible to get perfect chemical combination of the lime with the silicates and aluminates of the clay or shale unless the materials have been reduced to a very fine state of subdivision, and have been thoroughly amalgamated.

Chemical Process.—The calcining or clinkering is carried out in rotary kilns, which with modern practice are increasing in size, now averaging from 150 to 200 feet in length, and from 7 to 10 feet in diameter, being set at an angle to the horizontal of ½ inch to the foot. The raw material is fed into the upper end of the revolving kiln, while the fuel for raising the temperature within the kiln is introduced at the lower end, the raw material passing successively through the three operations of drying, calcining, and clinkering, on its passage down the kiln, the clinker leaving the kiln at red heat. This heat is removed by passing it through rotary coolers, and is used for heating the air for combustion passing into the kiln.

The cool clinker is now ready for the final grinding operation, but before being submitted to this the clinker is stored and mixed under cover in large bulk, so that again any small irregularities of the calcining operations are spread over the product of several days, and thus tend towards uniformity of the finished product.

Final Process.—After cooling and mixing, the clinker, which is material of hard and refractory character, is reduced to a fine powder with the aid of very powerful crushing and grinding machinery, details of which will be explained with the aid of lantern slides. The importance of very fine grinding was not realized until recent years, but its value will be understood when it is known that it is only the impalpable powder of the cement which has any cementituous properties—the coarser particles present being of no more value than their equivalent bulk of sand or crushed rock. It is common practice at the present time to so reduce the clinker that 85% will pass through a sieve having 32,400 holes per square inch, but at the new works at Bamberton, machinery has been installed to enable the cement to be so ground that 95% will pass through this sieve if required. This extra fineness materially increases the cost of production, but adds considerably to the cementituous value of the material. Using this fine ground cement a much richer and stronger concrete is obtained, by reason of the larger quantity of cementituous material present in the very finely ground cement, or on the other hand economies in cost of construction can be obtained by reason of the larger amount of aggregate which such fine ground cement will carry, to produce equal results.

During the process of grinding provision is made for the regulation of the setting time of the cement. Cement clinker ground without any such provision is always very quick setting. The method adopted at the Bamberton works is similar to that now almost universally employed in England, and consists of injecting steam into the tube mills during the final process of grinding together with the addition of a much reduced proportion of gypsum, which is used as a retarder. The effect of this process is to hydrate and thus remove the expansive properties of any loosely combined lime compounds which have resulted from any slight defects which have passed the earlier processes uncorrected, and thus produce a cement which is safe to use immediately after manufacture, even if taken hot from the mill, and by means of this process the setting time of cement can be regulated to suit all requirements.

Extraction of Heat.—The difficulty often experienced by engineers, however, in using hot cement is being provided against by the introduction, at the Bamberton works, of a separate cooling plant, through which all cement as it leaves the grinding mill is passed. This special plant extracts the heat from the cement, reducing it to atmospheric temperature before storage. This is a very important addition to the methods of modern manufacture and, although used largely in English plants, is being introduced for the first time into Canada, or indeed on the American continent, at the plant now being installed. After the cement has been submitted to the process described, it is stored, and mixed in large bulk at atmospheric temperature, before being placed on the market, and it is hoped that the provision which has been made at the new works to produce cement of absolutely uniform quality, will be appreciated by engineers and contractors throughout the western provinces of Canada.

The works at Bamberton are now just commencing manufacturing operations, and will be producing full output of 2,000 barrels per day before the end of June. The works were designed by the Associated Cement Company's own staff, and practically the whole of the machinery was manufactured in England. The work of construction was entrusted to Messrs. McAlpine, Robertson & Company, of Vancouver, under the supervision of the Associated Company's resident engineer's staff; the power for the plant being supplied by the British Columbia Electric Railway Company.

The lecture was illustrated by many interesting pictures of the machinery and plant used in the process of manufacture, all of which were most successfully explained by the lecturer.

PROPOSED FLOATING DOCK FOR VALENCIA, SPAIN.

The contract having been awarded for completing the harbor works of the port of Valencia, the Board of Harbor Works is now giving attention to the matter of docking facilities for the cleaning and repair of vessels, says the United States Consul at Valencia. About three months ago the board proposed to the Government the erection of a small shipyard to accommodate vessels of less than 300 tons. The latest project is a floating dock for handling sea-going ships up to 3,500 tons displacment. Harbor space is too limited to permit of a large dock at this time, according to the system employed at Kiel, Hamburg, Cardiff, Genoa, Barcelona, etc. The tentative plans, therefore, propose the construction on a smaller scale according to the most approved system, but in such a manner as to later permit it to be dismounted and used as a constituent part of the proposed floating dock of 8,000 tons capacity provided for in the approved scheme of port facilities. The details and specifications of the work have not been published, but the preliminary project as submitted to the Ministry of Fomento calls for an expenditure of about £55,000, the dock to be completed in two years. It is hoped that the plans will be speedily approved by the Government, in order to call for bids and award the contract. Engineers and others desiring to learn more about this project can address the Director de la Junta de Obras del Puerto, Sr. Don José Marie Fuster, Valencia.

THE FLAT SLAB SYSTEM IN FLOOR CONSTRUCTION

NOTES DESCRIPTIVE OF ADVANCES IN REINFORCED CONCRETE FLOORS IN PAST DECADE—COMPARISON WITH BEAM AND GIRDER SYSTEM—BEHAVIOR UNDER LOAD

By W. G. URE, B.A.Sc.

THE flat slab system of reinforced concrete floor construction may be defined as that system in which the load is carried from the slab directly into the columns without the use of floor girders or beams, the columns usually being built with a wide flaring top. One of the earliest engineers to make use of this system was Mr. C. A. P. Turner, of Minneapolis, Minn., who first described it in "The Engineering News" October 12th, 1905. In the course of his practice Mr. Turner had found that long span slabs were much more economical in general than those of shorter span and, after building panels up to 24 feet in span, he began to wonder if it were necessary to put in any ribs at all. He investigated the question thoroughly and developed a system of flat slab construction which he called the "mushroom" system. The word "mushroom" is his patented trade-mark, and in using this word to designate flat slabs other than those designed by him, an incorrect use of the term is made. Mr. Turner's patent covers the peculiar arrangement of steel over the column head used in his system, and shown in Fig. 1.

The principle of eliminating all beams and girders was also taken up by other parties, and several other patents taken out regarding it. Probably the first building to be constructed with this type of floor was at the plant of Proctor and Gamble, Armourdale, Kansas, which was built in 1903 from the designs of L. J. Mensch.

The owners and occupants of buildings were quick to appreciate the many advantages which this form of construction possesses, as compared to the beam and girder system. It has come into extensive use, and seems likely to largely supplant the older type, especially in such buildings as warehouses where very heavy floor loads must be provided for.

Since all loads are carried directly to the columns, all reinforcing metal must centre there. The steel is laid in bands about seven-sixteenths of the span in width, a band running along each side of the panel, and one along each of the diagonals. Thus each column has four continuous bands of steel passing over it. Fig. 1 shows the arrangement of the bands. Since the slabs are considered continuous over the supports the metal will lie at the bottom of the slab in the centre of the panel and in the upper part of the slab over the column. The steel passing over the column head is supported on a steel frame which holds the bars in place, takes some direct tension in the top of the slab, and aids in conveying the stresses to the columns. The latter are commonly built with a wide, flaring head in order to keep the shearing stresses down to the permissible values. The structure has been likened to an umbrella at each column, with the rest of the floor suspended from the edges of the umbrellas.

In comparing the flat slab system with the ordinary beam and girder system, the most obvious advantage of the former is the total elimination of projecting ribs below the bottom of the floor slab. Besides being a distinct improvement from the æsthetic point of view this permits a better distribution of light. In any building the light which is reflected from the ceiling is an important consideration. Figs. 2 and 3 show graphically how projecting ribs interfere with this reflection and the even distribution of light obtained with the flat slab system.

It also greatly simplifies the erection of shafting, as there is no interference by beams or girders. In the installation of sprinkler systems great economy results. There is nothing to prevent the water from spreading out evenly in all directions, and whereas it is often necessary to run a line of sprinkler heads down each side of a deep girder, one line would serve the same purpose if the girder be dispensed with.

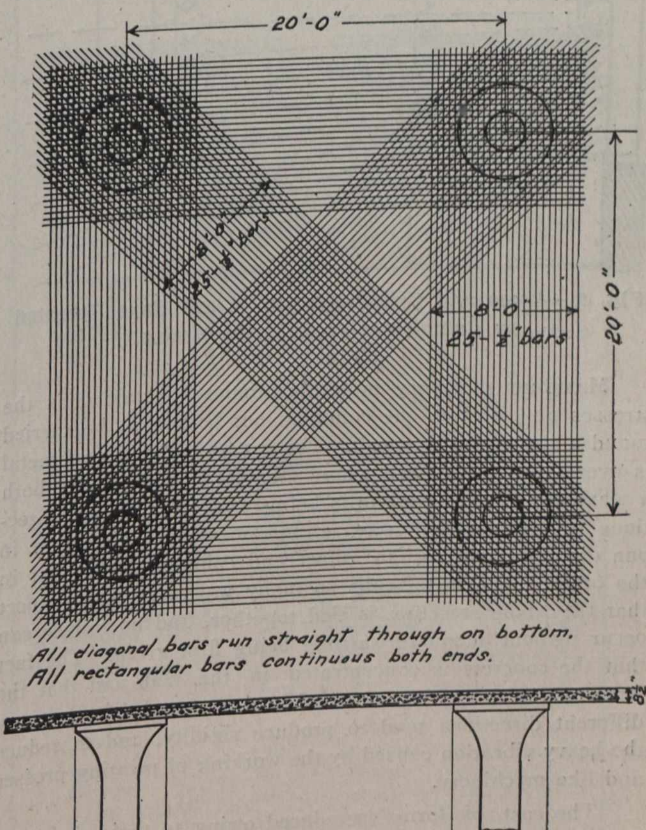


Fig. 1.—Typical Floor Reinforcement.

The height of any building required to obtain a given clear story height is reduced with a corresponding reduction in the cost. For instance, a building for the Toledo Lamp Works was originally designed for a beam and girder system with a 5-inch floor slab, 13-inch x 29-inch longitudinal girders and 10-inch x 23-inch transverse beams at 10-foot centres. The flat slab system finally adopted provided for a floor slab of a uniform thickness of 7 inches. This reduced the story height by 22 inches, which in a four-story building amounted to 88 inches, or more than seven feet. It was estimated that this change in plan meant a saving of from six to seven cents per square foot of floor area. Again, in the Grellet-Collins building, Philadelphia, the total thickness through the floor was seventeen inches less with the mushroom system than with the beam and girder system. Mr. Turner claims that for a given clear story height it effects an economy of about 10 per cent. of the material in the vertical walls.

In the matter of speed and ease of erection the flat slab is much superior to any other type. The centering is simple and easy, there being no beams to build around. There is no bother with stirrups, and is it claimed that it is easier to make a good bond between old work and new because the concrete is not so deep and the inert material known as laitance does not accumulate to so great an extent.

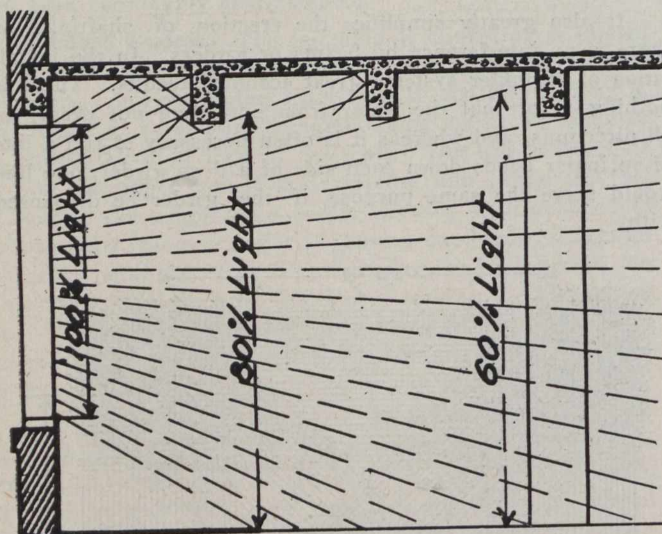


Fig. 2.—Beam and Girder System. Light Rays Reflected by Ceiling are Pocketed by Beams.

Maximum efficiency in reinforcement is attained as the stresses go direct to the columns, not having to be carried round a corner, so to speak. The greatest quantity of metal is over the column head where moment and shear are both a maximum. The concrete is being worked in several directions by the multiple way reinforcement, the distortion in one direction tending to offset and counterbalance that in the other. The metal runs so many ways over the support that the whole structure is tied together, and no failure can occur without adequate warning being first given. The fact that the concrete is concentrated in the slab and that the stresses due to any concentrated load are carried in so many different directions tend to produce rigidity, and to reduce the heavy vibration caused by the working of printing presses and like machinery.

The cost of forms is reduced owing to their simplicity and the fact that they can be so designed that they can be used over and over again without material alteration. In a warehouse built for the Terminal Wharf and Warehouse Company, of Boston, the forms were designed in the draughting room and shipped complete to the site. Since then they have been used in another building. Each panel was erected and removed fifteen times and some twenty, and at the end of that time were still serviceable.

In another instance, assuming the material delivered at the site on cars, and that form lumber could be used twice, the following results were obtained for the cost of forms:—

Floors with beams, girders and slabs..	10 cents per sq. ft.
Slab floor without beams	7 cents per sq. ft.

As to economy, it is claimed that the amount of material required to build a slab or panel that will carry a given test load is less than with any other type. This economy increases rapidly as the load to be carried increases, since the strength of the slab increases approximately with the square of the depth, and hence the relative increase in cost for a given increase in the capacity of the construction is small. In this connection it is well to remember that these floors are considered by many engineers to be lighter, and hence cheaper, than is good practice. However, a reputation has been built for them on their ability to successfully withstand very heavy test loads.

In a paper entitled "The Economical Design of a Reinforced Concrete Floor Panel," Mr. J. Norman Jensen gives cost data for a typical floor panel twenty feet square designed in fourteen different ways. He concludes that of all the designs the flat slab appears to be the most economical. His slab was heavier than Mr. Turner's, being designed by a method requiring considerably more steel. His figures for four of these systems, as illustrated in Fig. 4, accompanying the diagrams, and show a decided economy in the use of the flat slab system, it being 15 per cent. cheaper than its nearest competitor.

In common with everything else, however, the flat slab system has certain disadvantages. The greatest of these is undoubtedly the fact that no adequate theoretical analysis of the stresses in such a floor has ever been put forward, and in consequence there is great uncertainty as to the exact stress distribution within the slab. While this is true it must be admitted that, even at this early stage in its development, it is perfectly feasible to design a flat slab floor and guarantee its safety under the design load, and still maintain a good margin of economy over the earlier types.

Again, the fireproof qualities of the construction have been questioned as the main steel reinforcement in the panel is only protected in most cases by from ¾ inch to 1 inch of concrete on the bottom, a thickness quite inadequate to properly protect the steel in a severe conflagration. Also in a shallow slab of this sort an error in placing the reinforcement is liable to produce more serious results than in a comparatively deep beam or girder. On account of its greater deflection and the flaring column head the flat slab type of

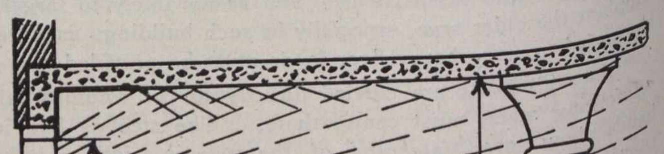


Fig. 3.—Flat Slab System. Light Rays Reflected from Ceiling Give an Even Distribution.

floor is more apt to set up excessive bending stresses in the columns than is the ordinary floor designed in the beam and girder system. Care in the design and in the placing of the steel will minimize these disadvantages.

The Behavior of a Flat Slab Under Load.—It is interesting to consider the manner in which the slab in such a system deflects under load, and the nature of the stresses set up by such deflection. Since our knowledge of these stresses is to a large extent based on experimental data, it will be well to describe as briefly as possible a few of the experiments which have been conducted for this purpose.

For a panel square or nearly so it is evident that the face of the slab tends to become a warped surface, assuming continuity over the columns and that the adjacent panels are also loaded. In other words, the slab assumes a dome shape over the column, and a bowl or dish shape in the central portion of the panel. There must then be a line of inflection passing around the column head and dividing off these two regions.

Assuming the slab to be uniformly loaded over its whole area, that part of the slab over the column head may be regarded as an inverted footing supporting a single concentrated load on an area at the centre equal in size and shape to the column capital. The central portion, on the other hand, is like a plate of roughly circular shape supported around the circumference and carrying a uniformly distributed load.

The main stresses would then be in the portion over the column head tension at the upper surface and compression at the lower surface, and in the central portion compression at the upper surface and tension at the lower surface. So, taking a strip of unit width from one column to another, the nature of the stresses would be similar to those in a beam restrained at both ends, and to resist these stresses the steel would be placed as shown in Fig. 1. On account of this restraint it is evident that the columns must be so proportioned that they can resist the bending stresses set up by an eccentric loading such as would occur with one only of several adjacent panels loaded.

