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THE APPLICATION OF DIESEL ENGINES TO LAND AND MARINE WORK.

By D. M. BRIGHT.

Introductory.—Within the last decade no prime mover has provoked so much comment as the Diesel engine, and as within the last two years, almost daily reference has been made in regard to its development, it may be of interest to make some particular reference to its early history.

The earliest known internal combustion engine was invented and made by a French Abbé in the year 1682. This engine utilized the energy produced by the explosion of an inflammable powder, but difficulty was experienced in controlling the power. About two hundred years later Rudolf Diesel, a German scientist, after many years of study and experiments on different types of heat engines, formed the opinion that very little improvement in their heat efficiency could result until the principles of working were modified.

Herr Diesel, in order to demonstrate his theories, decided to construct a new type of heat engine to utilize the maximum amount of heat from the fuel used.

In this engine only pure air is drawn into the cylinder and compressed, then the oil fuel is injected into this compressed air in the form of a fine spray and burns gradually as long as the injection is maintained. During the whole cycle the pressure in the cylinder does not rise above the compression pressure, unlike the ordinary gas engine where the combustible charge is drawn into the cylinder, is ignited and burned instantaneously or exploded.

In 1897, after four years of difficult experimental work, Dr. Diesel completed the construction of the first commercially successful motor in the Augsburg Works, and it was announced by the numerous engineering and scientific committees and deputations from various coutries, who tested the machine, that a higher heat efficiency was attained by it than by any other known heat engine. As a result of subsequent experience in practice, and the gradual improvement in the manufacture, still better results have been obtained and at the present time the thermal efficiency the motor attains is up to about 48 per cent., and the effective efficiency in some cases up to 35 per cent.

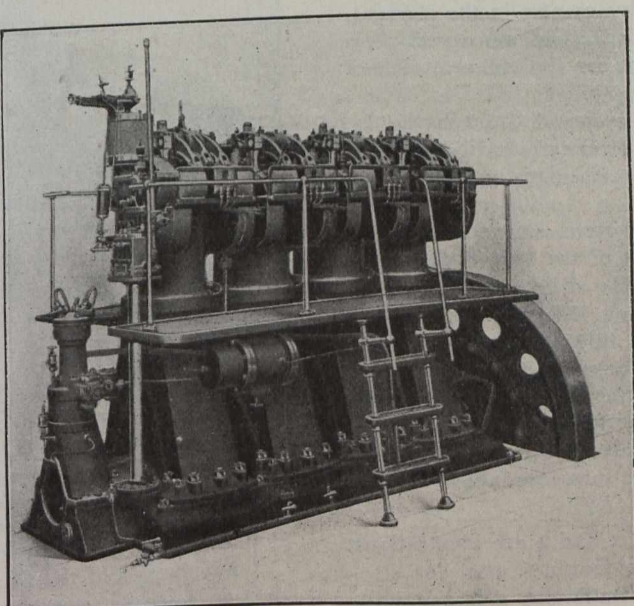


Fig. 1.—Four-Cylinder 200-h.p. Diesel Oil Engine.

The results of this first motor were considered so satisfactory that a large number of engineering firms obtained licenses to build. At the beginning of 1901 twenty-five firms on the Continent, one in the United States, and one in Great Britain were costructing Diesel engines.

General Description.—The engines work on the four- and two-stroke cycle and run according to requirements at low or high speed, and are made in vertical or horizontal types.

Four- (Stroke) Cycle Engines.—(1) In the first downward stroke of the piston air is sucked into the engine cylinder direct from the atmosphere through the main air inlet valve on the top of the cylinder. At the end of this stroke the cylinder is full of pure air at practically atmospheric pressure, ready for the compression stroke.

(2) In the next upward stroke the air is compressed to the required pressure, usually about 500 lbs. per sq. inch, thereby having a temperature of about 1,000 deg. Fahr., all the valves, of course, being closed during this action. As the compression is very approximately adiabatic nearly all the work in it is returned.

(3) During the early portion of the third and working stroke the fuel oil is injected into the cylinder above the piston by a blast of air at a higher pressure than that in the cylinder (about 800 lbs. per sq. in.) through a special form of needle spray valve. Combustion takes place during this period as the temperature of the compressed air in the cylinder is above the burning point of the oil fuel. After cut-off, when the fuel inlet valve closes, combustion continues for a short period, expansion then occurs and work is done on the piston for the rest of the stroke. Just before the piston reaches the end of its stroke the exhaust valve begins to open.

(4) In the final stroke the exhaust valve remains open and the burnt gases are expelled from the cylinder into the exhaust pipe, leaving the cylinder ready to receive a further charge of gas on the next down stroke of the piston, when the cycle of operations begin once more. Fig. 2 shows an indicator card of an actual Diesel engine of this type.

Two- (Stroke) Cycle Engine.—(1) Consider the piston at the end of its stroke in the bottom position. The cylinder is then full of air at nearly atmospheric pressure, and this is compressed during the first or upward stroke of the cycle to the usual top compression pressure of 500 lbs. per sq. in., as in the second stroke of the four-stroke cycle.

(2) During the second stroke, combustion, expansion, expulsion of the burnt gases to the exhaust and the filling of the cylinder with fresh air are the operations which have to be effected. Fuel is sprayed into the cylinder during the early portion of the stroke, through the inlet valve, by compressed air as before. This valve then closes and expansion occurs while the piston passes through about 78% of its stroke, at which point the exhaust valve opens and the products of combustion begin to pass out. Air under pressure of about 4 to 8 lbs. per sq. inch then enters the cylinder through a separate valve or port in the cylinder, being supplied from a so-called scavenge pump, which is quite separate from the air compressor for the provision of fuel injection and starting air supply.

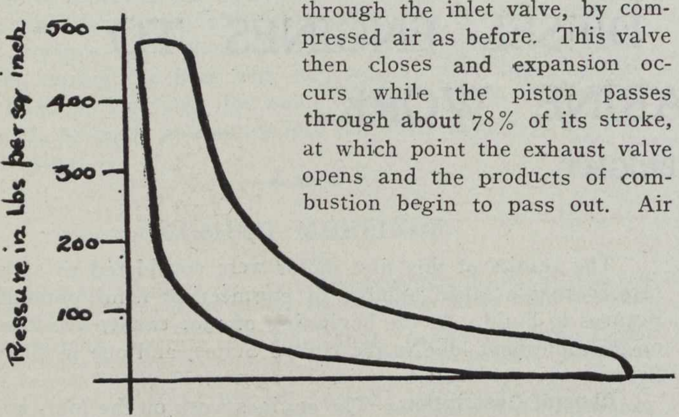


Fig. 2.—Indicator Daigram of Four-Cycle Diesel Engine.

All the exhaust gases are thus forced through the exhaust ports and at the end of the stroke the cylinder is left full of pure air with all the valves closed ready for the first stroke of the next cycle.

The indicator diagram for this cycle, as seen in Fig. 3, does not differ materially from that of the four-stroke cycle, as seen in Fig. 1, the most notable difference being the rapid fall off of pressure to F along E F; also during the process of exhaust the cylinder is filled with air from the scavenge pump. There is no longer a horizontal line representing the entrance of the air at atmospheric pressure, as in the four (stroke) cycle diagrams, since all the air is admitted at a pressure above atmospheric.

Figs. 1 and 4 are illustrations of Diesel engines used for electrical installations and pumping.

The main advantages of the Diesel engine are:—(1) Its extreme economy in fuel consumption over a wide range of load, and the entire absence of stand-by losses. Makers guarantee, on full load, fuel consumption to not exceed .46 lb. of fuel per b.h.p. per hour.

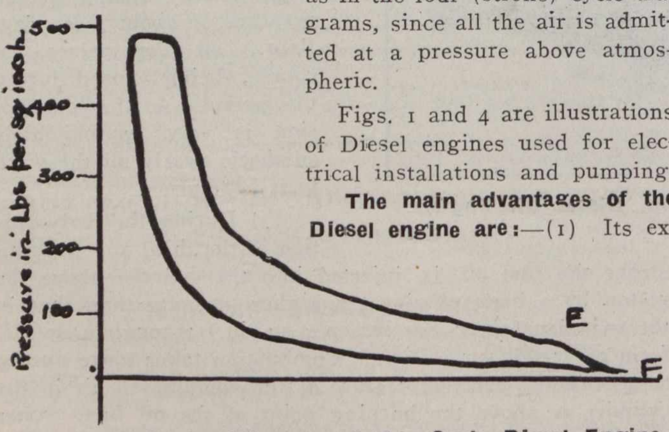


Fig. 3.—Indicator Diagram of Two-Cycle Diesel Engine.

(2) Its ability to use a safe, cheap, compact form of fuel, in the shape of high flash-point residual oils, obtainable in large quantities all over the world.

(3) Its freedom from pre-ignition, due to the fact that air only is compressed and not a mixture, thus eliminating a not infrequent cause of breakdown in other forms of internal combustion engines.

(4) No carburetters, vaporizers or troublesome ignition devices are requied on the Diesel.

(5) The engine can be started up from cold and put on load in one minute, and is ready for any load up to its full capacity at any moment.

(6) Lastly, one of its most important features is its great reliability, even when running for long periods with variable conditions of load.

Application of Diesel Engines to Marine Work.—A marine engine must, before everything, be absolutely reliable, and with the present perfection of the steam engine, as a result of close on a century's practical experience, it is easy from this to see that the Diesel engine had to stand a long, severe trial during its progress up to the present before it could be seriously considered as a motor for marine work. After some eighteen years, during which the engine has proved its excellence for stationary work, with a reliability equal to the best steam engine and excelling all others, it may be said to have proved its worth beyond question. Of course, marine practice is in many ways different to stationary working. Marine engineers are naturally a little apt to exaggerate this point, still, there is no doubt that the conditions of service at sea are in general much more severe than on land. That over 400 vessels at present equipped with Diesel engines, many of these running for years, and the many that are being built is proof that there will be many such vessels in the future.