Again, a point midway between columns along a line diagonal to the panel will obviously deflect more than a point midway between columns along the side of the panel. This would give rise to tension in the upper part and compression in the lower part of the slab along the side of the panel and in a direction perpendicular to it. These stresses are, of course, of only secondary importance, and the usual method of laying the reinforcement does not make any special provision for them. Cracks along this line, however, formed in numerous multiple panel tests on flat slabs, and even in some cases formed under the dead weight alone, are practical evidence of the existence of this tension.

The Corrugated Bar Company, of Buffalo, have developed a two-way system of reinforcing flat slab floors as distinguished from the usual four-way system, and have adopted the trade-name "Corr-Plate Floors." In this system the diagonal bands of steel are omitted, the entire slab being reinforced by steel placed parallel to the sides of the panel in both directions. One of the advantages claimed for this system is that these tensile stresses can easily be provided for, but as far as the author's knowledge goes it has not come into very extensive use as yet.

It is also probable that in the portion of the slab over the column there are compressive stresses set up along lines roughly parallel to the line of inflection and concentric with the columns due to the doming action; and also similar compressive stresses in the central portion due to the dishing action. These stresses are, of course, taken up by the concrete.

Shear in the flat slab is of two kinds; punching shear, and shear which indicates a tendency towards diagonal tension. The punching shear is a maximum at the outer edge of the column capital, and is due to the capital trying to "punch" a hole through the slab. The diagonal tension has its greatest intensity a short distance out from the column capital.

With regard to moments, the maximum moment occurs over the column, not at the centre of the slab, the critical section being at or near the edge of the capital. The moment coefficient by which to multiply the product of the load and the length, similar to the coefficient "one-eighth" in beams uniformly loaded and freely supported, has not been satisfactorily determined. As a result there are a great variety of moment factors being used. The question of shears and moments will be considered at greater detail elsewhere.

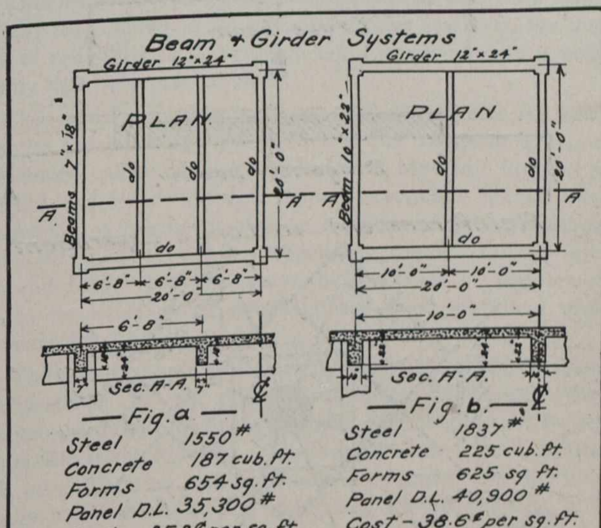


Fig. 4.—Four of Jensen's Fourteen Flat Slab Systems.

Mr. Arthur R. Lord, Research Fellow in the Engineering Experiment Station, University of Illinois, describes in detail a test made by him on a flat slab floor in the proceedings of the National Association of Cement Users, 1911. He describes it as an attempt to carry out a test on a floor in a building constructed under actual working conditions with some of the refinement that can be attained in laboratory testing. The test was made on the fourth floor of an eleven-story warehouse in Minneapolis. The floor was designed for a live load of 225 pounds per square foot, and was of 1:2:4 concrete 9 3/16 inches thick. **The panel was 18 feet 8 inches** by 19 feet 1 inch, and was forty days old when tested. Fig. 5 shows the manner of reinforcing.

The deformations in the steel and the concrete at the critical points were obtained by means of extensometers, and from the data thus obtained the various stresses were computed. Mr. Lord claims that the precision attained in his measurements was such that the stresses in the steel were obtained with a maximum error of 1,000 pounds per square inch, and in the concrete with a maximum error of 50 pounds per square inch.

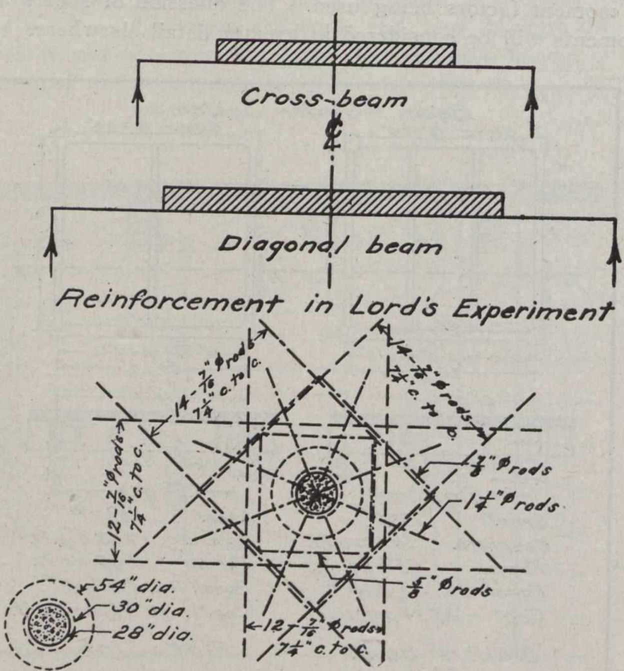


Fig. 5.—Column Used in Lord's Test, Showing Reinforcing.

With regard to deflection it was found that the presence of joints where new concrete is joined to old materially increases the deflection. For eight panels loaded the deflection in the centre panel was 1/1400 of the span, and for one panel only loaded was 1/1200 of the span. Deflections in the central panel were uniformly less than those in the outer panels. The maximum deflection found was at a bulkhead in an outer panel and amounted to 1/1000 of the span.

The stresses in the steel at the centre of the panel were found to be low, running from 2,000 to 4,000 pounds per square inch, and indicating a large amount of arch action reducing the computed stresses. The measurements indicated that the steel in the centre of the panel is most severely stressed for one panel only loaded. The diagonal and cross-band reinforcing were found to be taking practically the same stress, and this stress was approximately equally divided among the individual members of a band. In the steel over the columns the stress reached 16,000 pounds per square inch, so it is clear that this is the critical point in the design of such structures.

For the determination of the stresses in the concrete Young's Modulus was taken as 1,875,000 pounds per square inch. This gave compressive stresses at the edge of the capital of 650 to 675 pounds per square inch. While in this case these values are not excessive, it indicates that care must be taken to provide compressive reinforcement at this point if necessaryy. It is quite common practice to run the diagonal reinforcing straight through on the bottom, thus providing this compressive reinforcement and at the same time avoiding the need of placing four layers of steel in the upper part of the slab near the column which decreases to a considerable extent the effective depth of the slab.

The floor was carefully cleaned and closely examined for indications of cracks. With a load of 265 pounds per square foot faint cracks appeared at a bulkhead. Other such cracks appeared when the maximum load of 350 pounds per square foot was put on. One set ran along the centre of the cross-band, dying out at each end, thus indicating the tension in the upper part of the slab along the side of the panel previously mentioned. Another set appeared around the columns, and 2 inches to 3 inches outside the edge of the capital, furnishing another indication that the maximum moment occurs over the column, the critical section being at or near the edge of the capital.

With regard to the distribution of stress among the several bars of a band of reinforcing, some experiments made on broad, shallow beams by Prof. A. N. Talbot, of the University of Illinois, are of interest. The beams were 36 inches broad, 4 feet 10 inches long, and 3 inches deep, the ratio of depth to width being one-twelfth. They were loaded across their full width and freely supported at the ends for various proportions of their width. The beams were made and tested induplicate at an age of about sixty days.

The following table, from the National Association of Cement Users proceedings, 1911, shows a few of his results:

		Total load carried, in pounds.		
Beam No.	Supported.	Beam No. 1.	Beam No. 2.	Average.
711.1-2	Full width	15,550	15,800	15,675
713.1-2	Half width	15,000	17,000	16,000
715.1-2	Fifth width	14,900	12,250	13,500
717.1-2	Fifth width	14,550	16,000	15,300

All the beams had ten ⅜ inch round rods 3 inches from the face, and beams 717.1-2 had also ¼ inch round rods on 4-inch centres crosswise of the beam.

From these and similar experiments he concludes that for a beam supported over one-half its width there is no appreciable falling off in the load carried. For a beam supported only one-fifth of the width the decrease in strength is slight. Other tests made by Prof. Talbot on footings, as well as Mr. Lord's extensometer tests, bear out this result.

Prof. Talbot states his conclusion thus: "The width of the resisting section, as governing the stress in the steel, is composed of the width of the pier, plus the depth to the steel on each side of this, plus one-half the remaining width of the footing." In ordinary flat slab designs this would include all the steel in both diagonal and cross-bands, and we may therefore conclude that it is all nearly equally stressed regardless of whether it passes directly over the column head or not. The above discussion refers, of course, to stresses produced by moments only, as the resisting section to shear stresses will obviously only be equal in width to the column.

Mr. C. A. P. Turner's method of design* is based on experimental data obtained from tests made on full-size single panels. Details of particular tests are not to hand, but the general method may be described. Tests were first made on the steel reinforcing and its yield point determined. The slab was then built, using this grade of steel, and after being allowed to season a reasonable time was loaded until the steel reached this yield point, which Mr. Turner claims to be able to recognize from the behavior of the slab. Then, by simple proportion, an exact working load for a given tension in the metal may be determined.

*"Concrete Steel Construction," by C. A. P. Turner, Chap. 3.

In this manner he obtained the formula $\frac{wl^2}{50}$ for bending moment in the mushroom system. His corresponding formula for deflection is $\frac{1}{7000} \cdot \frac{wl^4}{\Sigma Ad^2}$ where

A = the area of one reinforcing rod.
d = the depth of the slab to steel.
l = the span.
w = the total load per square foot of floor area.

This deflection formula is backed up by tests on panels in buildings in which the measured deflections closely approximated those computed from this formula.

Another interesting test was that made on four panels on the tenth floor of the A. J. Franks Building, Chicago, in a manner very similar to that used by Mr. Lord, and hence will only be briefly referred to. A full description of the test, together with tables of measured stresses, are given in the report of W. K. Hatt, consulting engineer, compiled for, and published by the Concrete Steel Products Company, of Chicago. The floor was of the well-known "Cantilever Flat Slab" type, which is the trade-name of this company, analogous to the term "mushroom" used by Mr. Turner.

Under the design load of 256 pounds per square foot the maximum stress in the steel was 4,575 pounds per square inch, occurring in the cross-band over the capital; and the maximum stress in the concrete was 677 pounds per square inch occurring in the drop of a central column. Under a load of 624 pounds per square foot the maximum stress in the steel was 10,095 pounds per square inch in the centre of the span of the cross-band, and the maximum compressive stress in the concrete was 1,685 pounds per square inch in the drop of the central column. The maximum tension in the longitudinal column reinforcing due to eccentric loading occurred at a corner column and amounted to 5,000 pounds per square inch under the design load, and 11,600 pounds per square inch under the maximum load.

The above figures bring out the fact that the design is overbalanced with an excess of steel, that is, the maximum permissible stresses in steel and concrete are not simultaneously realized. This condition probably exists in all present designs for flat slab floors.

BELGIAN COAL PRODUCTION.

The total production of coal in Belgium during 1912 amounted to 22,983,460 tons, against 23,125,140 tons in 1911 and 23,927,230 tons in 1910. This decrease was due to the strike in the Borinage district at the beginning of the year, and also to the limiting of the day's work to 9 hours. Although this fresh decline in production may appear discouraging, it is in reality not unsatisfactory, says the American Consul at Liege, for, in spite of the further reduction of the working day from 9½ hours in 1911 to 9 hours in 1912, there was a decrease of only 141,680 tons, while the production for 1911 was 800,000 tons less than that of 1910; if the strike in the Borinage, which lasted over a month, had not taken place, causing a reduction in the output of 500,000 tons, the total output for 1912 would have been considerably greater than in 1911. The conclusion to be drawn from this is that the limiting of the working day has not had the disastrous results anticipated. The coal mines proceeded to improve their machinery, tools, etc., and the results for 1912 go to show that the increased effective power of the engineers offsets the reduced work of the miners.

GAS AND OIL ENGINES FOR ELECTRIC SUPPLY STATIONS.

By A. N. Rye.

From time to time a number of articles have appeared in the technical press dealing with the generation of electricity by gas and oil engines. Certain of these articles have dealt with private supplies, and have been of considerable interest, but the conditions of public supply are so different from private supply that it is by no means certain that a type of machine which has been satisfactory in one case will be equally satisfactory in the other case; for instance, the question of reliability is of so much more importance to a public supply than to a private plant.

The articles dealing with gas and oil engines for public supplies have, in many cases, been of the nature of estimates, and many engineers are not satisfied that the figures put forward can be obtained in actual practice. Under these circumstances engineers may be interested in the results obtained in a central station depending almost entirely upon gas and Diesel engines, where both classes of engines are run in the same power house by the same staff and under the same conditions.

The public supply of electricity in the Island of Guernsey is undertaken by the Guernsey Electric Light and Power Company, Limited, and was recently described by A. N. Rye in the Electrical Review. The supply was started in 1900 from a small station at Les Amballes, equipped with the plant usually installed about that date, i.e., Belliss engines, Babcock boilers, surface condenser, economizer, battery, etc.

At a later date a demand for power developed in the granite quarries at a distance of about 2½ miles from the generating station; as this load increased it became impossible to deal with it from the Les Amballes station, and a new power station was built at St. Sampson's in the centre of this load, and the Les Amballes station was continued principally to supply the lighting demand in and around the town of St. Peter Port.

TABLE I.—GAS ENGINES, ST. SAMPSON'S, 1912.

Month.	Units generated.	Tons coal.	Lb. per unit gen.	Per ton.	Cost.	Per unit.
January ...	51,720	75	3·2	17/10	£66 17 6	·31d.
February	50,628	68·5	3·0	"	61 1 6	·29d.
March ...	41,024	60	3·2	"	53 10 0	·31d.
April ...	47,185	46	2·14	"	41 0 4	·21d.
May ...	67,231	58	1·93	"	51 14 4	·18d.
June ...	54,845	52·5	2·14	18/6	48 11 3	·21d.
July ...	67,465	67·5	2·2	19/-	64 2 6	·22d.
August ...	72,172	75	2·33	18/-	67 10 0	·22d.
September	79,527	73	2·06	19/6	71 3 6	·21d.
October ...	101,126	90	2·0	"	87 15 0	·21d.
November	118,739	100	1·9	"	97 10 0	·20d.
December	93,214	84	2·0	"	81 18 0	·21d.
Total ...	844,876	849·5	2·25		£792 13 11	·225d.

The first plant installed in 1904 at the new station at St. Sampson's consisted of two gas-driven sets nominally of 180 kw. each, together with pressure gas producers and a battery of 1,200 ampere-hours, 420 volts, capacity. Later in 1908 another set of 220 kw. was added. Early in 1911 a Diesel driven set of 165 kw. was installed, and in December, 1912, another similar set was put down. At the old station at Les Amballes, certain steam plant was dismantled in 1911 and two Diesel-driven sets, each of 135 kw., were installed.

Under normal conditions the whole of the load at both stations is carried by the gas and oil-driven plant, the steam plant being used only as a reserve during repairs to the more economical, but less reliable, internal combustion engines.

It will be seen that no engines were installed during 1912, except the last set at St. Sampson's, and this was not running until 1913; consequently in the following figures all the results are from engines which have run at least one year, and the majority for a longer period.

TABLE II.—OIL ENGINE, ST. SAMPSON'S, 1912.

Month.	Units generated.	Weight of oil, lb.	Lb. per unit gen.	Per ton.	Cost.	Per unit.
January...	46,154	34,957	·75	51/-	£39 15 3	·20d.
February	8,107	6,466	·8	56/6	8 1 8	·23d.
March ...	54,831	38,525	·70	"	48 6 4	·21d.
April ...	46,966	32,281	·687	"	40 9 8	·21d.
May ...	47,345	32,044	·677	"	40 3 9	·21d.
June ...	43,976	29,689	·675	"	37 4 8	·20d.
July ...	46,624	30,379	·651	"	38 2 0	·20d.
August ...	46,053	31,400	·67	"	39 7 7	·20d.
September	36,462	24,906	·684	"	31 4 8	·20d.
October ...	30,259	21,228	·701	65/6	31 0 11	·25d.
November	4,999	3,503	·7	"	5 2 5	·25d.
December	35,909	26,515	·738	"	38 15 6	·26d.
Total ...	447,685	311,893	·696		£397 14 5	·213d.

During 1912 the gas and oil engines generated 1,865,236 units, of which rather more than half was generated by the oil engines; consequently both classes of plant had to run for long hours.

Very careful monthly records were kept of the performance of each class of plant, and the accuracy of these figures is proved by the fact that the total of the invoices for coal and oil for the year exceeds the sum of the monthly figures by less than 2½ per cent., and this difference is probably due to small losses in storage, etc.

The figures in Tables I., II. and III., being abstracts from the monthly records, are worked out on the units generated, the units sold not being available each month.

In comparing the performances of the different types of engine, there are certain points to be taken into consideration.

TABLE III.—OIL ENGINES, LES AMBALLES, 1912.

Month.	Units generated.	Weight of oil, lb.	Lb. per unit gen.	Per ton.	Cost.	Per unit.
January...	59,459	40,045	·675	54/-	£48 4 5	·19d.
February...	73,010	47,234	·615	59/6	62 11 8	·20d.
March ...	54,381	36,813	·677	"	48 15 6	·21d.
April ...	34,701	23,335	·672	"	30 18 4	·21d.
May ...	39,028	26,247	·673	"	34 15 6	·21d.
June ...	33,514	22,006	·657	"	29 3 2	·21d.
July ...	34,698	21,827	·629	"	28 18 5	·20d.
August ...	45,129	30,285	·67	"	40 2 6	·21d.
September	26,857	17,750	·66	"	23 10 4	·21d.
October ...	42,388	28,740	·678	68/6	43 18 8	·25d.
November	64,648	44,400	·688	"	67 17 10	·25d.
December	64,862	44,760	·69	"	68 8 11	·25d.
Total ...	572,675	383,444	·670		£527 5 3	·221d.

In the case of the gas engines, it must be remembered that two of these engines are more than eight years old; in 1911, they had got into a bad state of repair, with worn pistons, worn liners, etc., and it was decided to thoroughly overhaul all the gas engines and gas plant. This work was not completed until July, 1912, and the high fuel consumption of the first three months of 1912 is entirely due to the condition of the plant, and should be neglected when making comparisons. If, then, the months of April, May and June are compared, it will be seen that there was practically no difference in cost per unit for fuel between the gas and oil engines, but later in the year, although the cost of coal increased, the cost of oil increased in much greater ratio, and for the months of October, November and December the gas engines were very decidedly cheaper in fuel cost. This difference in cost is even more marked at the moment of writing, so much so that the Diesel engines are being run as little as possible, and the gas engines as much as possible. This preference for the gas plant is entirely due to the enormous increase in the cost of fuel oil, which has gone up 75 per cent. in price in less than two years.

In Tables II. and III., if the "lb. of oil per unit" column is examined, the wonderfully even running of the Diesel engines will be noticed.

Table III. shows this to most advantage, because the load factor of these engines is more nearly constant from day to day, and also because the engine in Table II. has developed more defects than the engines in Table III., which have run practically without trouble for the whole of the year.

The running of these Diesel engines shows very clearly one remarkable fact—the full load guarantee being .67 lb. of oil per unit, the actual consumption for the year exceeds the guarantee figures by less than 5 per cent.

Everyone who has had to run steam plant under similar conditions knows that the test results will be exceeded by at least 50 per cent., and even with gas plant it is difficult to keep within 20 per cent. of test figures.

It is quite possible to take one or two individual figures in these tables and query their accuracy. For instance, in Table III. the month of July shows an impossibly good figure under "lb. per unit." There are reasons for this, and other small errors, which it would be tedious to explain, and it was thought advisable to give the figures exactly as recorded without any alterations; that any small error in one month corrects itself later is proved by the close agreement with the figures for the complete year.

Table IV. shows the costs per unit sold for 1912 abstracted from the balance-sheet and given in detail, so that the station costs can be seen separated from the distribution costs. It should be mentioned that no part of the cost of the special overhaul to the gas plant is included in these figures.

TABLE IV.—Costs Per Unit Sold for 1912.

Generation—	
Fuel	.33d.
Oil, waste, water, etc.	.08d.
Wages and salaries	.16d.
Repairs—Buildings, plant, tools	.16d.
Accumulators	.05d.
	.78d.
Distribution—	
Wages and salaries, repairs mains, meters, etc.	.08d.
Rent, rates, taxes and insurance	.07d.
Management	.18d.
Total running costs	1.01d.

The above cost is without any interest charges, etc.

$$\text{Efficiency } \frac{\text{Units sold} \times 100}{\text{Units generated}} = 78 \text{ per cent.}$$

The efficiency figure is given so that direct comparison may be made with the monthly figures which are worked out on units generated; reducing the year's fuel cost to this basis, the result is .257d. per unit generated, the excess over the monthly figures being due to the running of the steam plant under very uneconomical conditions.

The above figures give the facts of the case, but would not be complete without some account of the running of the plant and the opinions formed by the engineers in charge of it.

So far as fuel costs are concerned, there is no doubt that in the special circumstances in Guernsey both gas and Diesel engines are very economical; anthracite peas for gas making can be bought at about the same price as small steam coal, and, in practice, this means that the fuel bill for steam working would be nearly double the cost for generation by gas. The fuel costs of the Diesel engines before the recent heavy rise in the price in oil were practically the same as for gas, but, at present prices, the cost of running the Diesel engines is so heavy, that it is fairly certain that no more engines of this type will be installed until oil prices fall.

Although the internal combustion engines have proved economical in fuel cost, it is certain that part, at least, of this saving must be set aside to pay for the heavier running costs in other directions; for instance, the lubricating oil bill amounts to over 10 per cent. of the fuel bill, and costs probably three times as much as the oil for a steam-driven station using reciprocating engines; while, if turbines are used, this item of expenditure becomes very small. The labor costs are highest for gas engines and lowest for Diesel engines, steam plant taking a position about midway between the two.

As compared with steam, the supervision charges are higher for both gas and oil engines. With internal combustion engines, the repair costs are one of the most serious items, and, in spite of all statements to the contrary, there is no doubt that quite a large amount of the saving in fuel must be spent on repairs.

After two of the gas engines had run for seven years and the third for three years, they had reached such a condition that repairs costing well over £2,000 were necessary to put them in good order, although large sums had been spent on repairs each year. This statement must, however, be qualified by explaining that these particular engines were of an early type, and there is no doubt that more modern engines could be maintained at a lower cost.

The Diesel engines have not been running sufficiently long to require much in the way of ordinary repairs, and for the greater part of the time all breakages have been covered by the makers' guarantees, but from the experience up to date it seems reasonably certain to expect that the repairs will be more costly than for steam plant, though it is hoped that the cost will not be so heavy as for the gas plant.

Reliability is a point of supreme importance for a public supply. Experience with the gas engines showed that internal combustion engines were not suitable for a public supply without the assistance of a large battery, and it is no exaggeration to say that without the battery it would have been quite impossible to maintain the supply with reasonable economy; there are so many things which may suddenly cause a gas engine to give up working, and it is impossible to guard against them. Therefore, either an extra set must always be running in parallel, thus increasing the fuel, oil and attendance charges, or a battery must be installed.

With this experience as a guide, it was decided that when Diesel engines were installed at Les Amballes station, it would be advisable to alter the battery arrangements, so that an output equivalent to the full load of one Diesel set could be available instantly if one of the running sets failed; this precaution has proved most useful; it allows the engines to be run at practically full load with safety, and it has saved a number of failures of supply that otherwise would have taken place.

It must not be assumed from the above remarks that the failures of gas or Diesel engines are always of a serious nature; the great majority of accidents that might cause an interruption to supply are quite trivial, and can be rectified in a few minutes, but they happen so suddenly that there is no time to run up a spare set. With the gas engines it may be a trifling defect in the ignition gear, or something causing pre-ignition or back firing. With the Diesel engine it may be a needle valve stuck open, or a compressor valve hung up; all of these defects may be of no importance, and the engine may be on load again in a few minutes, but unless a spare set is running, or there is a battery, they may cause an interruption to the supply.

Experience has shown that the gas engines are more subject to these little troubles than the Diesel engines, in fact, the Diesel engines have frequently run for several months without an involuntary stop, whereas the same cannot be said of the gas engines. On the other hand, the Diesel engine failures give less warning, and usually take longer to put right.

There is no doubt that, if a supply depends entirely on internal-combustion engines, more spare plant must be installed than in a steam-driven station. In the first place, internal combustion engines cannot be overlooked for emergency purposes, and of even more importance is the fact that a defective steam plant can often be run until the load falls at night, whereas a defect in an internal combustion engine must receive attention without delay. For instance, a leaky valve or a blowing joint on a steam engine can usually wait for attention, but on a gas engine, and more particularly on a Diesel engine, these defects may stop the set at once, and even if they do not do so it is generally advisable to shut down the set without delay to avoid the risk of serious damage, as the high temperature and high pressure of the gases cut the metal surfaces with surprising rapidity and may do much damage in a short time.

Another reason for having plenty of spare plant, particularly with Diesel engines, is the considerable degree of accuracy essential when making adjustments and repairs; this accuracy cannot be obtained on work carried out at night by a tired staff of men racing against time to get the plant on load again.

To sum up briefly, internal combustion engines can give a perfectly satisfactory supply, particularly if batteries are installed; but they are essentially different from steam plant, and must be installed and run with due regard to this fact.

Under favorable circumstances, these machines are economical, but it must not be forgotten that there are other expenses besides the fuel bill, and the fuel bill of the internal-combustion engine must show a handsome saving to justify the use of this class of plant.

Of the two, the Diesel engine appears to have certain advantages for central-station work, but, as long as the market for oil is subject to such severe fluctuations, the use of this engine is likely to be restricted to special cases.

The most useful field for the internal-combustion engine appears to be in small central stations; as the size of the station increases, the advantages of this type of plant decrease, until a point is reached where internal-combustion engines can only pay in exceptional circumstances, and at the present date this point appears to be reached when a station under average English conditions is of sufficient size to use steam turbines of 1,000 kw. or larger.

The results in Guernsey have fully justified the installation both of gas and Diesel engines, the great saving in the fuel bill being more than sufficient to balance the increased costs in other directions.

BLAST-FURNACE SLAG FOR BRICKS.

Slag bricks are now made by several standard methods, most of them involving hardening either in a steam chamber or an atmosphere of carbon dioxide. During the last few years experiments have been carried out in Germany on the use of slag bricks for engine foundations. The mortar used in these experiments consisted of one part burnt lime and ten parts granulated foundry-iron blast-furnace slag. These materials were thoroughly ground together in a mill, and the brickwork kept carefully moist during building and after being finished. In April, 1912, large cubes were taken from the various foundations and tested under compression. The results varied from 1,166 pounds to 2,688 pounds per square inch, comparing very favorably with best Portland cement concrete. The cost per cubic meter of brick work built of slag bricks with bricks at 17s. per 1,000 was shown to be about 11s 3d. The corresponding cost of concrete foundations varied from about 19s. 6d. per cubic metre for a 1 to 5 mixture to 12s. 1d. for a 1 to 12 mixture. Finally, tests were made on cubes built up of slag bricks hardened by means of carbon dioxide They were built on April 3rd, 1912, using mortar made as before, and were surrounded with moist sand, which was moistened afresh each day for eight days. The results in pounds per square inch were:—

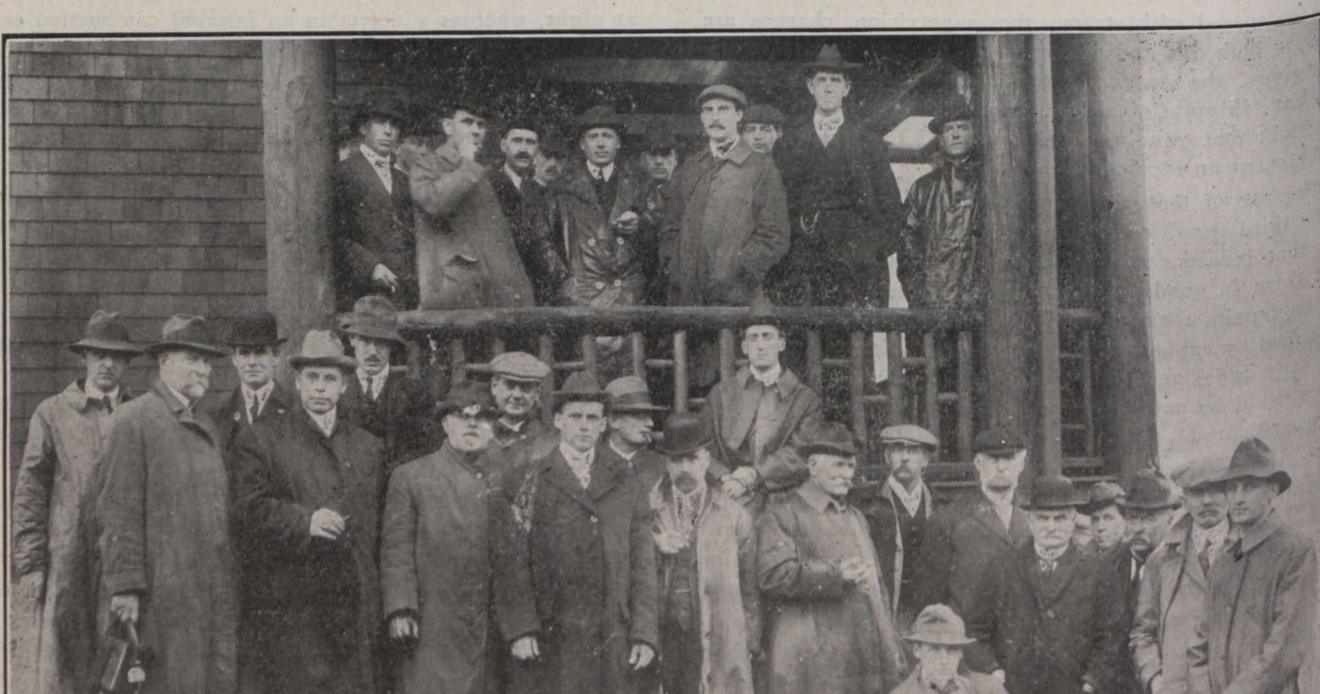
	Test No. 1.	Test No. 2.	Test No. 3.
May 3rd, 1912	2,133	1,835	1,707
June 2nd, 1912	2,290	2,133	1,920

The ratio of lime to granulated slag was 1 to 8 in test No. 1, 1 to 10 in test No. 2, and 1 to 15 in test No. 3.

A GIGANTIC DREDGING CONTRACT.

The contract recently awarded to a Canadian firm for the dredging in connection with the water front development of the city of Toronto under the direction of its Board of Harbor Commissioners is one of the largest ever undertaken in Canada. Some 31,000,000 cubic yards will be removed from the harbor at an estimated expenditure of nearly $6,500,000. Dredging operations will be carried on over the entire water front as far west as the Humber River, and the successful tenderer is getting plant in readiness to undertake the deepening of the harbor immediately. The work of filling the industrial area formerly known as Ashbridge's Bay will be carried on simultaneously. E. L. Cousins, B.A.Sc., is harbor engineer to the Commisssion.

VANCOUVER BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS



The accompanying photograph of the Vancouver Branch was taken on the occasion of a visit on May 10th to the Coquitlam Dam which is being constructed by the Vancouver Power Co., Limited. We are indebted to the resident inspecting engineer for taking the photograph, and to Mr. Challies, superintendent, Water Power Branch, Department of the Interior, for copy of it.

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REPORT ON INDUSTRIAL EDUCATION.

The report of the Royal Commission on Industrial Training and Technical Education ranks among the most important ever submitted to a Canadian Parliament. If its recommendations are acted upon and properly carried out, Canada's handicap due to lack of technical instruction will in due course assume lesser dimensions. The burden has been long standing. For half a century has been felt the need of a kind of education more closely allied to industry in its many branches. The appointment of the Commission in 1910 was a masterful stroke towards alleviating a growing responsibility.

A section of the report was submitted to the House of Commons last week, and other sections are to follow in the course of a few months. Sufficient has been presented to show that the Commission is of firm conviction in the matter of industrial training. It recommends a number of things, among which is a Federal grant of three millions yearly for the next ten years for foundation purposes, to be apportioned among the provinces on a per capita basis.

Of particular interest to engineers and manufacturers is the recognized need of courses of technical instructions for workmen, foremen, and managers, varying in degree from the general instruction for the increase of skill and ability among laborers, to the improvement of established courses in the existing institutions of highest rank. The decided stand taken on the question of technical schools co-ordinated with the industries, rather than purely trade schools, voices the opinion that practical workshop experience is the better training for thoroughness, speed, discipline and general industrial efficiency among men.

Important among its recommendations is that pertaining to instruction by correspondence from Provincial or inter-Provincial institutions. Canada is woefully behind in this form of dissemination of knowledge. Under the Commission's recommendation a few unfavorable aspects associated with instruction by correspondence would invariably disappear. The frequent visits of qualified travelling instructors to places too small to maintain the services of a permanent supervisor, will likewise tend to remove many of the difficulties and obstacles which arise and for a time hold instruction at a standstill, not infrequently causing a complete cessation of effort.

It is to be hoped that the Dominion Parliament will go a long way towards fulfilling the Commission's recommendations, now that the necessary information is before it. Canada has never had such an exhaustive knowledge of her own peculiar situation in matters pertaining to her capabilities and limitations in industrial training as she now possesses.

THE NEEDS OF THE HIGHER INSTITUTIONS.

The recommendation of the Commission on Industrial Training, which reads: "That existing institutions of college rank should receive whatever additional financial support may be necessary to enable them to adequately fill their place in a national system of industrial training and technical education," will be deeply probed, it is to be hoped. Canadian universities are well known to be struggling through a period of financial embarrassment sufficient to prohibit any development whatsoever towards the increasing demands upon them, and grave fears are expressed here and there of the necessity of an abridgment in departments already established. If industrial development is the question of the hour, it should be recognized in institutions now sufficiently equipped with qualified instructors and apparatus for the many phases of industrial training harbored within.

The universities and colleges have been making severe raids upon their money-bags to provide technical courses to meet the demands from an increasing number of students and the spread of industry over the Dominion. While these quantities increased, the former became lighter, and the growing inequality has not been adequately recognized by the Government. For instance, the University of Toronto authorities are fully aware of the crying need of a course in Ceramics. Emphasis from the Canadian Clay Products Manufacturers' Association at the time of their recent convention was unnecessary from the viewpoint of apprising the University of conditions in the clay-working industry. Their urgent demands, however, together with others, disclosed the fact that the great institution of learning of the Province of Ontario lacked funds to establish, even on a small scale, a course of instruction to serve their needs, although there was sufficient space available in its laboratories to house such a department.