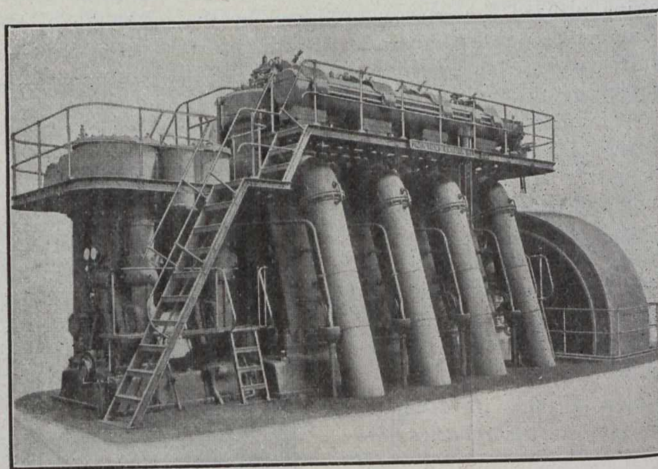


Fig. 4.—Four-Cylinder Two-Cycle 2,400 b.h.p. Engine.

Advantages of the Diesel for marine work are:—(1) Reduction in fuel cost over steam or other known engines.

(2) Reduction in weight of fuel carried for same power giving greater cargo space.

(3) The Diesel engine is relatively much more efficient than any steam engine in fuel consumption at low speed. This fact is of particular importance for vessels which run most of the time much below their full power and speed, such as war vessels, trawlers, coasting boats and boats on internal waterways.

(4) There are no stand-by losses, which may be an important point worth consideration when ships make frequent calls at ports.

(5) Fuel can be stored almost any place in vessel.

(6) Economy of space, and economy in weight of Diesel engines as compared with steam engines and accessories weigh on an average one ton to every 5 to 8 i.h.p. Diesel engines and accessories of slow speed type, that is, under 200 revolutions per minute, weigh one ton to every 10 to 15 b.h.p. For high speed types it is as much as 25 b.h.p. per ton.

(7) The reduction in staff, as no stokers are required.

Taking all the economies effected in weight of fuel, weight of machinery and engine-room space it may be safely estimated that the extra cargo which could be carried would be about 15% of the displacement of the vessel.

A comparative estimate has been made, showing that in a vessel of about 5,000 tons the net saving between Diesel engines and steam worked out over $5,500 per annum.

When a Diesel engine is installed in a vessel, the lines of vessel may be finer than if a similar powered steam engine were installed, still the most suitable speed of Diesel engines is, generally speaking, more than the most economical propeller speed. However, these two considerations about balance each other.

The ease and cleanliness in handling oil, as compared with coal, is another important point.

All the operations of the engine are under the eye of the engineer in the engine-room.

The absence of smoke is also noteworthy.

The initial cost of a Diesel plant is from 15 to 20% more expensive than a steam installation, including all auxiliaries in both cases, but it is to be emphasized that price-cutting would be a fallacy if the perfection of construction is to be maintained.

The Diesel engine can be used directly reversible or geared to propeller shaft.

There is a type of engine called the Semi-Diesel engine being used largely on cargo boats, barges and lake boats. This is an extremely simple engine, very reliable for class of boats stated above.

This engine compresses air alone and uses crude oil as a fuel. It operates on the two-cycle with crank chamber air compression. (See Fig. 6).

Air is drawn into the crank-case on the up-stroke of the piston through flap valves (B) on the side of crank case (C). This air enters the working cylinder (D) at the end of the

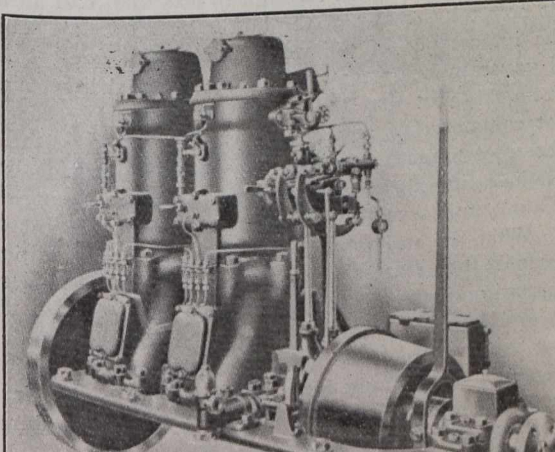


Fig. 5.—Direct Reversible Marine Engine.

down-stroke at (I), just after the expulsion of the exhaust at (G) from the previous power stroke. On the return of the piston this air is compressed still further to about 125 lbs. per sq. in. into a "hot bulb" (E) on the cylinder head. The charge of oil is then injected through (F) at the moment of maximum compression. The heat of the bulb automatically fires the mixture. This bulb is heated by a blow lamp for a few minutes before starting up.

It is one of the simplest and most reliable types of engines and shows almost equal economy of fuel. Initial cost is much cheaper for smaller powers than the Diesel.

Comparative Tables of Running Costs.
(Actual Log Book Figures).

Cents, per kilowatt hour generated.

Item.	Steam.	Producer Gas.	Diesel.
Fuel	1.78	1.74	0.60
Oil, waste, water, stores	0.24	0.38	0.06
Men's wages	0.64	1.36	0.34
Repairs and maintenance	0.74	1.60	0.16
Total operating costs per kw. hour generated	3.40	5.08	1.16

Load factor 12.45%, 16%, 14%.

The Birmingham Electric Tramways (England) show total operating costs in cents per kilowatt generated at switch-board to be .74 cents.

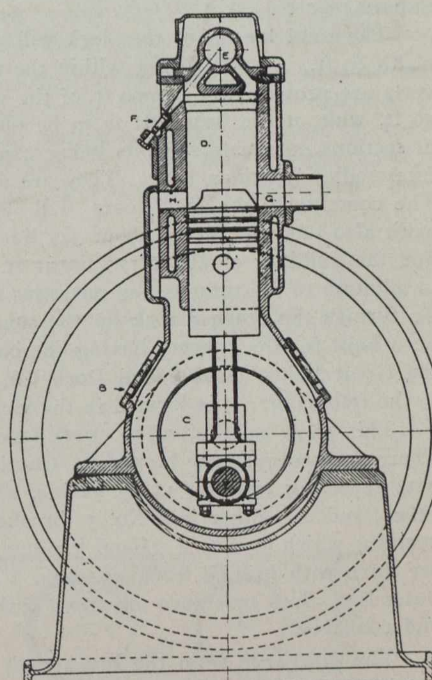


Fig. 6.—Section Through Direct Reversible Marine Engine.

The Diesel engine should be of special interest to Canadians, as its fuel is more prevalent in Canada and easier to transport than coal. Value of crude oil at the oil fields is about $3.50 per ton. These are the so-called residual oils which are obtained by the distillation of the oil from the well, the lighter bodied oils, benzene and lighting petroleum coming over first and leaving a residual oil. Its specific gravity is about .87, and owing to its high flash point is quite unsuited for lamp oil. There are certain other oils which have been used on Diesel engines, and in particular cases may prove of great value. A Diesel engine has been working on ordinary coal tar as a fuel, so one can readily see that there are many liquid fuels available.

ELECTRIFICATION OF MELBOURNE SUBURBAN RAILWAYS.

Offers of a representative character, from the leading firms throughout the world engaged in the manufacture and supply of electrical machinery and equipment, are now receiving the attention of the government of Victoria, Australia, in view of the conversion of the Melbourne suburban railways from steam to electric traction. While no figures have yet been disclosed, it has been announced that the competition amongst the tenders has been very keen. The offers give the option of adopting either the single phase alternating current or the direct current system. This proposed change in traction will involve a huge expenditure in a suburban railway system which (excluding the extensive cable tramway service also in operation) carried 96,163,296 passengers last year. A leading English eletrical engineer is now in Melbourne for a limited period for the purpose of giving expert advice to the government.

THE NEW LOCK AT THE SOO.

Coincident with the construction of large permanent steel ore docks at Lake Superior shipping ports, capable of accommodating the mammoth carriers recently built, provision is being made to facilitate the passage of such vessels through the channel at Sault Ste. Marie, where the existing locks are proving inadequate to the service. The principal work now in progress there is the building of the new Davis lock, recently described in the Mining and Engineering World, which was begun in March, 1907, and will not be completed until 1916.

Next to the Panama canal this is the most important aid to navigation now being carried out by the federal government; and it is due entirely to shipments of ore from Lake Superior ports.

The total length of the lock will be 1,715 ft. and its width 80 ft., 1,350 ft. being within the inner gates. Six culverts are provided for; 1,200 ft. of the wall is 50 ft. high and 26 ft. wide at the base. It is to be built up from bed rock in sections, alternate sections being constructed first and the intermediate sections later. They are 25 to 35 ft. in length. The concrete of the lock floors will be 1½ ft. thick. The work also includes lining about 325 linear ft. of tunnel rock, and the building of about 170 linear ft. of tunnel in trench, in addition to the tunnels and passages through the masonry. To furnish the crushed rock for the concrete work there has been built for the concern having the complete contract, viz., the Great Lakes Dredge and Dock Co., the plant described in the following. It is located in the vicinity of the new lock.

This plant is designed to crush Lake Superior trap rock. There are two gyratory breakers. One is a No. 7½ machine, with receiving opening 14 by 52 ins. set to crush to 3½-in. cubes, and the other is a No. 5 breaker with 10 by 38-in. opening which makes a 2½-in. product. Their foundations are flush with ground level, or about 8 ft. above the normal water line. Both machines are fitted with manganese mantles and concaves.

The discharge from the breakers is taken by a No. 7½ continuous bucket elevator, with centres 68½ ft. apart, and discharged to a 48-in. by 16-ft. iron-frame, revolving screen. From this the oversize rejections are returned through a spout to the No. 5 breaker, while the screen product falls to a storage bin, of heavy-timber construction, set 12 ft. above the rails of the 36-in. gauge loading track. This bin is 16 ft. wide, 48 ft. long and 21 ft. deep, with steel-rod reinforcement, and suitable discharge gates in the bottom.