The rapid growth and development of the country and the further application of science and scientific methods to all forms of production, construction, conservation, and administration, will continue to call for still larger number of graduates. In consequence the universities and colleges are sure to experience further necessity of increased financial support. It is gratifying that the Commission is of the opinion that this should be provided from a source that will not necessitate the fees required from students to be so high as to exclude suitable young persons who may seek the highest grade of technical instruction.

MONTREAL'S TUNNEL PROPOSAL.

A gross revenue of $3,000,000 and a net revenue of $1,500,000 for the first year, with the promise of 12 per cent. profit at the expiration of ten years, all derived from an initial outlay of twenty millions, is the subject of a report received by the Montreal Board of Control from Mr. F. S. Williamson, consulting engineer. The expenditure would provide for an underground tram service, with twelve and one-half miles of two-track lines. He estimates a four-line tube to cost $30,000,000, or $530 a foot, to which must be added the cost of stations.

Mr. Williamson is of the opinion that the trolley car in Montreal is doomed to disappear, and that before many years surface car traffic on business streets will be subjected to prohibitive measures, giving place to motor 'buses and tunnel systems.

The report is interesting in that the congestion of traffic on the central thoroughfares of both Toronto and Montreal are demanding material relief of some kind. The problem of surface transportation is certainly not new in either city, and, although the optimism of Mr. Williamson is to a degree corroborated by the adoption of motor 'buses and tubes in many cities in Europe and the United States, still we are rather inclined to believe that the disappearance from our busy streets of surface cars, with their motive power necessities, is not an affair of the next few decades.

It is stated that the chief engineer has been asked to report to the Montreal controllers on the report.

EDITORIAL COMMENT.

What is claimed to be a record in ground tunnelling is reported in connection with the Canadian Northern Montreal Tunnel and Terminal Company's work in that city. In thirty-one days 810 feet have been completed, the daily progress averaging from 22 to 28 feet per day for the latter part of this period. It will be remembered that the tunnel when finished will exceed three miles in length. Mr. S. P. Brown, managing engineer for Mackenzie, Mann & Co., is chief engineer of the work.

* * * *

The Canadian Northern Railway has been successful in its application to the House of Commons for a further subsidy to aid in the completion of its Transcontinental line. The House recently voted aid to the extent of $15,600,000, all of which, with the exception of $1,000,000, will be devoted to construction work on the line between Edmonton and Yellowhead Pass, B.C. The balance is for the Toronto to Ottawa line. The Temiskaming and Northern Ontario Railway was also subsidized to the extent of $2,000,000, and a bill authorizing the loan of $15,000,000 to the Grand Trunk Pacific Railway was passed.

* * * *

In a recent trade and commerce report the Canadian varieties of graphite were claimed to excel the Ceylon product for a few special purposes, and was suitable for many more, providing proper methods were adopted in grading the product. Although no regular trade has been established with the United Kingdom, the statement is encouraging, and if veins of uniform composition can be suitably worked and careful means employed to properly grade the graphite according to quality, Canadian producers will be able to establish a considerable business and satisfactorily compete with the plumbago industry of Ceylon for many purposes. The use of graphite seems to be constantly on the increase, and when the Canadian industry has completely emerged from the many preliminary obstacles which, up to the present, have been a most serious handicap, it is to be anticipated that more definite and systematic efforts will be successful in securing a share of the business open in Great Britain.

* * * *

At the annual Convocation of the University of Toronto on June 6th the honorary degree of Doctor of Science (D.Sc.) was conferred upon Mr. T. Kennard Thomson, who is a graduate of the School of Practical Science, '86, and whose prominence as a consulting engineer is widely known, especially in connection with caisson foundation practice and skeleton steel and reinforced concrete construction in New York City. The honorary degree is a new one in the University of Toronto, and the event is of further interest as it marks the first conference of an honorary degree by this University upon one of its graduates from the Faculty of Applied Science and Engineering or from the old School of Practical Science, and, in fact, upon any follower of the profession of engineering. It will be remembered that the University of Toronto has this year instituted an additional academic degree of Master of Applied Science (M.A.Sc.), open to the holder of the degree of B.A.Sc. who spends an additional year in attendance on a special course of study, upon which work he also compiles a thesis before presenting himself for the examination leading to the degree.

MODERN PIER CONSTRUCTION IN NEW YORK HARBOR

DISPLACEMENT OF WOODEN DECKS OWING TO EXPENSE OF MAINTENANCE—REINFORCED CONCRETE DECK SLABS ON WOODEN SUPERSTRUCTURE—MOISTUREPROOF AND PERMANENT

By CHARLES W. STANIFORD, M. Am. Soc. C.E.

THE present general port activity and agitation for a modernization and expansion of the dock and wharfage system in New York City indicate that at least the community at large seems the realize the necessity of keeping its producing plant, the harbor, up to date and at the top notch of efficiency. There can be no question that New York City's supremacy as a manufacturing and distributing centre is due to wise adaptation of its magnificent harbor. The phenomenal increase in the size of vessels, necessitating longer docks, and the great and constant increase in tonnage entering the harbor, both demand determined action in port development.

New York is approximately equidistant from the ports of Northern Europe and South America. Therefore, it will undoubtedly receive additional impetus in its commerce and shipping on the completion of the Panama Canal. Further, on the completion of the New York State Barge Canal, it will have a direct all-water route to the Great Lakes and the North Middle States and Canada, and the Cape Cod Canal will tap New England commerce.

Harbor Development.—In this period of harbor activity, it will be of interest to both the public and the engineer to describe the gradual development of the harbor, as such development was first systematically undertaken by the city, when, in 1870, the Department of Docks was organized for this purpose, and to show the types of pier construction evolved.

In considering the history of dock development in the city of New York, through the instrumentality of the Department of Docks, it must be borne in mind that, in its early days, the department was greatly handicapped in its progress by the fact that the city actually owned only a very small portion of its great water-front, most of it having passed, by successive water grants, into the control of private interests.

It had been the policy of the New York State Government, prior to the organization of the Department of Docks, to give to corporate interests or private persons grants of land under water in that portion of the present city outside of Manhattan, the object and hope in making such grants being that such cession of land under water would be a sufficient incentive for the investment of private capital in the development of the port.

The hopes of the state and city were fully realized; in fact, they were so generally fulfilled that when the port authority, created by the legislature in establishing the Department of Docks for the purpose of intelligent development under municipal control, began to consider the expansion of wharfage facilities to meet the demands of the growing commerce, it found but little actual water-front in possession or under control of the city.

That the early city authorities used wisdom and foresight in their work of providing for proper expansion of the harbor, is shown by the fact that, through their sagacity and good judgment, the number of piers in the harbor, owned by the municipality of New York, grew from 107 in 1868, valued at $20,000,000, to 232 in 1913, valued at $100,000,000 or more.

There has accrued, therefore, to the city, a return on its investment in this development of the dock system, a large sum of money in increased valuation and annual rent receipts, the latter aggregating in round figures about $4,000,000 per annum, the interest at 4% on a capital of $100,000,000.

It will be seen that, at the outset, the Department of Docks, concluded that proper growth and expansion of the harbor under municipal control depended on the acquisition and control of water-front property; and since the organization of the Department of Docks, this has been the policy followed by the city.

When, in 1870, the municipal authorities undertook the burden of increasing the wharfage facilities of the harbor, and of procuring funds for this purpose, it became necessary, as a basis for their work, to determine on some economic form or type of construction, both in regard to the pier structure proper and also the general location with respect to the available shore front, whereby the maximum wharfage accommodation could be developed without excessive or prohibitory cost.

The limited funds available and the small extent of water-front lands under the actual control of the city called for the greatest economy in space, the land requiring intense development in order to obtain the greatest possible extent of wharfage.

Bond issues to be applied to the development of wharfage had to show the same return on the investment, when executed by the city authorities, as if these finances were handled by private parties or corporate interests. Therefore, what might be termed the "principle of economy in expenditure of land and funds" was, of necessity, followed, and this principal was generally adopted by private interests as well, the consequent intensive use of the water front resulting in the adoption of a uniform method of development by a definite system, namely, parallel piers generally at right angles to the general direction of the water-front, with intervening slips wide enough to accommodate vessels of the type intended to berth at the piers.

This parallel system of economically constructed piers, with its resulting economy in space occupied and capital expended, was undoubtedly one of the greatest factors in stimulating the development and expansion of the wharfage facilities in the harbor, and in keeping them abreast of the constant increase in shipping and commerce. It has also created by far the greatest wharfage space of any harbor in the world.

The wooden pier, consisting of a timber deck and floor system supported by timber piles, became the adopted type. It was cheap, durable, and readily adaptable to all classes of shipping. One of the most important characteristics of piers of this type is the ease and economy with which it may be removed entirely, reconstructed wholly or in part, or expand-

* Extracted from Proceedings Am. Soc. C.E., May, 1913; paper to be presented to the society September 3rd.

ed at a low cost, to meet the increasing needs of commerce and shipping. A dock or system of docks sufficient to accommodate the shipping at the time it was built, might be found to be inadequate and obsolete within a comparatively short term of years, a complete re-arrangement being then necessary.

With timber structures, this transformation or reconstruction is a simple, rapid, and economical undertaking; it is difficult and costly with structures of stone, concrete, steel, etc. The use of concrete piles, reinforced concrete substructures or similar forms of construction, therefore, would not only have resulted in high first cost of construction, but the difficulty and expense incidental to the periodical removal, reconstruction, or expansion of dock structures of this type, as necessitated from time to time by the growth of shipping, would have rendered harbor construction work, as a revenue-producing municipal investment, practically impossible, and, consequently, would have greatly retarded the development of the harbor.

Types of Pier Construction.—The United States Government, by virtue of its power to control all navigable waterways in the country, established along the entire water-front or shore line of New York Harbor two lines: one the bulkhead line, which limits the extent outshore of the solid filling or reclaimed land under water; the other, the pierhead line, which determines the limit to which piers may extend beyond the bulkhead line. These piers must be of such construction that the free flow of the tidal water shall remain uninterrupted by the supporting columns. This construction, being a condition wisely insisted on by the Government to preserve tidal conditions and currents, governs, to a great extent, the handling of vessels, particularly of large ones, and affects the sanitation of the city, in that it prevents the accumulation of sewage and refuse which would occur in closed slips. With open slips, such matter is carried away by, and disseminated in, the tidal flow. All pier construction is limited to the area included between the bulkhead and pierhead lines.

The pier which meets these requirements, and was adopted by the city in its early history as the type of structure for berthing vessels (and also adopted by all private and corporate interests), is a wooden structure throughout, consisting of a deck resting on piles driven into the mud or hard bottom. The physical features of the harbor, the geological formation of the bottom, and the condition of the water, fortunately permit the adoption of this type of construction, which, in many other parts of the world, is not adaptable because the life of the timber itself in the water would not be permanent or fairly long-lived. Wood-boring animals, the teredo, limnoria, etc., are very little in evidence, and, therefore, wooden piles are practically permanent below the water-line in almost all parts of New York Harbor.

The prominent objectionable feature to wooden pier construction is the expense necessitated by the constant repairs of the deck sheathing and the continuous wear and tear of the fender system extending along the sides and outer ends of the piers. As to the remainder of the structure, piles, floor system, etc., its maintenance and repair is very economical and consists generally in the replacement, from time to time, here and there, of decayed portions of the timber above mean low water only, at inconsiderable expense.

Until seven or eight years ago, the piers were generally built with decks of yellow pine, 4 in. thick, laid on a system of yellow pine floor structure of ranges and stringers. This deck plank in turn was covered with a second layer of either 3- or 4-in. plank sheathing, laid diagonally or at right angles to the deck proper, to form a wearing surface for the traffic.

Constant repairs and renewal of this deck sheathing, caused by the wear and tear of team traffic, is augmented in great measure by the moisture, horse urine, etc., which saturates the wood and eventually finds its way to the underlying deck and rangers. This forms the greatest item incident to the expense of pier maintenance, the average life of the sheathing for most busy piers being about 6 years, or requiring a 17% renewal annually. As the cost of the deck sheathing is generally about 12% of the total cost of a pier, it will be seen that these sheathing repairs would aggregate 2% per annum of the cost of the entire structure.

New Pier Construction Practice.—Notwithstanding the necessity for constant repairs to the deck sheathing of the wooden pier, the parts of the remainder of the structure—rangers, caps, stringers, piles, and bracing—give excellent service. Maintenance is economical, the average life of the structure above mean low water line being from 20 to 25 years, the repairs aggregating an entire renewal above low water in that period of time. As the life of the piles supporting the structure is practically permanent when submerged below the water, the entire structure can be rebuilt after this period and made practically new by "bench capping" such piles as may be decayed above the water line and renewing the stringers, caps, deck, and sheathing; in other words, the pier structure proper, after a life of 25 years, is readily susceptible of renewal above the water line, the supporting piles below that line being to all intents and purposes permanent.

It will be readily seen that the life of the wooden pier structure would be prolonged still further, and the cost of maintenance and repairs reduced, by the elimination of the objectionable wooden deck sheathing and its replacement by some form of deck impervious to moisture and resisting the wear and tear of traffic.

It was with the object of eliminating this large repair expense incidental to the maintenance of the sheathing, and

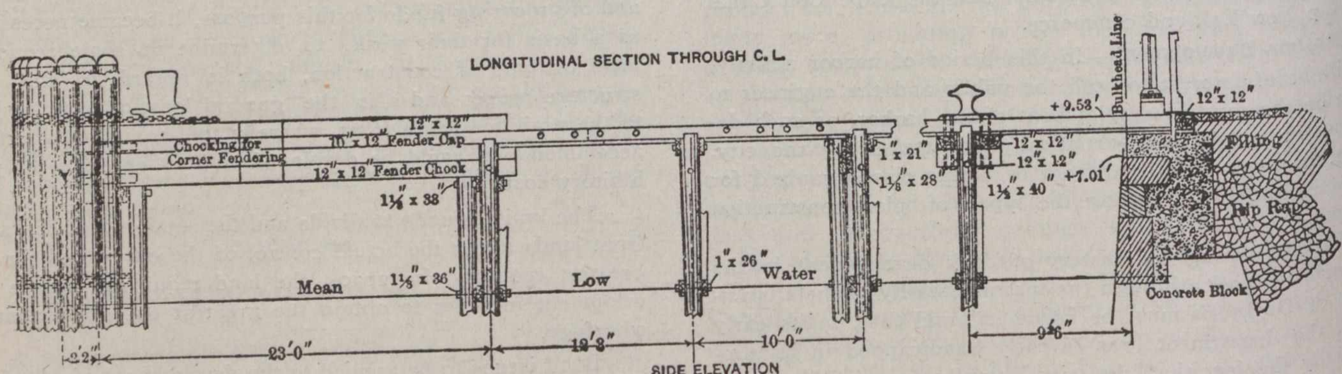

Fig. 1.—Detail of Single Story Reinforced Concrete Deck.

reducing maintenance cost generally, that a serious investigation and study was undertaken of the problem of producing a permanent deck surface supported by timber piles, assumed as permanent below the water line.

This study has resulted in the entire elimination of the old style of wooden deck in new structures, and the production of a new type consisting of reinforced concrete laid directly on the transverse cap system of the wooden pier substructure. This concrete is laid in slabs, spanning the pile bents practically as simple beams.

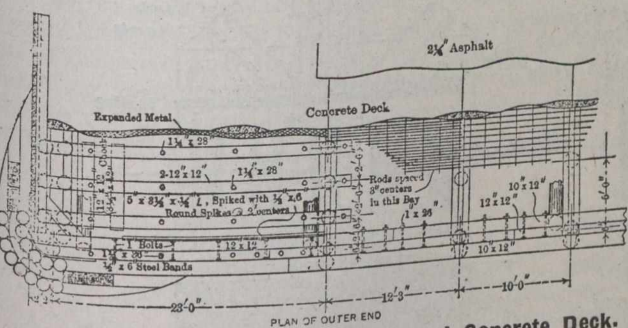

Fig. 2.—Corner Construction Reinforced Concrete Deck.

This new type of deck eliminates not only the 4-in. deck sheathing, but also the 4-in. deck proper and the underlying 12 by 12-in. yellow pine ranger system longitudinally of the pier on top of the transverse cap system, further increasing the life of the substructure.

A structure was thus evolved which had a permanent deck practically impervious to the penetration of moisture to the substructure, readily renewable from low water to the under side of the concrete deck, and permanent below the water line, with a first cost about equal to that of the old wooden deck pier.

The first step in the elimination of the great cost factor, the renewal of the deck sheathing, was the replacing of this sheathing by a concrete wearing surface, from 4 to 6 in. thick, laid directly on the old type of timber decking. This type forms a deck surface which is impervious to moisture, and is, therefore, a protection to the substructure, as well as a saving in maintenance.

The unit of cost of construction of a pier depends in a large measure on the size of the pier. As the outer portions, the sides, and outer end of a large pier are more rigid and heavier than those of a smaller pier, and, therefore, cost more in both labor and material, the relative cost per square foot of a short pier is considerably larger than that of a long one. The average cost of the old wooden deck pier of large dimensions is from $1.00 to $1.15 per sq. ft.

Further investigation and study resulted in the entire elimination of the wooden deck plank, deck sheathing, wooden floor rangers, etc., and the adoption of the present type of pier deck, as before mentioned, consisting of a reinforced concrete slab, 10½ in. thick, extending from centre to centre of the transverse pile rows placed generally 10 ft. apart. This slab is designed to carry a live load of 500 lb. per sq. ft. for the 10-ft. span between pile rows, and is reinforced with ⅝-in. square steel rods. The latter run longitudinally of the pier, are 6 in. apart, and are staggered so that only alternate rods terminate on the same pile row, with ⅜ by ⅜-in. separating rods. The slab is of 1:2:4 Portland cement concrete, with ¾-in. broken stone, the upper ½ in. of the slab being of Portland cement mortar finished smooth. This rod reinforcement is intended to be standard, but the substitution of trade sizes of equal strength and efficiency is permitted, subject to approval.

Definite illustrations of this type of pier construction are found in the two new piers recently completed by the Department of Docks and Ferries at the Gowanus Section, South Brooklyn, one at the foot of 31st Street, 1,475 ft. long, and the second at the foot of 33rd Street, 1,616 ft. long, each pier being 150 ft. wide. These piers are among the finest in the harbor, and are probably the largest of their type in the world. The unit cost is practically the same as that of the old wooden deck type. The decks have a crown of about 8 in., in order to shed the water. The in-shore end of the concrete deck rests on the bulkhead wall, but is not attached thereto, a horizontal plane joint allowing the deck to slide on the wall as it expands or contracts on account of changes of temperature.

Twenty-six piers with concrete decks have been built by the department during the past seven years. The earlier type, as exemplified by the Chelsea Section piers, consists of a 6-in. concrete deck surface reinforced with expanded metal and laid directly on the deck planking. The next type produced omitted the deck plank, and is represented by eight piers with decks consisting of a concrete slab, 6½ in. thick, reinforced with expanded metal, the slab spanning yellow pine rangers running longitudinally of the piers and generally about 6 ft. apart.

The final type evolved, omitting the timber floor system entirely, and placing a concrete slab reinforced with longitudinal steel rods directly on the timber-capped transverse pile rows, is represented by eight piers, the most important examples being those at the foot of 31st and 33rd Streets, South Brooklyn, and the Municipal Pier at Stapleton, Staten Island.

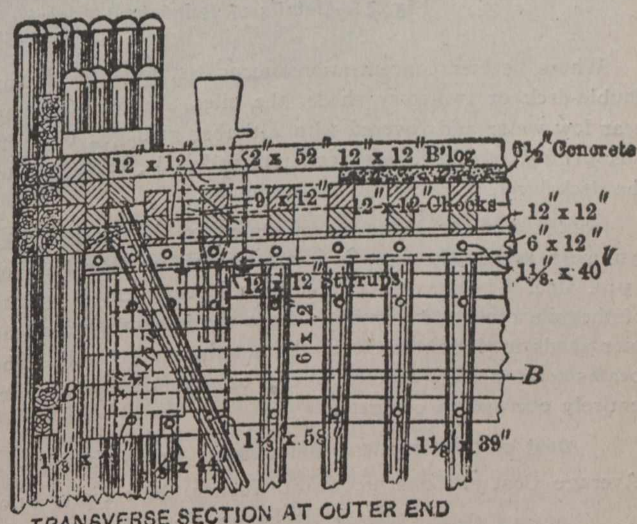

Fig. 3.—Pier Construction With Reinforced Concrete Deck.

All these piers have been built where the condition of the river bottom underlying them was such that no settlement could occur, and they have behaved admirably. No repairs have been necessary, except to the fender system, and none are anticipated for many years to come, excepting the renewal here and there of an imperfect pile, where rot may appear above the water line. Such renewals can be made at a minimum of cost—a few dollars per pile—by bench-capping, without any interference whatever with the integrity of the reinforced deck itself.

Column Foundations.—For single-story sheds, where additional bearing strength is required in the new concrete deck pier for shed column or superstructure support, the question has been treated in general in the same manner as in the other parts of the structure, that is, by adding the necessary number of piles to carry the load concentrations, assuming the piles to be permanent below low water and easily renewable above that plane.

Concrete Deck Pier.

Cost of construction, 31st Street Pier, South Brooklyn, no asphalt surface..........	$0.87 per sq. ft.
Cost of construction, 33rd Street Pier, South Brooklyn, with asphalt surface	0.97 per sq. ft.

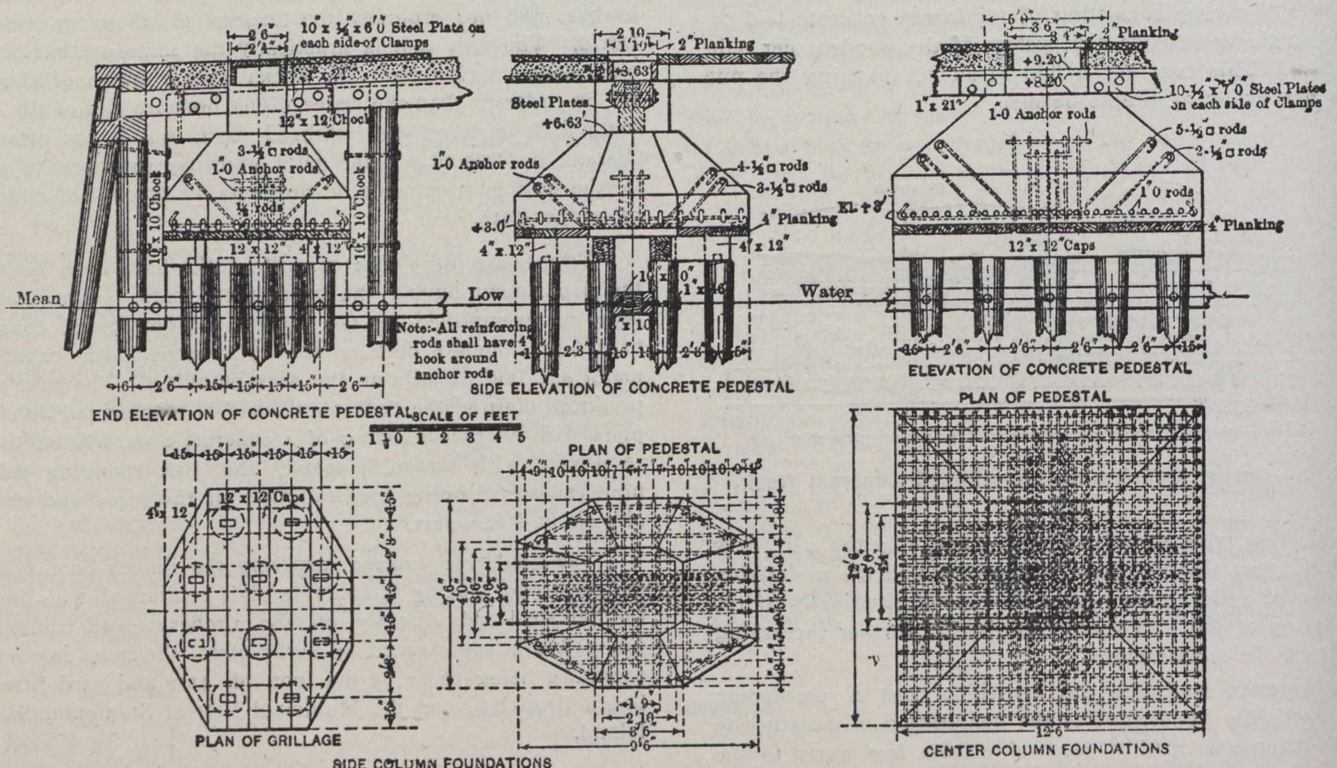

Fig. 4.—Details of Reinforced Concrete Deck and Column Pedestals, Two-Story Shed.

Where heavier concentrations occur, as, for example, in double-deck or two-story sheds, the piles are cut off at or near low water and covered with a timber grillage; built on this grillage are reinforced concrete pedestals, extending to the deck level, to carry the shed columns.

Railroad tracks, being a requirement on the South Brooklyn piers previously described, are carried on four lines of 15-in. steel I-beams, placed on the transverse clamp system of the pile rows and extending from the in-shore end of the pier sheds to within 60 ft. of the out-shore shed wall. The beams rest on steel saddles placed on the clamps, and are entirely encased in concrete.

Cost of Construction, Maintenance and Repairs.

Average Cost of Construction of Wooden Deck Piers, $1.00 to $1.15 per Square Foot.

Repair Costs of Wooden Deck Pier.

Description.	Percentage of total original cost.	Renewal required.
Sheathing	12	Every 6 years.
Backing log	1.8	Every 8 years
Fender chocks, including vertical sheathing	4	Every 10 years.
Fender piles	4.7	Every 12 years.
Decking	11.3	Every 15 years.
Bracing	7.1	50% in every 20 years.
Rangers and caps	24.4	50% in every 20 years.
Piles*	34.7	33⅓% every 20 years.

*Above M.L.W. only.

Economy being a prime factor in its construction, it was decided to try out the concrete deck surface for wear and tear of heavy team traffic, and the earlier decks, therefore, were finished with a smooth mortar surface to receive this traffic. Two years of experimenting on these lines, determined the fact that though the concrete surface was admirably adapted to light traffic, cargo handling by hand or

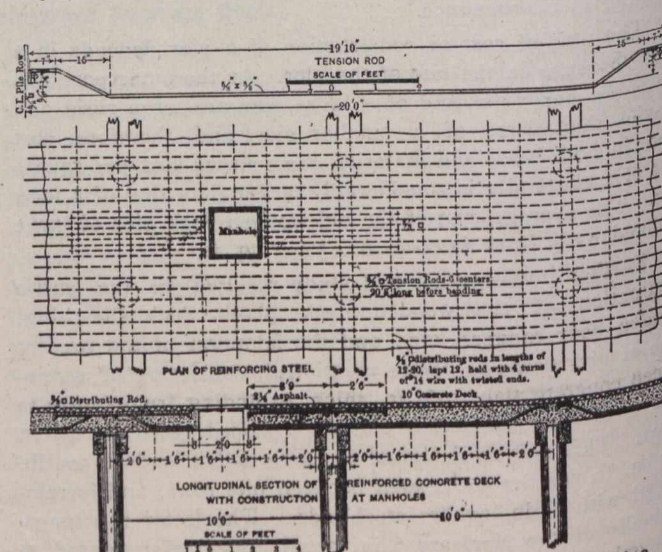

Fig. 5.—Two-Story Shed—Construction at Manholes.

motor trucks, etc., it could not stand the concentration of heavy team traffic confined within narrow lanes located generally in the centre of the pier. The grinding and turning of heavily laden trucks inside these narrow lanes or zones gradually caused surface rupture of the top coat of mortar.

It was decided, therefore, to place an asphalt wearing surface on the deck, and this has proven very effective.

The piers, at the foot of 31st and 33rd Streets, South Brooklyn, have been in service for about three years. No signs of cracking or other imperfections have appeared, and the piers, as a whole, are a complete success.

Repairs.—For the modern type of concrete deck pier, the cost of maintaining the fender system is about the same as that for the wooden pier; deck sheathing repairs are practically eliminated, except such minor asphalt patching as may be required, and can be considered negligible in a good asphalt deck under cover; the deck plank is eliminated; the life of the ranger and cap system is prolonged by the protection from moisture given by the impervious concrete deck, and the cost of maintenance and repairs, therefore, is reduced to a minimum.

(c) The supporting part, below the water line, is permanent; and

(d) The resulting structure is such that it can be readily extended, reconstructed, or, if necessary, entirely removed at a cost not prohibitive, as would be the case, for example, with most types of reinforced concrete deck-supporting structures.

II. That the department has produced permanent parts in the structures where these are essential. No attempt was made to obtain absolute permanency above low water, in the structure supporting the deck, for the reason that.

III. This portion of the structure, the caps, piles, braces, etc., protected as they are from saturation by urine and other objectionable fluids by the concrete and asphalt deck forming a protecting roof, can be maintained in good condition at a very low cost.

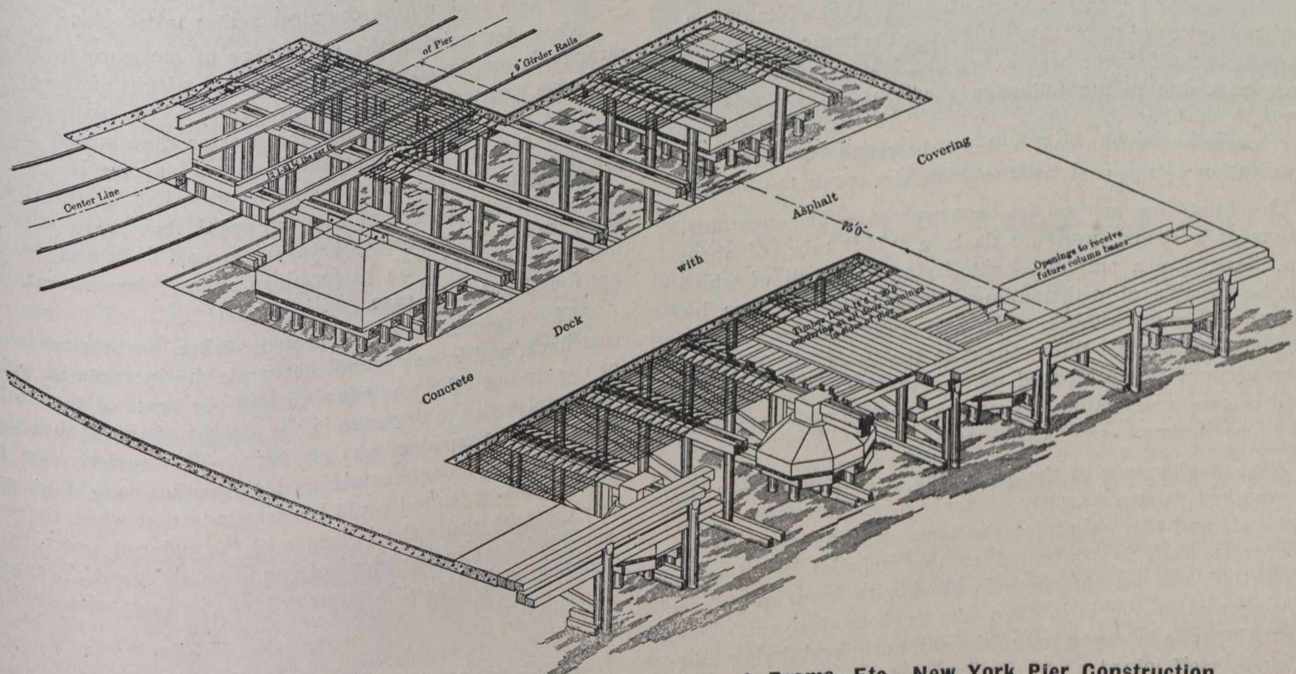

Fig. 6.—Showing Placing of Steel Reinforcement, Pedestals, Track Beams, Etc., New York Pier Construction.

Conclusions.—From the foregoing it will be observed that the problem which confronted the department was the elimination of the timber deck and deck-supporting structure of the wooden pier, by the substitution therefor of some permanent form of construction meeting the following requirements:—

(a) Economy in cost of construction and maintenance, the unit cost to be such as to produce or make possible a remunerative return on the capital invested.

(b) The construction to be of such character as to be readily extended, reconstructed, re-modeled, or, if necessary, entirely removed, as more intensive development of the area occupied by the pier or system of piers might be made necessary by the growth of commerce and shipping.

From what has been stated the following conclusions may be deduced:—

I. Admitting that timber piles and foundation work are generally permanent below the mean low water line in New York Harbor, the Department of Docks and Ferries has met the requirements of the problem by producing piers having the following characteristics:—

(a) The deck is absolutely permanent;

(b The substructure, above mean low water, is easily and cheaply repaired and maintained;

IV. The type of structure produced, approximating permancy, is now being built by the department at a first cost no greater than that of the former type of wooden pier throughout, and the cost of repairs and maintenance of the deck structure is almost entirely eliminated.

SELECTION OF SAND FOR CONCRETE.

The two most essential qualities to consider in sand are cleanness, that is, freedom from impurities, and coarseness of the grains. The sharpness of the grains and the mineralogical composition, according to "Concrete Costs," by Taylor and Thompson, while affecting to a slight extent the strength of the mortar for concrete, are not in themselves sufficient for accepting or rejecting a sand.

Cleanness, meaning by this not so much freedom from fine, clayey material as freedom from vegetable matter, is of prime importance, since such impurities may so affect the strength of the mortar as to make even a well-graded sand absolutely dangerous to use. The fineness of the sand and its percentage of silt passing a sieve having 100 meshes per linear inch, may also be a ground for rejection, since a fine sand always makes a weak mortar or concrete.

DETERMINATION OF WATER IN COAL.

By P. L. Teed.

At first sight the determination of water in quantities of coal would appear to be a simple operation in the hands of the assayer, and because of its simplicity one would expect great accuracy in the operation. In a paper read at a meeting of the Institute of Mining and Metallurgy, Mr. Teed makes clear, however, that the task does not admit of such accuracy as one might suppose. In his paper he endeavors:—(1) To show that in the simple drying method universally employed for determining the percentage of moisture in a fuel, reactions other than the simple volatilization of the water take place, which may materially affect the accuracy of the result, and (2) to describe an accurate and rapid though more complex process for determining the percentage of moisture in fuel. The method universally employed is that of taking a weighed quantity of 80-mesh coal, drying the same in a steam oven, and recording the loss in weight, but sources of inaccuracy exist due to the following reactions:—(a) Oxidation of pyrites making the result too low; (b) volatilization of matter contained in the coal making the result too high; and (c) oxidation of the coal itself making the result too high.