There are also provided two troughing-belt conveyers, each 16 ins. wide with 100 ft. centres, suspended on light wooden trestles, which have ⅛-in. rubber covering on their carrying surfaces. To these the excess stone can be diverted, as required, and borne to two stock piles, 60 ft. high, and having centres 120 ft. apart. By means of a timber-frame work, like that of a mine shaft, a tunnel, with gates at the top, is made to extend through the piles, enabling cars to be readily run under the gates and loaded. The tunnel tracks are parallel with those under the bin.

The entire plant is electrically operated on alternating-current, 3-phase, 60-cycle, 240-volts. Induction motors have been installed as follows: 75 h.p., 690 r.p.m., for driving the No. 7½ breaker; 30 h.p., 860 r.p.m. on the No. 5 breaker, 40 h.p., 860 r.p.m. for the elevator and revolving screen, and two 5 h.p., 1,150 r.p.m., each of which operates one of the belt conveyers. These motors are so placed as to secure for the plant the benefit of the most efficient belt drives, and they are protected from the elements and flying dust by suitable roofing and siding, which also permits free ventilation.

The unusual dimensions of the lock are made necessary, both by the ever increasing traffic on the lakes, and by improvements that have been found necessary in the operation of the two locks now there. The length in use will not only be utilized in handling longer boats, as they are built from year to year, but it also will make possible the entry of two of the longer craft in tandem style, a practice never yet indulged in.

At present the two or more boats often passing the locks together are locked through abreast of each other. Vessel owners and masters declare this is a dangerous proceeding. The boats, they say, not only require more time to take their positions in the locks in this way, but also that there is great danger from suction to the boat remaining in the lock when the first one steams away.

On more than one occasion lines have snapped and boats have drifted temporarily in a helpless manner in the locks.

The present largest lock, the Poe, is 100 ft. wide. The new one will measure but 80 ft., making it impossible to lock vessels through in any other way than tandem.

Probably the most distinctive feature of the new lock will be its depth. When opened for navigation it will present a loading depth of 24½ ft., or 6½ ft. more than the present depth accorded the boats of the great lakes. While all channels on the lakes are now dredged to a depth of but 21 ft., experts declare it will prove of less expense to dredge the channels deeper than to construct or remodel other locks.

The practical value of the depth presented by the present locks, an average of 18 ft. is displayed in the trouble the larger boats experience in locking through. Unnecessary delay is now experienced by the masters in locking through by the upheaval of water at the bow of the boat. Such conditions, engineers say, are due to the excess of water caused by the entrance of the boat to the lock being unable to escape fast enough at the sides of the boat. With the additional depth presented by the new lock, this water, it is figured, will be forced under the boat to the escaping channels beneath the flooring. With such facilities at hand vessels will be able to lock through in less than half an hour, while it now takes many of the larger ones over an hour.

The importance of the work now being done by the federal government on the new locks and canal here, may be seen from the fact that the present locks already float the greatest commerce of any inland waters of the globe. In 1911 the total tonnage amounted to 62,000,218, which is two and one-half times greater than that passing through the Suez Canal, and seven times greater than that of the Kiel Canal. What the traffic will amount to with the addition of another lock, the greatest yet constructed, remains to be seen.

The present commerce exceeds that borne by all ships, British and foreign, entering the ports of Great Britain in one year, and valued at an average of $654,010,844 annually. When completed the new lock will not only be by far the largest in the world, but will represent an expenditure of about $9,000,000.

PATRICIA LAND.

Mr. J. B. Tyrrell, who led the Government expedition to the Hudson Bay through the new district of Patricia, has returned to Toronto and commenced the preparation of his report to the proper authorities.

According to him, there is a larger area of tillable land in this section than was at first supposed, and he is confident that the bog lands are so situated that their drainage is a simple problem. The best land in Patricia is forest covered, and other large stretches resemble Temiskaming, rocky ridges, in which hardly a clear acre of good soil may be found, alternate with large sections of promising land. Mr. Tyrrell states that this portion of the Dominion will some day be a sportsman's paradise, as the swamps teem with flocks of wild ducks and the rivers abound with fish.

TEN THOUSAND HORSE-POWER HIGH-PRESSURE TURBINES FOR THE BIASCHINA ELECTRIC POWER STATION.

The Biaschina electric power station near Bodio, Northern Italy, built by the A. G. Motor, utilizes the water of the River Tessin, with its tributaries, with a total head, between the Gotthard Railway stations of Lavorgo and Bodio, of 840 feet.

The water intake is located 500 feet down the valley from Lavorgo Station, on the right bank of the River Tessin, where the water is diverted by means of an overflow weir, built slantingly across the river. The water is then conducted to a special filtration reservoir, where it is cleared of any deposits of sand or other impurities; from here a closed canal of about 5½ miles length takes the water to the forebay, from which the water is led to the four turbines, each consuming at a head of 840 feet about 138 c.f.s.

The upper portion of the feeder conduit is in the form of a pressure tunnel, which at the point where the pressure reaches 260 lbs. per sq. in. is connected up to two separate steel pipe lines of about 67-in., inner diameter.

operated gate-valves of 24-in. diameter are located inside the power-house, near the wall. These valves may be opened or closed from the machine house floor by a hand-wheel controlling an intermediate distributing valve, which directs the pressure water to the servomotor, or pressure cylinder, accordingly. In front of each valve an expansion piece is fitted in order that, in case of repairs, the valve may be quickly and safely removed.

The total power of 12,000 horse-power is developed by only one single runner wheel fitted with double pear-shaped buckets of cast-steel mounted around the circumference of the wheel. The water is discharged under full pressure of 840 feet through four needle nozzles, forming a circular solid jet, which again impinges upon the buckets of the runner. The nozzles from which the water is escaping with a velocity of 220 feet per second are most carefully designed and supported in such a way that the forces originating from the reaction of the water cause least possible vibration.

The governing mechanism for controlling units of this large capacity requires to be designed most carefully in order to safeguard the operation of the machines in cases of sudden changes of load. For this plant Escher Wyss & Co.'s patent Universal oil-pressure governors have been

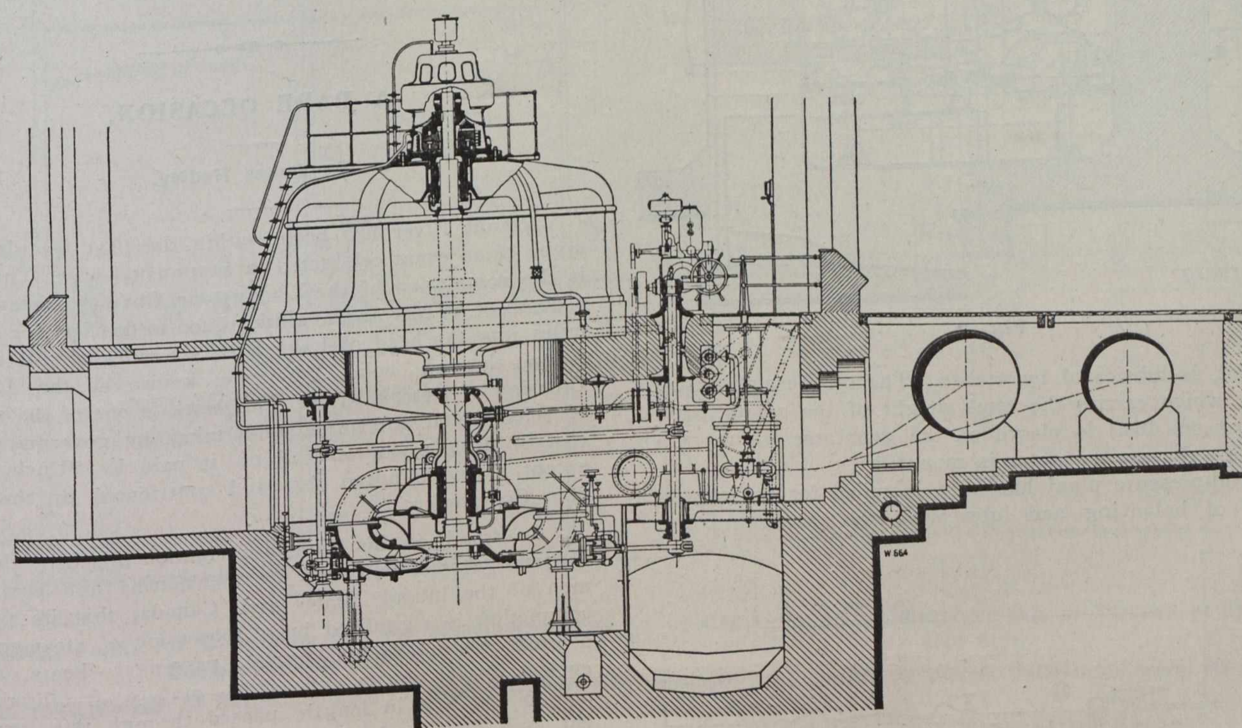


Fig. 1—Longitudinal Section through 10,000 H.P. High-pressure Turbines.

Each of the two pipe lines delivers the necessary amount of water required by two high-pressure impulse wheels, each capable of developing an output of 10,000 horse-power when running at 300 revolutions per minute. However, in accordance with the specifications, each of the wheels is designed so as to yield a maximum power, at full opening, of 12,000 horse-power.

For various reasons the vertical shaft arrangement was given the preference over the horizontal type, following recommendations made by Escher Wyss & Co., as similar turbines running on a vertical shaft designed and constructed by the same firm had given great satisfaction. The accompanying cuts show the general design of this type of turbine. The initial installation consists of three units with a total maximum output of 36,000 horse-power.

The two inlet pipes for each turbine are arranged symmetrically to the turbine axis, and are connected to the main pipe lines at an angle of 90°. The hydraulically

installed. Their oil-pressure pumps and speed pressure and speed pendulum are driven by belts off a transmission shaft situated underneath the power-house floor. The governor is usually operated by pressure oil, but each governor is also provided with a hand-wheel, so that the whole unit may be temporarily controlled by hand. The servomotor of the governor operates the vertical main regulating shaft, which latter, by means of a system of levers and rods, is connected up to the needle nozzles; the regulating needles are consequently controlled directly by the governor. These needles are so designed that they, in any position, are practically balanced, so that the capacity of the governor might be reduced, and also a most even working of same is obtained. The various pins and joints are provided with bearings on both ends, designed for grease lubrication, so that the wear and friction is reduced to a minimum. From the servomotor each nozzle can be adjusted according to the load under which it is to work, and it is also possible, if necessary, to entirely close two or more of the nozzles of each unit.

All bearings, not only those of the main shaft, but also those of the transmission gear and regulation shafts, are fitted with removable babbitted bearing bushes. The shafts are provided with continuous ring oil lubrication, except that the governing shaft, the movement of which

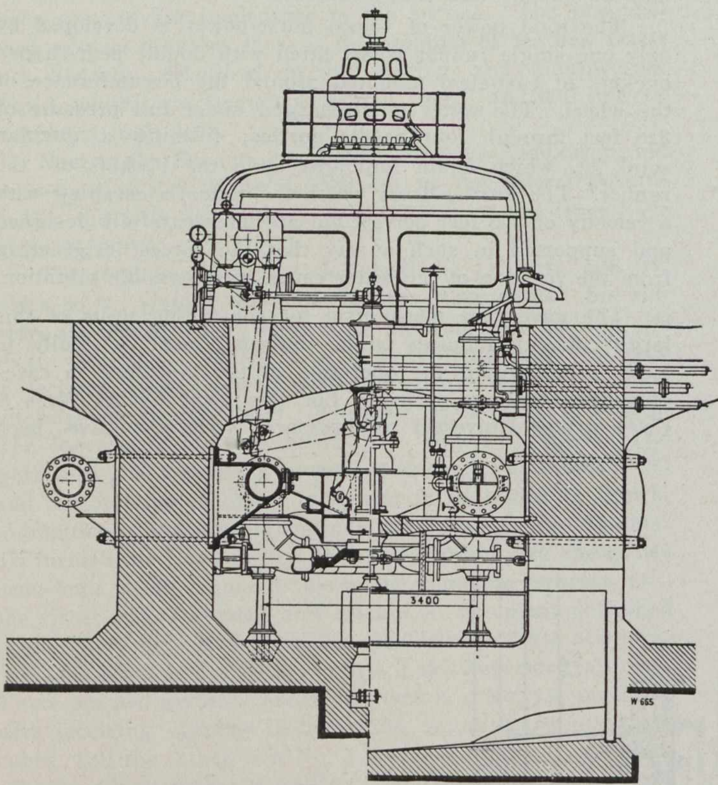


Fig. 2.

is limited, is lubricated by grease. The oil-pressure thrust bearing, which carries the total weight of the rotary parts (about 100,000 lbs.) is placed on the generator frame. On top of this the exciter stator is mounted.

An oil-pressure plant has been installed for the special purpose of balancing and lubricating the thrust bearing.

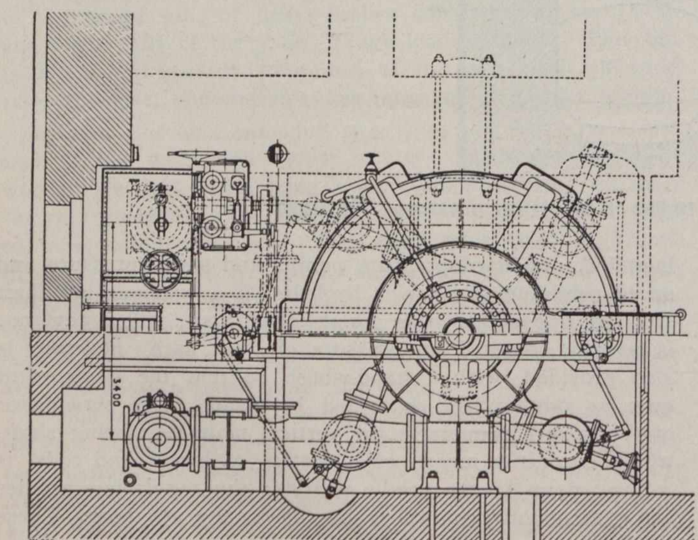


Fig. 3.

As the maintenance of continuous service depends chiefly upon the proper working of this bearing, the oil plant has been most carefully studied and designed accordingly. The oil-pressure piping is arranged in accordance with the so-called "ring system," whereby it is possible to disconnect any one of the four units without having to stop any of the other machines. There art two pumps, of which one always is kept in reserve. Both are of the Escher Wyss & Co. type, and each is driven by gear from a separate impulse wheel of about 30 horse-power. In the basement, immediately beneath the pumps, two oil reservoirs with a capacity of about 1,750 gallons have been provided. The two reservoirs are so connected one to the other that it is possible for any pump to take oil from either of the reservoirs. Each pump is also fitted with an air-chamber; the air for the latter is furnished by the sniffing cock, which is mounted on the air-chamber so that the oil may not be mixed with the air.

In order to be able to undertake repairs in the turbine pits also without having to shut down the whole plant, arrangements have been made so as to separate the various chambers by water-tight partitions. For emptying these chambers, each has been fitted with an injector with which it is possible to drain about 2,200 gallons of water per hour. The necessary pressure water for this purpose is tapped from the pressure pipe line, and in such a way that should one or the other pressure pipe line not be working, any of the chambers can still be emptied.

A RARE OCCASION.

By James Hedley.

Detroit River has been, within the past few days, the scene of an event celebrated in an unusual way. This event is the completion of the Livingstone Channel, excavated to a depth of 23 feet and a width of 400 to 600 feet for thirteen miles into the head of Lake Erie, six miles of this distance being through solid limestone, known as the Limekiln Crossing of Detroit River. This work is one of the wonders of science and enterprise, undertaken by government at a cost of $10,000,000, and all of it paid by "Uncle Sam" except a few hundred thousand contributed by the Canadian Government.

So greatly is this boon to navigation prized by the Lake Carriers' Association and by the marine and commercial men of the inland States and Canada, that its practical completion is signalized by a procession of steamers upon a great scale. Yachts, ferries, passenger boats, revenue cutters, motor boats and great, modern freighters, from 400 to 600 feet in length, passed through this enormous cut, first downward with the current, then back to Detroit, 22 miles, to the accompaniment of flags, bands, siren whistles and the shouts of thousands of spectators, assembled from the lake cities. One steamer, the "Britannia," carried 1,700 guests. The great steel steamer, "William Livingstone," appropriately named, as the channel is, after the president of the association—an indomitable pioneer in the modern improvement of the Great Lakes waterways, headed the procession.

Work was begun on this important achievement in the spring of 1908, when the contractors began the huge cofferdam, which enclosed what is known as the dry-work section, about a mile of the river bed near the upper end of the rock cut. Actual channel digging was begun in the fall of the same year, after powerful steam pumps had drained that part of the river bed enclosed by the dyke. Of the four contracts let, Nos. 1 and 2 were to Chicago parties. Section 3, about 18,250 feet in length, was completed by McNaughton & O. E. Dunbar, of Buffalo, and Section 4, in Lake Erie, 29,000 feet, by G. H. Breyman & Bro., of Toledo.

MEASUREMENT OF ACTUAL STRESSES IN REINFORCED-CONCRETE STRUCTURE.*

By W. K. Hatt.†

This paper is mainly an account of the general features of a test of a reinforced-concrete floor of flat-slab construction. The full report of the test with all pertinent data was made to the Leonard Construction Company, Chicago, which has permitted the writer to use the report as a basis for this paper.

Nature of Tests.—In brief, the floor was loaded with pig iron in increments, and the accompanying deformations were measured in the steel and in the concrete at all critical points, with a view to fixing a safe limit of loading and to understanding the mechanical action of the structure.

The Structure Tested.—The building tested is the Franks Building, Chicago, Ill., a 10-story-and-basement warehouse used by the printing and paper trades and the type of construction used was the "Cantilever Flat Slab" system. The design load on the floors was taken at 250 lb. per sq. ft. The panel dimensions were 19 ft. 4 in. by 20 ft. 3 in.

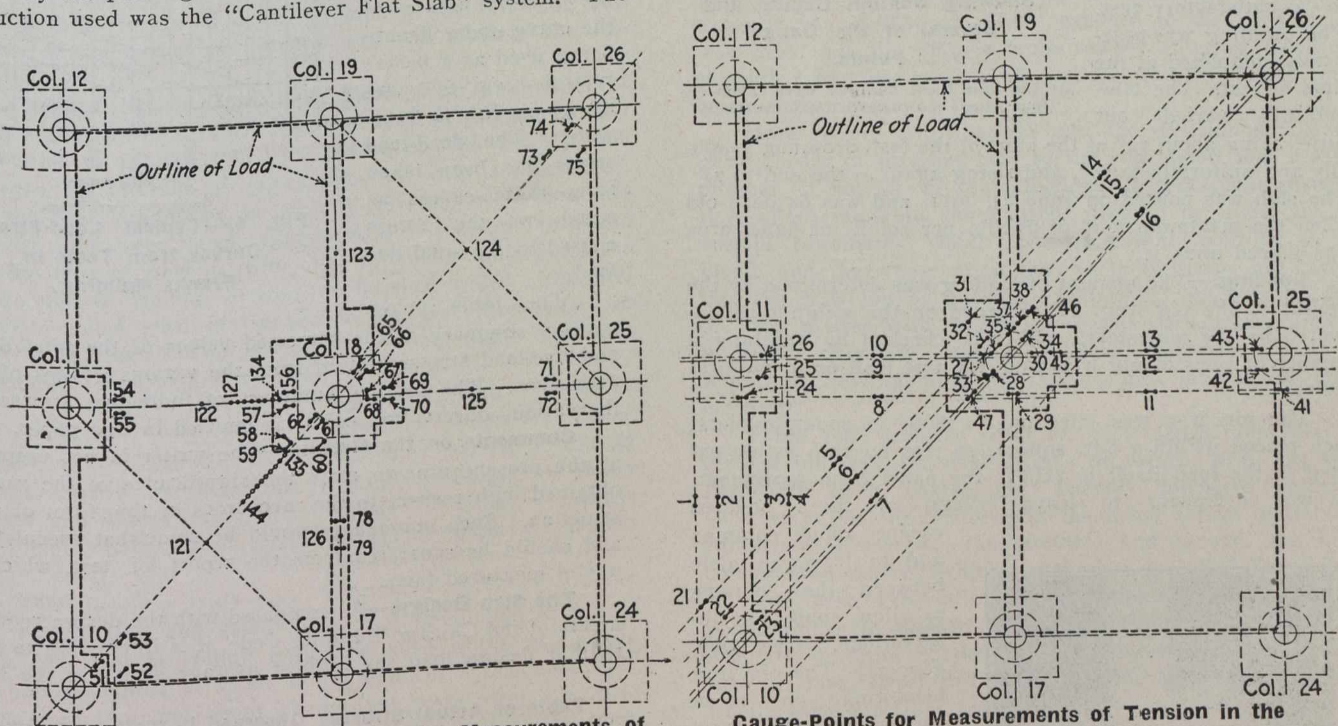
The four panels under observation were in the interior of the building, and on the tenth floor, where the columns were of minimum size. As the effective clear span and the eccentricity of column loading were the greatest, the location was such as to insure the most severe test possible.