The following method has been evolved:—The apparatus, consists of a 100-cc. pressure flask, a "U" tube, of about ½-in. bore, and a sulphuric-acid drying tube, all of which must be capable of withstanding atmospheric pressure; besides these, sound rubber corks and some form of vacuum pump are necessary. With regard to the latter, the Sprengel water vacuum pump worked off the main supply has been found to give a reduction in pressure equal to about 725 mm., and to be in every way satisfactory.

The employment of the apparatus is as follows:—In the dry weighed flask a quantity of finely divided coal (80-mesh) is placed, and the weight of the same determined by difference; this flask is connected to the weighed "U" tube, whose limb nearest the flask is filled with lump quicklime, while that more remote is filled with finely-ground quicklime; this "U" tube is connected to the sulphuric acid drying tube, which is itself joined up to the Sprengel pump with an intervening tap. The pump is started and a vacuum gradually created (the speed of the outcoming gas being shown by the bubbles in the sulphuric acid drying tube); the flow of water through the pump is gradually increased, until a vacuum of about 700 mm. is created; then boiling water is poured into the beaker in which the flask containing the coal is standing, while to the beaker in which the lime tube is situated, a boiling aqueous solution of either sodium chloride or calcium chloride is added, care being taken that the corks of the tube are not wetted with the solution. The reactions taking place are as follows:—

Under the reduction of pressure and at a temperature of the boiling water surrounding the flask containing the coal, the water in the coal, together with volatile matter varying with the nature of the coal, distils off and passes into the lime tube where, in accordance with the following equation—

$$(CaO + H_2O = Ca,OH)_2,$$

the water originally in the coal is chemically retained, while the other volatile matter from the coal, owing to the absence of any chemical affinity for the lime, and the higher temperature of the lime tube (due to its being surrounded by a boiling aqueous solution of sodium chloride or calcium chloride), passes through to the sulphuric acid drying tube, where some of it is retained, discoloring the sulphuric acid, while other portions pass through to the pump.

At the end of about half an hour, the whole of the water having passed from the coal to the lime tube, the tap adjoining the vacuum pump is turned off, the beaker of boiling water surrounding the coal flask is removed, and the air gradually let back through the sulphuric acid drying tube into the apparatus; then the apparatus is taken to pieces, the lime tube washed, wiped, placed in a desiccator to cool, then weighed, the increase in weight noted (this increase is solely due to water from the coal) and the percentage of water in the coal calculated.

In the new method the two errors due to oxidation no longer exist, because the water is distilled from the coal in the absence of air, and consequently no oxidation can take place; with regard to the error due to volatilization of matter in the coal, something more must be said, for the volatilization still takes place, but since the temperature of the quicklime tube is higher than the coal itself, no condensation can take place in this tube unless chemical action takes place.

When determining the percentage of moisture in an anthracite, it was found that the increase in weight of the drying tube was greater than the loss in weight of the anthracite in the coal flask, by an amount far greater than would be accounted for the fact that the aqueous vapour in the air originally in the apparatus would be absorbed by the drying tube; naturally it was at first supposed that there must be some leak in the apparatus between the coal flask and the drying tube, but this, on performing a blank experiment, was not found to be the case.

The experiment was repeated, using anthracite in the coal flask, and it was found that while the increase in weight of the drying tube was equal to 2.78 per cent. of the anthracite employed, the decrease in the weight of the anthracite in the flask was equal to 2.52 per cent. This curious fact having been undoubtedly established, the author sought for some explanation of it, and could but conclude that when the water left the coal under the influence of the reduced pressure and heat, it left it in the physical condition of charcoal, capable, like charcoal, of absorbing many times its own volume of gas.

PRODUCTION POWER PLANTS.

The United States Bureau of Mines has published a study of the producer-gas plants using anthracite. Such a plant has large conservation and commercial possibilities. Government experiments for eight years have demonstrated not only a very low fuel consumption per horse-power hour, but also the possibility of utilizing commercially low grades of bituminous, lignite and peat.

There are in present use engines with aggregate capacity of 200,000 horse-power deriving this power from producer gas. Engines with power from blast furnace and coke oven gas aggregate 350,000 horse-power. The latter type is largely in steel works, the power being used for mills and furnaces.

There are producer-gas plants in 46 states, the District of Columbia and Alaska. From 1909 to 1912 such plants increased from 474 to 722, or 52 per cent. Horse-power increases from 11,250 to 187,140, or 68 per cent. Plants using anthracite increased from 415 to 610 and their power from 48,100 to 89,470; those using bituminous from 37 to 77 and power from 54,150 to 86,605; those using lignite from 23 to 32 and power from 9,000 to 10,230.

The producer-gas power plant has proved economical in obtaining power and in using fuels such as peat and lignite. Texas in 1912 had 28 producer-gas power plants, of which three used bituminous coal, six used anthracite and 19 used lignite.

CONCRETE CULVERTS.

By F. H. McKechnie, B.A.Sc.

(Continued from last week, p. 827.)

The Old Rail Culverts.—The old rail culvert is not one in very general use, but is used, more or less, as a substitute for the regular reinforced beam or arch culvert. The Oregon Short Line Railroad uses box and arch culverts reinforced with steel rails.

In the box culverts the rails in the cover plate are spaced close together under the tracks and further apart towards the ends. The rails are all set base downward and the side walls are well battered to give wide footings.

In the arch culverts the rails are laid alternatively base and head downwards and are bent as nearly as possible to the shape of the arch. The spacing of the rails is the same as that for the box culverts. Under the centre, where the spacing of the rails is closest, two parallel strips of expanded metal are embedded on the intrados. The side and wing walls are braced together by cross walls of concrete, thus holding the filling of gravel or rocks in the invert.

The concrete used in the culvert is mixed in the usual proportions of one, three, six for such structures, Portland cement and broken stone being used.

I-Beam Culverts.—This is a type of culvert quite extensively used on the Canadian and American railroads, and is particularly used and useful where a wide culvert opening is necessary on account of a low elevation of grade above stream bed and where a large waterway is needed.

The accompanying figure (Fig. 9) shows a construction adapted for culverts, cattle passes, drainage ditches, etc., ranging from ten to fifteen-foot spans. The arches are usually quite flat, the twelve-foot arch having a radius of sixteen feet for a chord of twelve feet and corner curves of two-foot radius to the face of the abutment, which has a batter of one in twenty-four.

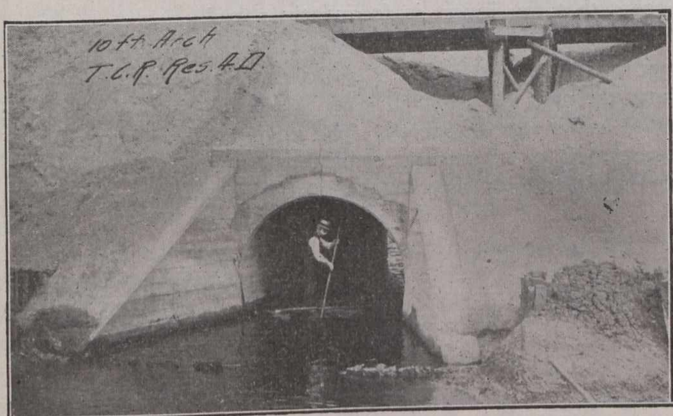

Fig. 9.—Typical Railroad Culvert With 10-Foot Opening.

For single track the length of the culvert is nineteen feet, and twenty feet and a half over the parapet walls. The thickness of the concrete at the crown of the arch is eighteen to twenty-three inches and five lines of ten to twelve-inch I-beams, sixteen feet long, spaced two feet apart, are placed under each track, embedded in the arch with about three inches of concrete below and eight inches above at the crown.

The upper surface of the arch is made to form, with the parapet walls, a basin or trough in which the ordinary ballast is laid, thus allowing the roadbed to be continued unbroken over the structure. The wing walls may be built straight or flaring, as desired. The invert is laid with a twenty-six-foot radius and scouring may be prevented by apron walls at the ends.

The culvert shown is one of this type with a ten-foot opening, and contains about one hundred and ninety yards of concrete.

Fig. 10.—Typical Railroad Culvert in Earlier Stage of Construction.

The Box Culvert.—Flat slabs for culverts resting directly on the abutments are used in spans of from four to sixteen feet. Box culverts for railroad work are similar to highway culverts, but must be built to carry the greatly increased loading coming upon them. The side walls are usually reinforced so as to withstand earth pressure due to dead and live loads. When the abutments are sufficiently heavy at the base for this wall, it may be designed as a simple slab supported at top and bottom. Thus the walls may be greatly reduced in thickness over what is required for a wall of plain concrete.

It is frequently, depending on the material on which the culvert is built, necessary to carry an inverted slab continuous between the side walls to provide ample bearing for the heavy loads coming on these foundations. When such a floor slab is used it should be of the same strength as the cover slab, with the bars inverted in the top of the slab. Wing walls, when used, may be designed the same as for an ordinary retaining wall.

In calculating moments in box culverts of this type, a live load is assumed of 50,000 pounds on axles, five-foot centres, and 10,000 pounds per foot of track. This load may be taken as distributed uniformly over ties eight feet long. The manner in which the live load will be distributed when it reaches the culvert cover will depend on the character of the embankment.

It may be assumed that the line of zero stress in the embankment, due to live load, follows a slope of one-half to one, which is much more nearly vertical than the ordinary angle of repose. For fill of less than two feet, the impact allowance should be one hundred per cent., between two and four feet, seventy-five per cent.; above four feet an allowance of fifty per cent. may be made.

Let P_L = unit pressure on cover per square foot due to live load.

Let P_D = unit pressure on cover per square foot due to dead load.

Then $P = P_L + P_D$

Total load per linear foot = 10,000 pounds, and adding 50 per cent. for impact = 15,000 pounds.

$$15{,}000 = P_L\left(\frac{8+h}{2}\right) \text{ or } P_L = \frac{30{,}000}{h+16}$$

$$P_D = 100h$$

$$P = \frac{30{,}000}{h+16} + 100h = \text{total superimposed load per}$$

square foot on cover.

The beam culverts similar to those described are often used where the arch culvert might just as well be employed. The argument most often advanced by advocates of the beam culvert, as compared with the arch, is increased waterway. Other possible advantages are a simplicity of arrangement of false work and a greater ease of analysis. Taking up this last argument, while it is admitted that the reinforced beam is a comparatively simple structure and the arch a very complex one, it will be shown, nevertheless, that there is no such advantage, since an arch designed by the very same method is the stronger of the two.

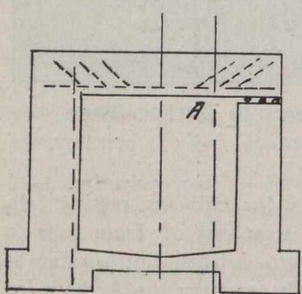

Fig 11.

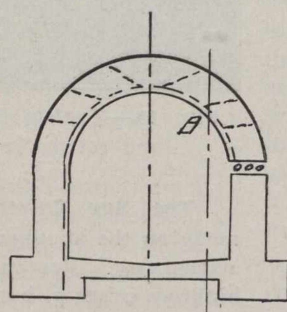

Fig. 12.

Fig. 11 shows a flat top culvert of usual design, consisting of a concrete beam, reinforced with steel tension members embedded near the lower edge, and shearing members arranged diagonally near the ends, supported on reinforced concrete abutments with the bed of the stream paved with concrete.

It is an easy matter to determine the proportions of such a beam required to carry a given load, the beam being a comparatively simple structure from a mathematical standpoint.

Fig. 12 represents an arch having the same span and height of opening and reinforced in a similar manner and with the same thickness of material at any point in the span.

A comparison of the two designs, the properly designed beam culvert of Fig. 11, and the arch culvert derived from it in Fig. 12, shows that the arch culvert is far the stronger and more efficient design, although by no means a properly designed arch.

Assume both beam and arch supported on rollers, so as to be absolutely free from all horizontal forces and unable to offer any resistance to horizontal thrusts. Now, with the same loading on the two structures, the bending moments at any given point of the span are the same for both. Thus the bending moment at A, of the beam is the sum of the moments of all forces to the right of that point. The same is true of the bending moment at the point B, of the arch, since all the forces are vertical and equal in both structures. The bending moment is balanced by the moment of resistance of the section, which is greater in the arch at every point except the crown, where it becomes equal to that at the middle of the beam. At any vertical section other than the crown, the compression is slightly greater in the arch than in the beam, but the tension and shear are less, and at no point of the arch is the compression greater than at its crown, which, like the middle of the beam, is the weakest point in the structure, neglecting shear. In shear the arch has a very decided advantage over the beam, as the section is very much increased at the region of maximum shear. We have, then, the remarkable deduction that a very badly designed arch, not even capable of resisting horizontal thrusts, is as strong as a properly designed beam, having the same section and reinforcement.

If we take both structures under practical conditions, all pressure back of the abutments tends to weaken the beam culvert, by increasing the compressive stresses in the upper fibres of the beam.

No provision can be successfully made in the beam for contraction or expansion.

In the case of the arch, all pressure back of the abutments adds to the strength of the structure, since it sets up moments counter to those produced by the vertical loads, thus tending to reduce the bending moments at the weakest sections. Every inch of upward curvature in a beam culvert increases its strength.

Design of Arch Culverts.—The variations in the design of arch culverts have considerable effect on the cost and efficiency. To combine the least cost with the greatest efficiency, the following conditions should be considered:

(1) The amount of masonry.

(2) Simplicity in the work of construction, forms, etc.

(3) The design of the wing walls.

(4) The design of the junction of the wing walls with the head walls.

(5) The safety and permanency of the structure.

These conditions are more or less antagonistic to each other, but to obtain the best results in design a proper proportion must be reached between the opposing conditions

Arch culverts differ only in size from ordinary arches except that the invert is frequently paved.

A common method of connecting the wings to the abutments is to make an angle of fifteen to thirty degrees away from the axis of the arch and to build them up with the usual batter and thickness. The angle of the wings may be determined by the natural conditions, such as rate of stream, ice conditions and material back of wings.

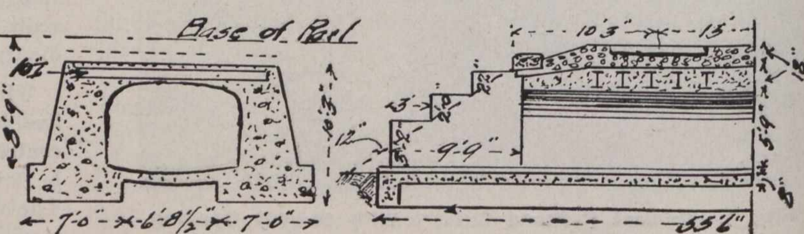

Fig. 13.—Embedded I-Beam Culvert.

To give the best entrance to the culvert for the water and ice, the wings should be carried up to the springing line of the arch flush with the inside face of the abutment and with the same batter. This leaves an entrance to the culvert perfectly smooth, and without corners in which ice or timber might block.

For small concrete arches, plain, from five to fifteen feet in span, they are generally semi-circular arches. For twenty to thirty feet, segmental arches offer some advantages; for the same length of intrados a little wider span is given, the area of the waterway is a little greater, for the same length of span there is a little less masonry. The segmental arch, on the contrary, requires ten to twenty-five per cent. greater thickness of arch ring and abutments.

Trautwine gives the following formula for the depth of keystone:

$$\text{Depth of key in feet} = \frac{2\sqrt{\text{radius} + \text{half span}}}{4} + .2 \text{ feet.}$$

This is for cut stone. For concrete the result should be increased by one-eighth.

Rankine's rule for crown thickness is:

For single spans — $2\sqrt{.12 \text{ radius}}$

The crown thickness may also be found approximately by first determining the approximate crown thrust. This may be found by obtaining the centre bending moments for all loads, as for a beam, and dividing by the rise. The proper value for crown thrust is that one producing equilibrium about the point of rupture.

Trautwine's rule for determining the thickness of abutments for arches, in feet, at the springing line, for any abutment, the height of which does not exceed one and one-half times the thickness at the base is: The required

$$\text{thickness} = \frac{\text{radius in feet}}{5} + \frac{\text{rise in feet}}{10} + \text{ or } - 2 \text{ feet.}$$

The radius used is that of a circle passing through the two springing lines and the crown, on the soffit.

This formula is applicable to a semi-circular, segmental, or elliptical arch. This thickness is given to resist the thrust on the wall, arising from the earth pressure of the embankment of any height, over and around the wall.

Where the earth only extends a few feet above the top of the arch, it is evidently safe to consider the half arch, with its abutment and weight above, as the equivalent of a vertical faced wall of the height of the embankment, and find the thickness of the wall to insure stability, as in retaining walls, or using the thickness followed in practice, that is, from two-fifths to one-half the height. Any greater height of embankment would probably not require any greater thickness of abutment wall. The great stability of the wall, resulting from increase of weight of material above, would balance the increased thrust.

A more extended discussion is impossible on account of the very involved character of such a discussion.

The following method of designing semi-circular arches of reinforced concrete, for spans up to fifty feet and with not more than ten feet of fill over crown is suggested by Dan. B. Luten:

$$\text{Crown thickness} = \frac{\text{span}}{30} + \frac{1}{3}.$$

The outer to be drawn with the centre one-tenth of the span below the centre of the inner circle. The back of the abutments tangent to the outer circle and battered one in four.