The diagonal reinforcement was eighteen ½-inch round bars, 40 feet long, spaced 5⅝ in. on centres. The cross bands were composed of sixteen ½-inch round bars 44½ feet long, spaced 6⅜ in. on centres. The slab thickness was 9¼ inches, increased to 13¼ inches near the columns. The concrete mix was 1:2:4 in the floors and 1:1:2 in the columns.

Methods of Observation.—The observations were made by experienced observers: Prof. H. H. Scofield, of Purdue University, and Prof. W. A. Slater and W. E. Ensign, of the University of Illinois Engineering Experiment Station, with the assistance of Prof. L. W. Weeks, of Purdue University.

The deformations were determined by the use of extensometers of the type devised by Prof. H. C. Berry, of the University of Pennsylvania, a former pupil of the writer at Purdue University. On the steel a gauge length of 10 in. was used, which, with the multiplying lever in the instrument, gave direct readings of unit deformations of 0.00002 in. per in., corresponding to stresses of 600 lb. per square inch in the steel, and it was possible to estimate clearly fractions of this amount. For the concrete readings the gauge-length was 6 in., and the direct reading of unit deformations was 0.000033 in. per in., corresponding to a stress of 133 lb. per square inch, and it was possible to estimate fractions of this amount with accuracy.

Errors in operating the instrument were reduced to a minimum by taking every reading at least five times, and by calibrating on a standard bar at frequent intervals. Four standard bars were used throughout the test, all of these being embedded in the concrete and subject to the same temperature changes as the rods in the test floor, but free from any stress due to applied load. By reading on these bars between sets of five or six test readings, the observations on the materials under test were freed from errors caused by temperature differences and from systematic errors.



Gauge-Points for Deflections and for Measurements of Compression in Concrete.

Gauge-Points for Measurements of Tension in the Slab Steel.

Fig. 1.—Locations of Gauge Lengths for Steel and Concrete Stresses, and Points at Which Deflections were Measured.

Deflections were measured to 0.0001 in. by use of the deflectometer described in a previous test for actual stresses.

Tensile deformations were measured throughout the test over 42 gauge-lengths on the steel reinforcing rods. Compressive deformations in the concrete were measured over 26 gauge-lengths. Deflections were observed at 24 points. Also, 27 other readings of deformations were taken throughout the test, to study such phenomena as the arch and slab action, the distribution of stress, and the eccentric loading on the columns at the edges of the loaded area. The locations of the various gauge-lengths are shown by the two diagrams Fig. 1; see, also, the view Fig. 2.

The observations were arranged in groups, each designed to cover adequately some particular feature, and

* A paper read before the Indiana Engineering Society.

† Professor of Civil Engineering, Purdue University, Lafayette, Ind.

symmetrically located observations were obtained as a check in every case where possible, in order to cover variations in the quality of the concrete at different points.

It should be remarked that the results from the use of the Berry extensometer are reliable only after the observer has had considerable preliminary practice with this instrument. The holes in the steel bars must be carefully reamed, the instrument must be protected from the heat of the hands, and the contact points must be seated under uniform pressure. Observance of these requirements, multiplied observations, and frequent reference to the standard calibration bar, are the conditions of success.

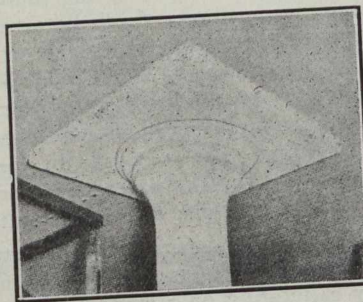


Fig. 2.—View of Slab from Below, Showing Column Capital and Several of the Gauge-Points.

(At the time these pictures were taken the four panels shown carried 20% overload)

The conditions were exceptionally favorable to a satisfactory test. The building was practically completed at the time of test. The temperature varied but little, being about 74° at the start of the test, dropping gradually and uniformly to 70°, and rising again at the end to 74°. The slab was poured on June 23, 1911, and was 64 days old when the maximum load of 624 lb. per sq. ft. of panel area was placed upon it.

Loading.—The amount of loading was determined by the weight of the pig iron as recorded on the weigh bills delivered by the teamsters, and was checked by weighing a number of piles of pig iron from the test load on a platform scales.

The pig iron was piled on the floor in separate piers, each placed within a 2-ft. square, so that no arch action existed in the load itself to relieve the panel from movement. It was necessary to leave several of these squares vacant about columns and to leave an aisle between the columns to allow space for observations. (See view Fig. 3). The pig iron belonging on these vacant squares was distributed over the remaining squares of the same panel. It will be apparent that under this procedure the real load intensity, as affecting bending stresses and deflections, is the intensity of loading over the loaded area (about 90% of the panel area), rather than the nominal or average load over the entire panel area.

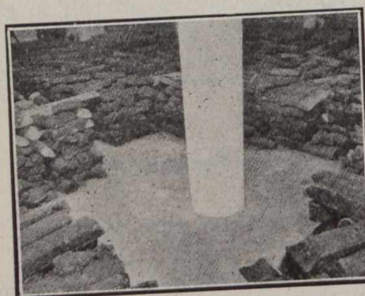


Fig. 3.—View of Slab with Pig-Iron Loading, Showing Space Left for Making Readings.

(At the time these pictures were taken, the four panels shown carried 20% overload)

All gauge-lengths were measured and checked throughout before loading was started. When the loading reached certain amounts, distributed evenly over four panels, it was discontinued and allowed to stand for six hours before the observations were made and the loading resumed.

The increments of load at which measurements were made were as follows: 75, 150, 256 (the design load), 312 (intensity 359), and 624 (intensity 717) lb. per sq. ft., the latter load being applied only to two panels adjoining diagonally. Readings were also taken with 256 on two diagonal panels and 312 on the other two panels, and with 468 on two diagonal panels and 156 on the others, but without waiting for the six-hour interval to elapse before taking readings.

The total number of complete observations over single gauge-lengths was over 2,000, and the total individual readings over 10,000. The test occupied one week's time.

Stresses.—The stresses were determined from the observed deformations by using a modulus of elasticity of 30,000,000 lb. per sq. in. for the steel, and 4,000,000 lb. per sq. in. for the concrete. The latter value was determined from tests of three concrete prisms poured from the concrete in the test slab and tested at Purdue University at an age of 77 days.

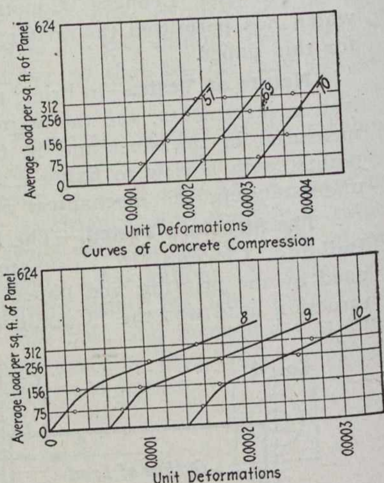


Fig. 4.—Typical Load-Strain Curves from Tests in Franks Building.

Load-deformation curves were plotted for each observation point, the known nature of the curve under flexure being used as a basis; typical curves are shown in Fig. 4 herewith. The dead-load stress has been taken from these curves as equal to the stress caused by an equal live load.

The table below gives a summary of the corrected values of the total dead- and live-load stresses found from the various groups of observations. The detailed summary of individual stresses at the various observation points is omitted in this paper.

Comments on the Results.—The writer is not prepared at the present time to state the significance of the results obtained with respect to the mechanics of this form of construction. Such statements would be somewhat speculative, and should be separated from the report of test, which is one of measured facts.

The Slab Design.—As compared with the design requirements of the Chicago Building Code, it is interesting to note that at design load the highest average stress in the steel

Table of Actual Stresses Observed in Test of Franks Building.

All stresses are the final values for total dead and live-load, and are given in pounds per square inch.

Average of Observations Nos.	Description	Live-load, lb. per sq.ft. 256	312	624
STRESSES IN SLAB RODS				
5, 6, 7, 14, 15, 16	Center of span, diagonal band	1071	1920	6950
8, 9, 10, 11, 12, 13	Center of span, cross band	4539	6140	10095
31, 32, 33, 34, 35, 37	Over capital at center column, diagonal band	3440	4350	9280
27, 28, 29, 30	Over capital at center column, cross band	4575	4840	8140
21, 22, 23	Over capital at corner column, diagonal band	1920	2280	7540
24, 25, 26, 41, 42, 43	Over capital at side column, cross band	2690	3138	5315
COMPRESSIVE STRESSES IN CONCRETE		560	650	1206
56, 57, 59, 60, 68, 69, 70	On slab at center column	677	778	1685
61, 62, 65, 66	On drop at center column	318	370	1515
51, 74	On drop at corner column	329	378	650
52, 53, 73	On slab at corner column	189	217	420
54, 55, 71, 72	On slab at side columns			
MAXIMUM BENDING STRESSES IN COLUMNS				
104	Compression in concrete, corner column	680	840	1660
109	Compression in concrete, side column	416	512	1000
84	Tension in steel, corner column	4980	6000	11620
99	Tension in steel, side column	2220	2640	5880
DEFLECTIONS IN INCHES				
121, 124	Center of panel—at 6 hours	0.123	0 156	0.475
	Center of panel—at 24 hours	0.142		0.500
	After standing unloaded 6 hours	0.091		
	After standing unloaded 2½ days			

Note: The loadings of 256 and 312 pounds per square foot were on four adjacent panels. The loading of 624 lb. per square foot was on two panels adjoining diagonally.

is 5,078 lb. per sq. in. (average of observations 11, 12 and 13), while the highest average compressive stress in the concrete is 677 lb. per sq. in. On the basis of safe working stress in the steel of 16,000 lb. per sq. in., and in the concrete of 35% of the ultimate strength (which averaged over 3,250 by tests of prisms) or 1,100 lb. per sq. in., it appears that the steel is stressed to 31% of its safe load, while the concrete is stressed to 62% of its safe load. It appears, therefore, that the design is overbalanced with an excess of steel. At the highest applied load of 717 lb. per sq. ft. the ratio of the steel and concrete stresses remains practically unchanged.

Column Bending.—The eccentric action of the test load was most marked on the corner columns of the loaded area, and was sufficient to produce a tension in the steel of 4,980 lb. per sq. in.

With respect to the strength of the structure, it may be said that a nominal load of 624 lb. per sq. ft. of panel, which actually was 717 lb. per sq. ft. of loaded surface, was applied without producing any permanent damage to the building. At this load the highest observed average total dead- and live-load stresses were less than 12,000 lb. per sq. in. in the steel and less than 1,700 lb. per sq. in. on the concrete.

IRON AND STEEL PRODUCTION IN CANADA.

The American Iron and Steel Association has compiled from returns furnished direct by makers the following sta-tistics of the output of finished iron and steel in the Do-minion:—

Finished Rolled Iron and Steel.—The production of all kinds of finished rolled iron and steel in Canada in 1911 amounted to 775,424 tons, as compared with 739,811 tons in 1910, an increase of 35,613 tons, or over 4.8 per cent. Of the total production in 1911, 86,383 tons were iron and 689,041 tons were steel, against 83,918 tons of iron and 655,893 tons of steel in 1910. The following table gives the production of leading articles of finished rolled iron and finished rolled steel in Canada in the last three years in tons (2,240 lbs.). The production of one plant has been estimated for 1910 and 1911:—

	1909. Tons.	1910. Tons.	1911. Tons.
Rails	344,830	366,465	360,547
Struct. shapes and wire rods	74,136	80,993	76,617
Plates and sheets	36,241	26,642	14,833
Nail plate, bars, etc.	207,534	265,711	323,427
Total	662,741	739,811	775,424

Forged Iron and Steel.—The total production of forged iron and steel by rolling mills and steel works in Canada in 1911 amounted to about 18,832 tons, of which about 787 tons were iron and about 18,045 tons were steel. In 1910 the production of forgings amounted to about 18,165 tons, of which about 1,258 tons were iron and about 16,907 were steel.

Cut Nails and Wire Nails.—In 1911 the rolling mills and steel works in Canada which operated cut nail or wire nail factories produced about 652,861 kegs of steel cut nails and steel wire nails of 100 lbs. each, as compared with about 327,580 kegs in 1910, about 374,100 kegs in 1909, and about 298,000 kegs in 1908.

Active Rolling Mills and Steel Works.—In 1911 there were 27 works in six provinces which made steel ingots or castings, or rolled iron or steel into finished forms, against 24 works in six provinces in 1910, a gain of three works. Of the total in 1911 there were 21 works which rolled iron or steel into finished forms and six which made steel ingots or castings but not finished forms of rolled iron or steel, while in 1910 the number of works which rolled iron or steel into finished forms was 20 and the number of works which did not roll finished forms was four. In 1911 there were four idle rolling mills and steel works, against three in 1910.

Of the 27 active rolling mills and steel works in Canada in 1911, six were located in Nova Scotia, six in Quebec, 11 in Ontario, two in Manitoba, and one each in New Brunswick and British Columbia. On December 31st two plants were being built in the province of Quebec.

ELEMENTARY THEORY AND PRINCIPLES OF STREET CLEANING.*

By S. Whinery, Consulting Engineer, New York City.

The cleaning of city streets is necessary for reasons which may be summarized as the preservation of the public health, the physical comfort and convenience of the people, and a regard for decent cleanliness and good appearance. Of these, the preservation of the public health must be considered of first importance.

Filthy streets have long been held by sanitary authorities to be a prolific cause of disease, but our views as to the exact way in which street filth causes or propagates disease have, in the light of more recent investigations and conclusions, undergone a notable change. The prevailing idea in the past among sanitarians and physicians, as well as in the public mind, has been that filth and organic matter in the process of decay give off poisonous gases or exhalations capable of conveying, if not of creating, various diseases in the bodies of those exposed to them. Thus, it was held that the effluvia from sewers entering dwellings through untrapped pipes and fixtures was the direct cause of much sickness.

More recent investigations and the development of the germ theory of diseases lead to the conclusion that a large number, if not all, of the infectious or contagious diseases that affect mankind are caused, directly or indirectly, by specific organisms which propagate and multiply in the blood, and that these organisms or their germs are carried into the body not by gaseous exhalations, but only by solid or fluid matter with which the germs are incorporated or to which they are attached. These conclusions have an important bearing upon the theory and practice of street cleaning.

From the sanitary point of view street dirt may be divided into two physical classes or forms: first, the comparatively fresh, coarse and recently deposited material, such as animal excrement and the usual refuse matter and rubbish that reaches the streets; and second, the finely comminuted matter, which, when dry, is called street dust.

The first, especially when damp, possesses sufficient ponderability to prevent its being taken up and carried by ordinary currents of the air. In the second form named, that of dust, street dirt is, from the sanitary standpoint, wholly different from the first.

When the coarse material reaching the street is not removed with reasonable promptness it is subjected to the drying effect of the sun and air and to the pulverizing action of travel, and is thereby reduced to a condition of powder so fine and light that it readily floats in the air when disturbed, and may be carried by winds or breezes to considerable distances. While thus suspended in the air it may be breathed into the lungs or deposited upon the bodies of those in the vicinity. Assuming that this street dust is infected with disease germs, it is obvious that the conditions could not be better for disseminating them and conveying them into susceptible human bodies.

If the views here outlined are accepted as true, they indicate that important changes should be made in the present practice of street cleaning. Efforts should be more particularly directed, first, to preventing the formation of street dust; and second, to the removal by efficient methods and in a manner that will prevent unnecessary dissemination of such dust as may be unavoidably formed.

Heretofore in American cities the principal object has been to remove the coarse street dirt at such intervals of time as convenience or necessity might dictate by methods

* Abstract of a paper read before the American Public Health Association, September, 1912.

and apparatus not well adapted to removing the dust, which was largely allowed to remain on the street. If the quantity of dust became sufficient to cause discomfort when blown about by the winds, the streets were sprinkled with water to lay the dust. This was a palliative only, since but a small part of the dust was washed into the sewers and the remainder was left on the street to be again converted into dust when the intervals between sprinkling were long enough to allow the moisture to evaporate. Until quite recently the streets in all our cities were cleaned almost exclusively with coarse-fibre street brooms or the horse-power sweeping machine, and this practice still largely prevails in most cities and towns. As a means of removing the coarser dirt these methods are reasonably effective, and would be quite satisfactory if the sweeping could be done at sufficiently short intervals. But where the streets of heavy travel, and consequently of large accumulations of refuse, are swept but once daily, or at longer intervals, and usually at night, the heat and travel during the day are sure to convert much of the dirt into dust which the coarse-fibre brooms stir up but do not satisfactorily remove.

It is true that the sweeping machines are usually preceded by the sprinkling wagon for the purpose, mainly, of preventing the clouds of dust that would otherwise be raised to the annoyance of those exposed to it, rather than to facilitate the removal of dust from the street. If not enough water is used to just moisten the dust and cause it to adhere and aggregate, most of it will remain on the street, while if too much water is used the dust is converted into a paste, which the brooms plaster upon the street surface to again be converted into dust under the action of sun and travel.

For the purpose of removing the coarse accumulations, patrol or hand-cleaning with broom or scraper, or both, is most efficient and satisfactory. This is true if for no other reason than that the dirt is more promptly and frequently removed. The cleaner passes over his beat several times during the day and thus removes the refuse before it has had much time to dry out and become pulverized.

For the removal of such dust as cannot be prevented, the only effective and satisfactory way yet developed is to wash the surface with water. This may be accomplished either by the use of machines of the squeegee type, which scrub the surface, or by flushing with water under pressure to dislodge and carry away the fine material. For the latter either flushing machines or hose attached to fire hydrants are available.

It is true that these methods if thoroughly used carry the removed dust into the sewers or drains, which is regarded by many as objectionable, and as likely to clog the pipes. This might happen where the whole of the street dirt, coarse and fine, is thus carried together into the sewers, though the writer does not know of any instances where actual trouble has thus resulted. The practice of cleaning the streets wholly by squeegeeing or flushing is not, however, to be recommended, if for no other reason than that it would be impracticable to do the work several times each day, and thus prevent the formation and flying of dust.