The square inches of steel required to reinforce one edge of the arch for one foot in width to be $\frac{HL}{400{,}000C}$.

Where H is the height of the opening in feet.

C is crown thickness in inches.

L is the live load in pounds that can be concentrated in single track, over half the span.

Reinforcing of Culverts.—These remarks will apply chiefly to the semi-circular arch culvert, as they are practically the only culverts built without reinforcing of any kind.

Anyone at all familiar with the condition of the arch culverts along our railroads is aware of the only too common occurrence of cracked concrete culverts.

The most frequent cause of failure is the unequal settlement of the foundations under the two ends of the structure, causing ugly, disfiguring cracks at right angles to its longitudinal axis and, indeed, often noticed extending across the intradosal face of the arch. Similar cracks often occur in the invert. Another type of crack much in evidence is one running longitudinally along the centre line of the invert where the arch usually has the least thickness, indicating unequal settlement of the sidewall foundations.

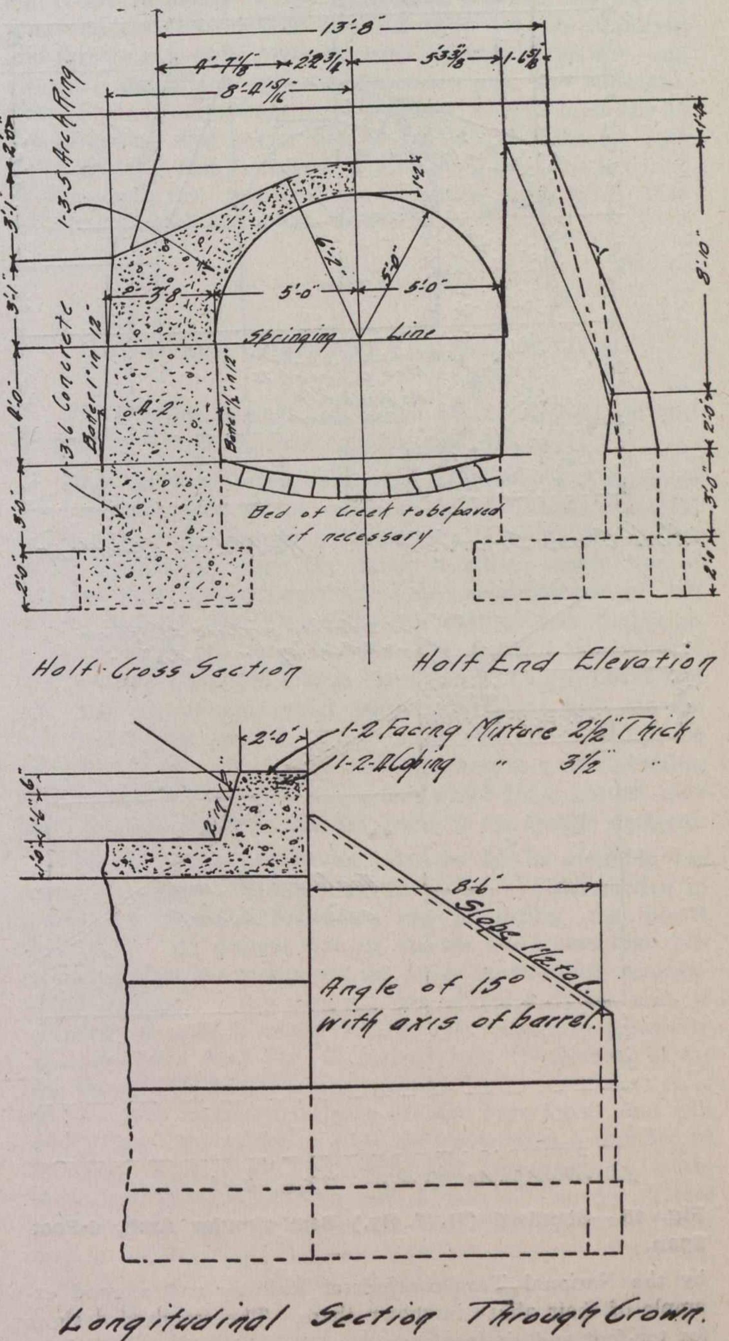

Fig. 14.—Standard (N. T. Ry.) Semi-circular Arch, 10-Foot Span.

Contraction and expansion from changes of temperature, as well as shrinkage stresses, have also been known to have caused cracks in concrete culverts, but these causes of failure are not so common as unequally yielding foundations.

If the culvert is properly reinforced, such conditions as those described above do not occur because the culvert will act as a monolith. The culvert will be capable of beam action and cracks will not appear so readily as in a plain concrete structure, thus far greater durability is assured.

Such a culvert will stand up under more severe conditions imposed by traffic and nature than one not reinforced, and if both were subjected to the same test the reinforced structure would remain intact for a much longer period of time.

Semi-circular arch culverts are in very common use in Canada, without reinforcing. They are used almost entirely

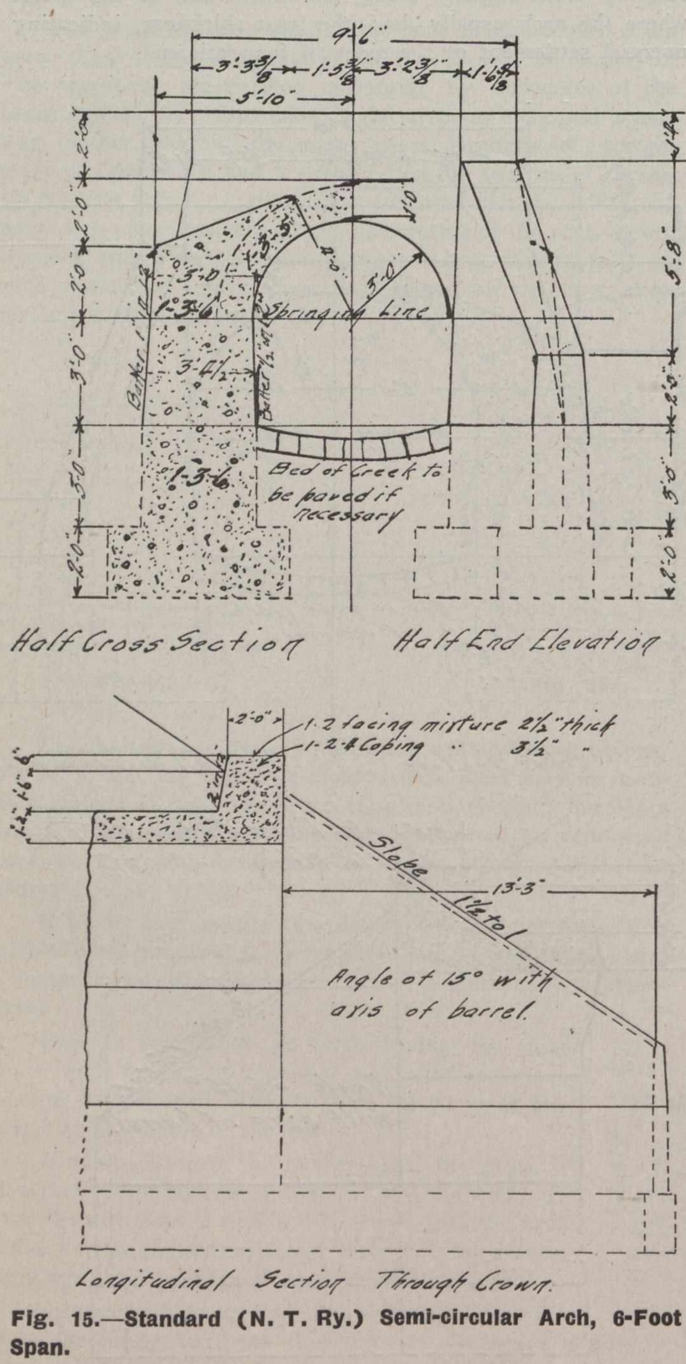

Fig. 15.—Standard (N. T. Ry.) Semi-circular Arch, 6-Foot Span.

by the National Transcontinental Railway and a good example of their abuse is shown there. The standard designs for ten-foot and six-foot spans are shown in Figs. 14 and 15. These culverts are put in, in the majority of cases, without any reinforcing whatever and with foundation conditions far from ideal. Piling is driven, but in a great many cases there is such a large body of poor clay material overlying the solid stratum beneath, that the piling receives very little lateral support, and so, when the fill is made and the pressure comes on the back of the abutments the piling gives away laterally causing longitudinal cracks in the arch. This condition may be prevented by putting in a solid floor of concrete, reinforced diagonally with twenty-pound rails, so as to form a grillage. This enables the culvert to withstand the lateral pressure and the uneven settlement, if it is not too pronounced. With the arch reinforced as well the culvert is practically insured against failure.

The character of the failures in these culverts is well shown in a report compiled by Mr. C. R. Young, B.A.Sc., on a number of the culverts in District "B" of the National Transcontinental Railway. This report shows that about seventy-one per cent. of the culverts on the report show cracks.

The only conclusion that can be arrived at from a view of Mr. Young's report is that all culverts of greater span than five feet should be reinforced, and that provision should be made for expansion joints in those of long barrel.

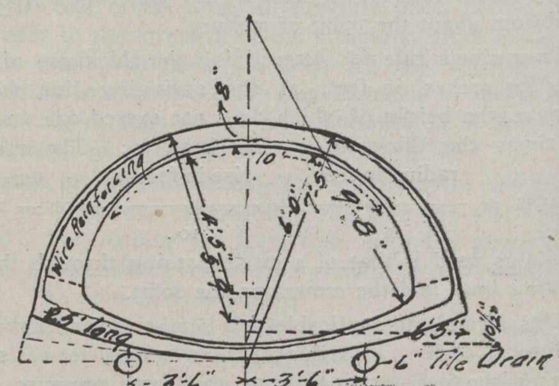

Fig. 16.—Reinforced Concrete Arch Culvert.

Below is given a description of a reinforced concrete arch culvert built at Kalamazoo, Michigan. This is shown in section in Fig. 16.

The culvert is one thousand and eighty feet in length, with a clear width of nine feet ten inches and clear height of six feet. Its grade is from 0.4 to 0.5 per cent. The masonry is entirely concrete, composed of sand, gravel and Portland cement in the general proportions of about one part of Portland cement to six parts of sand and gravel. Actually the upper arch was made with a little stronger mixture and the lower arch a little weaker. Anywhere there was likely to be a little extra pressure a richer mixture was used, under street crossings and where the underlying soil was particularly treacherous.

For reinforcing, a woven steel wire was used. The members of this fabric extending around the culvert were No. 11 steel wire and two layers of the fabric were used, making a total length of wire surrounding the culvert of 175 feet per linear foot. The dotted lines in the figure show changes in the shape of the bearing portion of the concrete, according to the earth on which the culvert is laid. Under parts of the culvert, resting on quicksand two lines of tile drains are laid under the invert to remove the excess water. When drained, it became firm and a good foundation. Before backfilling, interior and exterior of the arch surface were well brushed with neat cement grout.

Costs of Culvert Construction.—Eighteen-foot, semicircular arch.

The culvert was built under a trestle sixty-five feet high before the trestle was filled in.

The foundation being such that piling was necessary, the railway company drove piling to support a concrete foundation two feet thick and a concrete paving twenty inches thick. The barrel of the culvert was one hundred and forty feet long, but no expansion joints were provided. Cracks developed later, about fifty feet apart, due to the lack of provision for expansion.

The contractors were provided with a large quantity of quarry spalls which had to be crushed by hand. The stone was shipped in drop bottom cars and dumped into bins built on the ground under the trestle. The sand was shipped in ordinary coal cars and dumped into bins. The mixing boards were placed on the surface of the ground and wheelbarrow runways were built up as the work progressed.

The cost of 1,900 cubic yards of concrete in the culvert was as follows, per cubic yard:

1.01 bbls. of Portland cement	$2.26
0.56 cu. yds. of sand @ 60c.	.32
Loading and breaking stone	.25
Lumber, centres, cement house and hardware	.64
Hauling materials	.04
Mixing and placing concrete	1.17
Carpenter work	.19
Foreman (100 days @ $2.50)	.13
Superintendent (100 days @ $5.50)	.29
	$5.29

Only 19 yards per day of concrete were placed, with a gang of 21 negroes @ $1.10 per day. The item for superintendence is high.

Cost of concrete pipes, previously described in this article. The cost of molding the four-foot concrete pipes is estimated as follows:—

Two per cent. of $40 for forms	$ .80
Assuming that a single set of forms can be used only fifty times before being replaced.	
1.1 cu. yds. stone and screenings @ $1.85	2.04
0.8 bbl. of cement @ $2.10	1.68
10 hours' labor @ 28c.	2.80
	$7.32

This gives a cost of $1.83 per linear foot of pipe, of $7 per cubic yard of concrete.

The cost of transporting and installing concrete pipes, on account of greater weight and a greater number of pieces, would probably be very nearly double that for cast iron pipe. However, it is evident that the cost of a concrete pipe culvert in place would be but a small fraction of the cost of cast iron pipe culvert of the same diameter, if the haul is only a moderate distance.

SAVING OUR FORESTS.

"Constant progress in forest conservation" is the keynote of the fourteenth annual report of the Canadian Forestry Association, which has just been issued from the office of the secretary, Mr. James Lawler, Canadian Building, Ottawa. The report, which contains all the addresses made by the prominent forestry experts, legislators and officials at the convention held in Victoria, B.C., is replete with the latest views of the most advanced minds in this line of national public activity. The great strides forward of the Federal and Provincial Governments, two of whom passed far-reaching legislation within the year, unusual progress of the science of forest protection among lumbermen, and the numerous changes in the Canadian Forestry Association itself, all indicate most clearly that the country is rapidly taking up the issue and making for more adequate protection of the great forest heritage. Copies of the Canadian Forestry Association report are to be had free, from Mr. Lawler, on application.

AUTOMATIC SPRINKLERS AND HOTEL FIRES.

The question of fires in hotels in the United States is receiving a great deal of attention just now, and many publications are taking up this hazard not only with respect to loss of the building, but to the lives endangered nightly. The average fire occurrence in hotels during 1912 was one to every thirty-three hours, and during 1913 so far the hotel fire rate has been one every thirty hours. It is stated that eighty-five per cent. of the fires occur between six o'clock p.m. and six a.m.; almost fifty per cent. between midnight and three a.m.; twenty-five per cent. between three a.m. and six a.m., and fifteen per cent. between 9 p.m. and midnight. Hotel fires, it says, were more frequent in 1912 than any of the preceding five years, and so far the increase for 1913 has kept up. The statement is also made that for a period of five years the property loss is estimated at more than $25,000,000, with heavy loss of life.

CANADIAN FORESTRY ASSOCIATION.

The fifteenth annual convention of the Association will be held in Winnipeg, July 7th, 8th and 9th, 1913.

This meeting should be of vital interest to all Canadians who are interested in the conservation of Canada's natural forest resources. Canada's forest area is about 800,000,000 acres, containing some six hundred billion board feet of merchantable timber, worth in the neighborhood of ten billion dollars. But Canadians are cutting this timber at a rate of about 100 board feet per acre, or eight billion board feet per year; the fire loss is estimated to be 950 board feet per acre per annum, which means that these fires are destroying young growth, forest litter and soil fertility on hundreds of thousands of acres That there is a crisis coming is apparent to all—when the forests which for a century men have thought inexhaustible are going to be greatly depleted.

This emergency must be prepared for by stopping the waste in logging, milling and utilization, the destruction of timber by insects and fungus, and protecting the forests from fire. At present Canada spends much less than one cent. per acre per annum on the forest lands under management, and only a fraction of this absolute forest area is growing trees as it might be, the rest being comparatively unproductive. How can Canadians stop the losses, arrest the waste? There is but one answer. Public opinion, public interest, and public conscience are the only forces that will ever make for progress. At the convention a number of practical papers will be read and discussed of problems relating to the great central part of Canada. These will include that of protection and perpetuation of the forests of Western Ontario, and of northern Manitoba, Saskatchewan and Alberta; the best methods of handling prairie forest reserves, and the possibilities of the same in supplying timber, fence posts, poles and cordwood for the settlers; the need of getting under timber the sand lands, which will never produce any other profitable crop but trees, and the rate of growth in the central parts of Canada as a basis for deciding the possibility of economical forestry under these conditions. These will be accompanied by the discussion of the value of forests as windbreaks, sources of stream supply, and as cover for insectivorous birds. Farm forestry, shelter belts to protect buildings and orchards, and the use of hedges will be discussed, as will also the dangers from insects and how these may be dealt with.

COAST TO COAST.

Victoria, B.C.—If plans which a joint committee of the Victoria and Saanich councils are considering are carried out, a magnificent highway along Shelbourne St. to Mount Douglas Park will be constructed. The thoroughfare undoubtedly would be one of the best in the city, and by connecting the city with one of the finest spots in this section would prove an attractive addition to the already numerous beauty spots of which the city and adjoining territory boast. Plans of the proposed improvement have been under preparation for some time and were submitted at a joint meeting of representatives of the two councils. These plans show a roadway leading from Bay Street out to and around Mount Douglas, the entire length being approximately three miles. To fully improve this roadway by constructing sidewalks, boulevards, pave an eighteen-foot roadway on either side with a double tramway line in the centre would, it is estimated, cost in the neighborhood of $240,000. To construct only the pavement portion at present would cost approximately $150,000. The city has for some time been contemplating improvements to the Mount Douglas Park. The location is remarkable for its natural beauty and the magnificence of the view to be obtained therefrom. With a thoroughfare such as is suggested Shelbourne Street would be made the connecting link between the city and the park, and the attractions for visitors would be greatly increased. To raise the necessary funds the city and Saanich would have to take the money from general revenue or submit by-laws to their respective ratepayers. But until it is ascertained to just what extent the Government is prepared to go, the financial aspect of the matter will be allowed to stand.