The danger of clogging the sewers by flushing the dust only into them is very remote. The quantity of the dust remaining after proper coarse cleaning is small. Careful determinations by the New York Commission on Street Cleaning and Waste Disposal (1907) showed that on smooth pavements cleaned by the patrol system the accumulation of dust in forty-eight hours after the street had been washed either by hard rains or by flushing, does not exceed 5 or 6 per cent. of the total daily quantity of street dirt, though on rough stone-block pavement it may be much larger. This quantity is so small that its disposal through the sewers could hardly cause serious trouble. In fact, the large volume of water used tends rather to flush and clean out the sewers.

If the views here outlined are sound, the theory and controlling principles of street cleaning may be summed up as follows:—

First—Street dust is the form in which street dirt is the most dangerous to the public health.

Second—From the sanitary point of view, therefore, the most important function of street cleaning is the prevention of the formation of street dust and the prompt and safe removal of any such dust as may accumulate on the streets.

Third—To prevent the formation of dust the coarse and usually most excrement and refuse should be collected and removed as effectually and as frequently as practicable, before it becomes dried and pulverized. The most effective and satisfactory way of doing this is the patrol or hand-sweeping method.

Fourth—For the removal of the dust that will accumulate to some extent, scrubbing or washing the street surface with water is the only practical and effective method yet devised.

The ideal system of street cleaning would, therefore, be efficient patrol or hand-cleaning through the day, or during a longer period if the volume of travel in the evening requires it, and thorough scrubbing with squeegees, or washing with water under pressure by flushing machines or hose at night, as often as may be necessary.

It may be objected that the funds at the disposal of the street cleaning departments of most cities would not permit the adoption and adequate application of this system in many American cities. To this it may very properly be answered that in matters seriously endangering the public health the question of cost should not be controlling, unless that cost be absolutely prohibitive, or wholly out of proportion to the benefits that would result.

Actual experience, however, seems to prove that the method here recommended need not be so expensive as to be discouraging.

The streets of Washington are notable for their cleanliness. The method here recommended has been in use there for nearly two years with most satisfactory results both as to effectiveness and cost. In the report of the Street Cleaning Division for 1911 it is stated that in the neighborhood of 1,000,000 sq. yds. of street surface were cleaned every day except Sundays and holidays by the patrol system. The hand-cleaning was supplemented by washing the surfaces about one and one-half times each week. The report states (see Report of Street Cleaning Division, page 5):—

"Under the above system of street washing it is found that the streets are almost entirely free from dust. Any dirt which may accumulate does not have time to be pulverized, and the particles are too heavy to be disturbed or blown about by an ordinary wind. Under the old method of sweeping these heavier and coarser particles were removed, but most of the dust remained, to become a source of annoyance when disturbed by the wind or rapidly passing vehicles, although the streets might have appeared to the eye to be clean."

The cost of the work per 1,000 sq. yds. cleaned once is stated to have been as follows:—

Hand-cleaning patrol system	$0.1753
Washing by squeegee	0.1162

But as the washing was done, on an average, only one and one-half times per week, the sum of the above figures does not give the correct average cost, which, for 1,000 sq. yds. cleaned once during a week (six days), may be arrived at as follows:—

Hand-cleaning, 1,000 sq. yds. daily equals 6,000 sq. yds. per week at 17.53 cents per	$1.052
Washing with squeegee 1,000 sq. yds. 1½ times per week, equals 1,500 sq. yds.	0.1743
Total for combined cleaning once of 6,000 sq. yds. of street	$1.1795
Equal to a cost per 1,000 sq. yds. cleaned once of..	0.1966

This figure seems very low, and probably could not be duplicated in many other cities where the business streets carry a much heavier travel, but it proves that this system of cleaning need not be unusually expensive.

The cost where the flushing machines were used is reported to have been 31.57 cents per 1,000 sq. yds. cleaned once. Assuming that the streets were flushed one and one-half times per week, as in the case of the squeegee, the cost of the combined cleaning once of 1,000 sq. yds. will be found to be 25.42 cents, which must still be regarded as a very reasonable figure.

It should be noted, however, that in neither case do these figures of cost include the value of the water used for washing. The quantity of water required per 1,000 sq. yds. cleaned once as determined by trials in New York, is about 150 gals. for the squeegee and about 470 gals. for the flushing machines; but the cost of this water would be offset, in a measure at least, by the cost of that which would otherwise be used for supplemental sprinkling where the ordinary sweeping machine is used.

SLUDGE ACCUMULATIONS AT SEWER OUTFALLS.

The subject of the relation of sludge deposits to nuisance was discussed by Mr. Langdon Pearse, assistant engineer, Sanitary District of Chicago, at the recent meeting of the American Public Health Association in Washington, D.C.; the paper, slightly condensed, is given below.

The sludge nuisance in the Back Bay Fens in Boston, as reported by Mr. John R. Freeman to the Charles River Basin Commission in 1903, was so marked and the deposits of sludge so large for a small stream (amounting to one-fourth the entire capacity of the basin) that extensive dredging and the removal of the sewage by means of sewer extensions was recommended. In the case of the Providence River in Rhode Island, dredging has relieved conditions. No exact measurements or details, however, have been given.

In the report of the Sanitary District of Chicago, October, 1911, Mr. George M. Wisner, the chief engineer, has described conditions of the fill in the Main Channel of the Sanitary District and given analyses of the same. The anlytical data show a rather heavy material compared to the sludge found in sewage disposal plants, resembling more nearly a grit-chamber sludge than a true sewage sludge. The effect of the sludge on the water passing above in the canal is detrimental, although quantitatively difficult to express. From the most marked sludge deposits just above the power house, considerable ebullition of gas occurs in the summer, and even in the winter, which helps in maintaining the oxygen content at a very low level. In portions of the canal near the city, studies have been made on the distribution of oxygen in the cross-sections, and a difference has been noted between the content at the top and the bottom, the bottom usually being lower. Some variation has also been found between the two banks before mixing is complete, a distance of four to five miles. Where the oxygen content is low the distribution through the section is practically uniform, complete mixing having taken place.

The presence of large sludge deposits and scum in the arms of the Chicago River, known as the Stock Yards slip or Bubbly Creek, is responsible for a condition of nuisance and degree of odor which might not occur to such extent could the suspended matter be kept moving and even partially oxygenated. Dredging has been carried on at times.

In New York harbor, reference has been made to sludge deposits in the report of the Metropolitan Sewerage Commission, and comment has been made on the indications of oxygen in the lower layers of the water through the presence of a reddish surface on the black sludge. This phenomenon indicates the oxidation of the ferrous sulphide. This has also been observed in experiments in the laboratory of the Sanitary District of Chicago, where several inches of sludge were placed in the bottom of shallow jars, the liquid above containing oxygen.

A few quantitative experiments, made by Mr. H. W. Clark, are given in the report of the Charles River Basin Commission, 1903, in which two grams of mud or sludge were placed in ½-gal. bottles full of fresh water, or salt, and the reduction of oxygen was followed. In five days the oxygen in fresh water was reduced to an average of 61 per cent. saturation from an initial complete saturation, the extremes being a reduction to 81 and 33 per cent. saturation. An experiment was also made, with continuous flow, using 9 in. of mud in a tank 12 ft. deep, the liquid being at first 5 and later 7 per cent. sewage. In general the surface layers contained more oxygen. Comment is also made on the production of odors in tidal waters by bacterial reduction of the sulphur compounds in sea water. In the examination of the conditions in the Fens basin, referred to previously, it was found that hydrogen sulphide was formed which rose through 6 ft. of water. No oxygen was found below a surface layer 6 in. deep.

On the absorption of oxygen by sludge, some comments have been given by Mr. Almon L. Fales, supervising chemist of the Sewer Department in the city of Worcester, Mass. In 1903 he conducted some experiments on the aeration of sludge and liquid in a tank holding 1,500 gals., and found that in the early period of the experiments it was necessary to aerate several times a day, but later once in 12 hours proved sufficient. It was also observed that the dissolved oxygen disappeared much more rapidly in the layer just above the sludge. Occasionally after 12 hours or less had elapsed after aeration the dissolved oxygen would be exhausted in the layer just above the sludge, while the top liquid would still contain as high as 25 per cent. saturation. After the experiments had been continued for three weeks it was found that the liquid just above the sludge lost all dissolved oxygen in 24 hours, while the top liquid showed 125 per cent. saturation. The super-saturation was caused by the propagation of chlorophyl containing micro-organisms which gave the liquid a greenish tint. Similar phenomena can be noticed at times in streams of intermittent flow where the dilution is not sufficient to prevent nuisance.

In shallow, wind-swept waters, sludge deposits may prove a greater source of odor, owing to the constant agitation of the waves. An experiment has shown that any disturbance of sludge under water is undesirable from the standpoint of prospective odors.

Of the remedies at hand, dredging seems to be in general but a temporary expedient, aside from its value in cleaning up offensive conditions. Unless a hydraulic suction dredge be used and large space be available for the ponding of the sludge, it may be difficult to remove all the material which should be classed as sludge. With a dipper dredge probably only the more gritty material would be removed, although conditions may be much improved thereby. The composition of sewage sludge, as found in sedimentation tanks of various types, ranges from a specific gravity of 1.01 to 1.06, and seldom exceeds 1.10, the water content running from 85 to 95 per cent. This is a material which is fairly liquid.

The only permanent remedy, Mr. Pearse states, is to prevent deposits. The dilution available, however, may require further treatment. To-day, screening is available where the areas tributary are relatively small and the sewage fresh, and in case screening be not sufficient, various styles of sedimentation tanks, either of the single or double-deck type, can be used to advantage.

It is difficult to state any hard-and-fast criterion that will cover all cases. The amount of dilution affords one key. Mr. Pearse suggests that where a stream is large and the dilution great, so that oxygen is always present to a high degree except in the vicinity of the sludge banks, dredging may prove an appropriate remedy. This is particularly true when the velocities of flow are sufficiently high to keep the settling material moving at other points.