Winnipeg, Man.—The city of Winnipeg has under consideration the expenditure of $14,000,000 towards bringing a supply of 25,000,000 gallons of water per day from Shoal Lake. The estimate is based upon two pipe lines, the first of which would require four years in building. The construction of the second, requiring a time of like duration, would be proceeded with upon completion of the first and would be, generally speaking, an auxiliary line. A gravity system will be used. City Engineer Ruttan submitted an alternative estimate on a combined gravity and pumping system which would cost in the neighborhood of $11,500,000 for construction, but would entail an annual expenditure for maintenance exceeding the gravity system alone by approximately $168,000.

Quebec, Que.—A new electric water-leak alarm is being installed on ocean vessels. It includes a series of small iron boxes screwed at several different heights to the bulkhead of each compartment. Each box has an electric device connected to a convenient indicator-board, which is fitted with small glow-lamps of different colors, and is in circuit with an electric bell. As water reaches the lowest iron box, electrical contact is made, the lamp corresponding to the lowest level lights up, and the bell rings until switched off. The lamp remains lighted as the water rises to the second box, switching the current to the second lamp, or until the receding water is below the lowest contact, breaking the circuit.

Ottawa, Ont.—The final report of the Bradbury committee on the pollution of navigable streams was tabled by the the chairman, the member for Selkirk, on June 2. The report recommends that the government arrange, during the recess, for a conference of representatives of each of the provinces, of the International Waterways Commission and the chairman, Mr. Bradbury, to discuss the whole problem "with a view to overcoming local difficulties and agreeing upon some form of remedial legislation which could be passed concurrently by the Dominion government and the provincial legislatures." The committee also recommends that it be re-appointed at an early period, next session, with a view to carrying to completion the work now begun. The report states that Dr. Hodgetts, of the Commission on Conservation, has been asked, while in England this summer, to inquire as to the latest methods of sewage disposal in the old country, and to obtain furthur information as to sewage and water conditions.

Toronto, Ont.—The work of opening up the northern territory by the construction of good roads goes on apace. J. F. Whitson, the man who is spending the $5,000,000 granted for the development of New Ontario, points out his progress in a recent report to Hon. W. H. Hearst, minister of lands, forests and mines. Gangs of several hundred men are scattered through the north laying out highways. Great progress is being made, especially in the Rainy River district. "Six camps on road construction have already been established in the Rainy River country employing 80 men, and within the next week or two, 100 to 125 men will be at work in this district," says Mr. Whitson. "By the end of June this number will be doubled." A very large section of land, which is badly in need of additional roads, will be opened up for settlement this year. Road making in Rainy River is very easy compared with other districts. Roads can be made at a reasonable cost as a result of the fires which swept over the country in 1894 and three years ago. A few camps will be started soon in Thunder Bay. Four camps have already been established in Sudbury, and a large force of men is at work. Work in Nipissing is well under way with about 100 men employed. In Timiskaming a number of camps have been started between Englehart and Matheson, and between Matheson and Cochrane.

Montreal, Que.—W. G. Ross, president of the Harbor Commissioners, and M. P. Fennell, secretary of the Board, left Montreal last week to visit the numerous lake ports, where they will go carefully into the grain handling facilities on the Great Lakes. The party will visit Fort William, Port Arthur, Duluth, Tiffin, Port McNicoll and other ports where grain is handled in large quantities. Messrs. Ross and Fennell will also interview the larger grain exporters of Western Canada with a view to having them ship their grain through Canadian ports and especially through the port of Montreal, in preference to the American ports which are now enjoying a large part of the Canadian business. It is expected that as a result of this trip, a large portion of the business now going through American ports will be diverted to Canadian channels, as the only reason local officials can give for this business going to the United States is that the people of the West are not familiar with the facilities which the Canadian ports offer.

Moose Jaw, Sask.—Official announcement was made recently by Hon. Robert Rogers, Minister of Public Works at Ottawa, that the Government had decided to erect two interior storage terminal elevators at Moose Jaw and Saskatoon, to have a capacity of three to four million bushels each and to cost in the neighborhood of a million dollars. The locations for the elevators for Alberta have not yet been decided upon but in all probability the first will be at Calgary. In addition to these interior storage elevators the Government has decided to erect a big transfer elevator on the Pacific coast, which will be owned and operated by the Government in order to handle the grain business which it is expected will flow west by the Pacific when the Panama Canal is opened. A Government-owned terminal elevator of large capacity will also be built at Port Nelson to handle the wheat which will go north by the Hudson Bay route and this will be ready by the time the line reaches the seaboard. There has been provided in the supplementary estimates four million dollars so that work can be proceeded with at once. Orders have already been given to the Grain Commission, under whose supervision the new elevators will be built, to proceed at once with work on the Moose Jaw and Saskatoon elevators. Both these cities have offered free sites and it is likely the offers will be accepted. The Commission will select the sites at once. The new elevators will be thoroughly modern in every respect, will have full inspection equipment and also hospital equipment for the drying of grains. They will have a capacity of three to four million bushels and will cost in the neighborhood of a million each. As soon as locations are settled in Alberta, work will be started there also. The commission will, it is expected, visit the Coast this summer and make arrangements for the new Pacific Coast elevators. The building of these elevators, it is believed, will do much to solve the difficulties of the annual blockade and transportation problem which faces the western farmer yearly. Hon. Robert Rogers has been particularly interested in this question and has given a great deal of attention to the subject and that the Government is going ahead with the scheme on a large scale is due to the efforts of the Minister of Public Works.

St. Catharines, Ont.—With an expenditure of $50,000,000 planned for the next five years in the deepening of the Welland Canal, there will be an activity in the counties through which this waterway passes that will in some respects rival the work on the big canal across the Isthmus of Panama. Tenders are being called for the construction of the first sections of the work, beginning at the Lake Ontario end. The route to be followed has been settled definitely. It is to follow the Valley of Ten Mile Creek from Lake Ontario, crossing the present canal below lock No. 11 at the level which now exists there, the rise having been effected by three isolated locks with suitable pondage areas intervening. This level is carried through to the foot of the escapement below Thorold, which is overcome by three locks in flight and a single lock on the upper level, in the town of Thorold. Beyond Thorold the level of low water in Lake Erie will be held to Port Colborne, the present canal route being generally followed except between Port Robinson and Welland River. It is proposed to utilize the Welland River and at a point near Humberstone where the present sharp bend will be done away with by a cut-off. The guard lock will be built in this cut-off and will be utilized to protect the canal from the high water of Lake Erie. How great an improvement the new canal will be over the old may be gauged from the fact that instead of 27 locks, as at present, there will be but seven. The scheme is to build the locks 800 feet long by 80 feet wide, with capacity for 30-foot draft, though the canal will not at present be built with a draft of that amount. The reason of this is that the Soo has not yet the 30-foot draft. When it has the Welland will be deepened, but the same locks used. One of the questions that had to be met in planning the new canal was how the Welland River would be crossed by the canal at the town of Welland. On this point Hon. Mr. Cochrane stated to the House that the engineers recommend turning the river into the canal. The minister expressed the opinion that to do this would mean a saving of money and the towns would be helped out, too, by bringing the water supply from the lake. There will be no final dedecision, it is understood, until the towns have been heard from. These towns are Welland, Thorold, Merritton and St. Catharines. The conference to be held with them by the Government will settle the proportionate part of the cost which each of these municipalities should pay to secure fresh water from Lake Erie in the construction of the large pipe line contemplated.

Montreal, Que.—City Engineer Janin has submitted his report to the Board of Control on the measures necessary for the improvement of conditions in Montreal's street car service. This marks the first step toward the betterment of conditions. Mr. Janin's report contains the following important suggestions: The elimination of all unnecessary stops; the placing of switchmen at every important junction point; teaching passengers to have their fares ready; the installation of larger and clearer signs on cars; the relief of congestion in the rear part of cars; the prohibition of the hauling of freight in day time; better supervision of traffic at junction points; doing away with delays at the central office; the prevention of "short-turning" of cars at the option of the conductor; the installation of autobus lines to supplement the tram-cars. Mr. Janin, in his report, has made no recommendations which will entail any large expenditure either by the Tramways Company or the city, and his report cannot be taken as a final solution of the street car problem.

PERSONAL.

D. ROSS, B.A.Sc., is assistant to Mr. Malm, electrical and traction engineer, Toronto Railway Company.

MR. J. E. RITCHIE, B.A.Sc., has accepted a position with the Toronto Iron Works, Toronto, as designing engineer.

CHARLES H. CLAPP, of the Canadian Geological Survey will become a member of the School of Mines faculty at the University of Arizona at the beginning of the next year.

MR. H. H. COUZENS, the new manager of the Toronto Hydro-Electric System, arrived from England last week, but will not take actual charge of the system till July 1st.

MR. L. W. RUNDLETT, at present city commissioner of Moose Jaw, Sask., has been appointed city engineer. This position will be in conjunction with that of city commissioner.

MR. NORMAN K. HAY has been appointed city engineer of Sydney, N.S., to succeed Mr. Campbell. Mr. Hay has been construction engineer with the Dominion Iron and Steel Company.

MESSRS. P. W. ST. GEORGE, J. A. JAMIESON and F. A. BARBOUR have been appointed by the city council of Montreal to report on the nature of the site selected for the filtration plant.

T. KENNARD THOMSON, consulting engineer, of New York City, was in Toronto on Friday last. He attended the commencement ceremonies of the University in Convocation Hall and received the degree of Doctor of Science (Honoris Causa).

S. A. WOOKEY, H. M. STEVEN and V. H. EMERY are directors of the Dominion Mineral Exploration Syndicate, with main offices in Kingston, Ont. Mr. Wookey is field engineer. All three are graduates in mining engineering of the University of Toronto.

HON. THOMAS TAYLOR, Minister of Public Works for the province of British Columbia, has been appointed to represent the Government of British Columbia at the annual meeting of the International Good Roads Congress, which commences June 23 in London, Eng.

MR. JOHN SPROAT, for 35 years road superintendent of Delta, has retired from that position. At a recent banquet which Premier McBride attended Mr. S. A. Fletcher, government agent, pointed out the fact that during his long career Mr. Sproat had built and located 800 miles of road, 300 miles of trails, and 300 bridges.

OBITUARY.

MR. JOHN BRECKENRIDGE died at Calgary, Alta., at the age of 52 years. Deceased was born in Ayrshire, Scotland, in 1861, and removed to Peterborough, Ont., in 1867, where he received his education. He was one of the best known and most successful contractors in Canada, having had charge of many important undertakings, notably the C.P.R. irrigation system in that province, which took five years to complete. His firm has also had charge of the C.N.R. construction from Edmonton, Alta., west through Yellowhead Pass to Port Mann. In addition he was connected with many large industrial, mining and other enterprises.

COMING MEETINGS.

CANADIAN ELECTRICAL ASSOCIATION.—Annual Convention will be held in Fort William, June 23, 24 and 25. Secretary, C. E. Bawden, Birkbeck Bld., Toronto.

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

THE INTERNATIONAL GEOLOGICAL CONGRESS.—The Twelfth Annual Meeting to be held in Canada during July and August. Opening day of the Toronto Session, Thursday, August 7th. Secretary, W. S. Lecky, Victoria Memoriam Museum, Ottawa

THE INTERNATIONAL ENGINEERING CONGRESS.—Convention will be held in San Francisco in connection with the International Exposition, 1915.

NATIONAL ASSOCIATION OF CEMENT USERS.—Tenth Annual Convention to be held at Chicago, Ill., Feb. 16-20, 1914. Secretary, E. E. Kraus, Harrison Bld., Philadelphia, Pa.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—176 Mansfield Avenue, Montreal. President, Phelps Johnson; Secretary, Professor C. H. McLeod.

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

MANITOBA BRANCH.—Chairman, J. A. Hesketh; Secretary, E. E. Brydone-Jack, 83 Canada Life Building, Winnipeg. Regular meetings on first Thursday of every month from November to April.

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

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

TORONTO BRANCH—96 King Street West, Toronto. Chairman, E. A. James; Secretary-Treasurer, A. Garrow. Meets last Thursday of the month at Engineers' Club.

CALGARY BRANCH—Chairman, H. B. Mucklestone; Secretary-Treasurer, P. M. Sauder.

VANCOUVER BRANCH—Chairman, G. E. G. Conway; Secretary-Treasurer, F. Pardo Wilson. Address: 422 Pacific Building, Vancouver, B.C.

VICTORIA BRANCH—Chairman, F. C. Gamble; Secretary, R. W. MacIntyre; Address P.O. Box 1290. Meets 2nd Thursday in each month at Club Rooms, 534 Broughton Street.

MUNICIPAL ASSOCIATIONS

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

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

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

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

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

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

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

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

UNION OF ALBERTA MUNICIPALITIES.—President, F. P. Layton, Mayor of Camrose; Secretary-Treasurer, G. J. Kinnaird, Edmonton, Alta.

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

CANADIAN TECHNICAL SOCIETIES

ALBERTA ASSOCIATION OF ARCHITECTS.—President, R. W. Lines, Edmonton; Hon. Secretary, W. D. Cromarty, Edmonton, Alta.

ALBERTA ASSOCIATION OF LAND SURVEYORS.—President, L. C. Charlesworth, Edmonton; Secretary and Registrar, R. W. Cautley, Edmonton.

ASSOCIATION OF SASKATCHEWAN LAND SURVEYORS.—President, A. C. Garner, Regina; Secretary-Treasurer, H. G. Phillips, Regina.

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

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

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

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

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

CANADIAN CEMENT AND CONCRETE ASSOCIATION.—President, Peter Gillespie, Toronto, Ont.; Secretary-Treasurer, Wm. Snaith, The Thor Iron Works, Toronto, Ont.

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

CANADIAN ELECTRICAL ASSOCIATION.—President, A. A. Dion, Ottawa; Secretary, C. E. Bawden, Birkbeck Bld., Toronto.

CANADIAN FORESTRY ASSOCIATION.—President, Hon. W. A. Charlton, M.P., Toronto; Secretary, James Lawler, Canadian Building, Ottawa.

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

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

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

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

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

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

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

CANADIAN STREET RAILWAY ASSOCIATION.—President, Patrick Dubee, Montreal; Secretary, Acton Burrows, 70 Bond Street, Toronto.

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

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

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

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

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, F. C. Mechin; Corresponding Secretary, A. W. Sime.

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

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

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

INSTITUTION OF MINING AND METALLURGY.—President, Bedford McNeill; Secretary, C. McDermid, London, England, Canadian members of Council:—Prof. J. B. Porter, H. E. T. Haultain and W. N. Miller and Messrs. H. W. Claudet, S. S. Fowler, R. W. Leonard and J. B. Tyrrell.

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

MANITOBA ASSOCIATION OF ARCHITECTS.—President, W. Fingland, Winnipeg; Secretary, R. G. Hanford.

MANITOBA LAND SURVEYORS.—President, J. L. Doupe; Secretary-Treasurer, W. B. Young, Winnipeg, Man.

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

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

ONTARIO ASSOCIATION OF ARCHITECTS.—President C. P. Meredith, Ottawa; Secretary, H. E. Moore, 195 Bloor St. E., Toronto.

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, N. Vermilyea, Belleville; Hon. Secretary-Treasurer, J. E. Farewell, Whitby; Secretary-Treasurer, G. S. Henry, Oriole.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, J. S. Dobie, Thessalon; Secretary, L. V. Rorke, Toronto.

TECHNICAL SOCIETY OF PETERBORO.—Bank of Commerce Building, Peterboro. General Secretary, N. C. Mills, P.O. Box 995, Peterboro, Ont.

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

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

QUEEN'S UNIVERSITY ENGINEERING SOCIETY.—Kingston, Ont. President, W. Dalziel; Secretary, J. C. Cameron.

REGINA ENGINEERING SOCIETY.—President, A. J. McPherson, Regina; Secretary, J. A. Gibson, 2429 Victoria Avenue, Regina.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—President, H. C. Russell, Winnipeg, Man.; Hon. Secretary, Alcide Chausse, No. 5. Beaver Hall Square, Montreal, Que.

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

SOCIETY OF CHEMICAL INDUSTRY.—Wallace P. Cohoe, Chairman, Alfred Burton, Toronto, Secretary.

TECHNOLOGY CLUB OF LOWER CANADA.—President, F. E. Came; Secretary-Treasurer, E. B. Evans. Meets twice yearly.

UNDERGRADUATE SOCIETY OF APPLIED SCIENCE, McGILL UNIVERSITY.—President, W. G. Mitchell; Secretary, H. F. Cole.

WESTERN CANADA IRRIGATION ASSOCIATION.—President, Duncan Marshall, Edmonton, Alta. Permanent Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

WESTERN CANADA RAILWAY CLUB.—President, R. R. Nield; Secretary, W. H. Rosevear, P.O. Box 1707, Winnipeg, Man. Second Monday, except June, July and August at Winnipeg.