Comparison on the basis of the cost per cubic yard of dredging and of sludge collected in tanks, is difficult. Roughly speaking, per cubic yard of material handled, dredging has the lower cost price. The total annual cost per cubic yard of sludge collected in a sedimentation plant, with Emscher tanks, would be considerably higher. The effectiveness and scope for application of sedimentation plants is, however, quite distinct from that of dredging.

The conclusions are: (1) Sludge deposits may form when velocities of flow are low. (2) The effect of sludge deposits is governed somewhat by dilution; nuisance may exist, locally, even though dilution be very great. (3) Sludge deposits will use up oxygen from the supernatant liquid. (4) Three remedies are available: dredging, by-passing the locality, and the removal of suspended matter before discharge. (5) Dredging is efficient as a cleaning-up process; it is not a permanent remedy, in that it may not reach all material, and is executed at infrequent intervals. (6) By-passing the locality is a temporary expedient, which may relieve present conditions and perhaps cause trouble later elsewhere. (7) The removal of suspended matter by screening or sedimentation is effective, and of permanent service. (8) Screening will remove the coarser material, the results depending very largely on the character of the sewage. (9) Sedimentation will remove practically all the settling suspended matter. (10) Effectiveness and cost must be balanced to suit physical conditions.

STREET ENCROACHMENTS IN TORONTO.

The question of street encroachments was the subject of a report by Mr. T. D. LeMay, O.L.S., the city surveyor of the city of Toronto, to the City Council. The text of the report is as follows:—

The problem of enforcing strict adherence by architects and builders to street lines as defined by registered plan, by-law or otherwise, is one which merits immediate attention. Instances of encroachment on public thoroughfares are comparatively common, some of them undoubtedly due to ignorance, others the result of carelessness or wilful disregard of the limits of the street as defined by an Ontario Land Surveyor. Attached hereto are three sketches of encroachments of this nature that have recently come to my knowledge, and which, in my opinion, should be the subject of firm action by the proper official. The general question of taking such steps as will obviate similar occurrences in the future could be solved by the employment of an official whose duties would be the definition of all street lines in the city for those erecting buildings, and the detection of encroachments that have been created by the erection of buildings of comparatively recent date. The information at present in this office being of such a meagre nature, would involve unlimited access to the field notes accumulated by the old established land surveyors of the city, which are, of course, their private property, and which they would not be prepared to throw open to the inspection of such an official, whose duties must very appreciably interfere with their practice, especially in the case of the older portions of the city, where the side lines of the lots are to a certain extent defined by possessory boundaries, and where the location of the street line constitutes for the purpose of the builder the whole survey. It might, of course, be possible to arrange some fee to be paid for each copy of notes taken, amounting to from $5 to $20 each, which, estimating the number of permits for 1912 at 8,000, would amount to a very considerable sum in the course of a year, even if the city were only called on to take action in, say, one-third of that number; and further, estimating at the rate of ten surveys a week for each such specially appointed official, it would be necessary to employ about six fully qualified land surveyors and a similar number of assistants, with an aggregate expenditure for salaries of about $14,000 per annum. The cost in this case appears to me to be prohibitive, and after careful consideration I would strongly recommend as an alternative that a by-law be passed enacting that every person applying for a permit to erect a building, any portion of which is designed to be at a less distance that two feet from the street line, or a building on any street upon which the building line is fixed by by-law, shall be required to hand to the City Architect simultaneously with his application, a plan of survey, made by an Ontario Land Surveyor, showing clearly the street line with reference to the kerb or some other permanent offset point. These plans to be forwarded to this office, where they could be placed on record with other information of a like nature. It would then be the duty of a specially appointed permanent official, being a duly authorized Land Surveyor attached to this office and working under my supervision, to check by means of the information given on the surveyors' plans the position of such buildings with regard to the street line or building line. A further duty of such an official would be to look out for and make careful enquiry into any apparent existing encroachment, and generally to compile such information in the way of ties to existing monuments as would tend to place this office more in a position of being able to dispense with the very valuable assistance that we obtain as a matter of courtesy from other surveyors in the city. In conclusion, I cannot too strongly suggest that immediate action be taken to do away with the frequent encroachments on public highways that are already, in many instances, too narrow for the volume of traffic that they must carry.

AMERICAN SULPHURIC ACID INDUSTRY.

It is estimated that some 200,000 tons of sulphuric acid are used annually in the iron and steel and coke industry of the United States out of a total consumption of 3,250,000 tons. The iron and steel industry, indeed, uses such quantities that a tendency is developing for steel companies to erect and operate their own sulphuric acid plants. A coke plant consuming 2,000 tons of coal per day would produce from 14 to 30 tons of sulphate of ammonia daily, according to the nitrogen content of the coal used. Therefore, each 2,000 tons of coal, high in nitrogen, converted into coke daily, would call for a production of 10,000 tons of 50 deg. Be. sulphuric acid per year. By-product coke-ovens are now projected which will require 100,000 to 150,000 tons of 50 deg. Be. sulphuric acid per annum, in addition to the figure shown above.

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CONTENTS OF THIS ISSUE.

PROTECTION OF CANAL LOCK GATES.

The protection of canal lock gates from possible injury from vessels is most important. Injury to the gates always means delay of less or greater length of time, and delay during navigation season on important traffic routes is most serious. Conditions demand the utmost facility in passing vessels through the canal during the open season.

An accident on the Welland Canal last week makes a total of five to date this season. This accident, which is noted in another column of this week's issue, is very similar to the others which have occurred this season. It caused a delay of some forty-eight hours in the operation of the canal, at the close of the season, when it is most important that the route should be open. The necessity for more adequate protection for the lock gates is very apparent. The Gowan safety device, which was described in a recent issue of *The Canadian Engineer*, has been very successful on the Welland Canal as a protection for vessels striking the gates lightly and forcing them open. This device consists of four very strong cast-steel fingers, two on each leaf of the gate, one towards the top and the other towards the bottom. These fingers project a couple of feet beyond the miter, so that one leaf can be pushed back very nearly the full length of the finger, but still give support to the opposite leaf. As vessels rarely hit the gates with great speed, this device prevents a number of accidents which would otherwise occur.

The number of serious accidents which have occurred this year, however, demonstrates the fact that a more efficient means of protection must be used.

The Panama Canal gates are protected by chain fenders. The function of these fenders is to prevent the lock gates from being rammed by a ship that may approach too near the gates under its own steam, or by escaping from the towing locomotives. In operation the chain is stretched across the lock chamber from the top of the opposing wall; when it is desired to allow a ship to pass the chain is lowered into a groove made for the purpose in the lock floor, and is raised again after the ship has passed. A hydraulically operated system of cylinders holds the ends of the chain. If a vessel should run into the fender, the chain is paid out gradually by an automatic release until the vessel comes to a stop.

It is time that the lock gates of the Welland Canal were equipped with some such protection as this. The capital cost of installing such devices is insignificant as compared with the resulting damage and delay due to these constantly recurring accidents.

ACCIDENTS AND SAFETY PRECAUTIONS.

This week a railroad collision in Ontario accounted for several deaths and a large number of injuries. A prominent citizen in an automobile on his way to the station to meet the hospital train, was sufficiently hurt in a street car collision to prevent him from proceeding on his errand of mercy. These two incidents are passing from memory with the usual few days' wonder, indignation and sympathy. Within a week or so the stories will be buried in official records and newspaper files. Leaving them out of consideration, for the moment, they are still a grim reminder of the toll this country is paying for its craze for speed, its disrespect for human life. Every day brings its tragedies which might have been averted were the desire for haste reduced and the respect for the individual life increased. Is the price we pay for our much-vaunted hustle worth the hustle and the dregs we get? Here is the account in part for the three latest years:—

Three years, 1909-1911.	Killed.	Injured.
Fires	792	.....
Industrial	2,729	5,873
Steam railroad	1,467	4,751
Electric railroad	265	7,347
	5,253	17,971

No official record has been kept of persons injured in fires, but the number is large. The above figures, compiled from official sources, show that fires, industrial and railroad accidents have killed five persons and injured sixteen persons every day during the past three years. That is the total, in cold facts, of the quickly forgotten daily incidents. In addition to lives lost in fires, the annual fire waste in Canada amounts to an average of $20,000,000. These losses of life and property are shown, by careful analyses, to be caused largely by carelessness, caused in turn by an insane desire for speed. Adequate fire resistance is sacrificed for the sake of speculative building, which has become almost synonymous with the erection of poor quality in the quickest time for the most money. Our building by-laws are generally lax. Loose matches are an everyday danger. On every hand, one sees carelessness with fire risks.

Sometime ago, the subject of industrial accidents was discussed in parliament. Mr. H. H. Miller submitted a resolution, stating it to be the duty of the government to make a thorough investigation as to the facts and conditions as a result of which some means might be devised for the better protection of employees and of preventing so great a loss of life and so great and frequent accidental injury. The Minister of Labor at that time made the following statement: "We can say with certainty at this moment that a year hence another 2,000 lives will be swept off the list of workers in Canada, and in another two years there will be 20,000, whose industrial efficiency will be permanently impaired as a consequence of the callings in which they are engaged."

Our railroad accidents constitute the worst feature of the price we pay for hustle. Since 1888 to the end of 1911 7,728 persons have been killed on Canadian railroads and 27,574 persons injured, an annual average of 322 killed and 1,149 injured. Here, again, we can find the same basic cause, viz., the delusive craze for speed. Delayed trains are forced to make up time with disastrous results. Hazardous risks are taken by those responsible for operation with the lives of hundreds at stake. Taking chances is the curse of American railroading. Carelessness, which usually is the direct result of speed ambition, in some shape or form, accounts for a large number of accidents. Last year, for instance, 36 persons were killed and 108 injured by trains at highway crossings. An improvement was seen in the number of protective crossings, which increased by 166 over the preceding year. There is probably in that fact a direct connection with the reduced number of accidents at highway intersections during 1911. These crossings are usually protected by gates, overhead bridges, subways, bells and watchmen. The last two have been proved by experience to be of little value. Gates, which usually consist of cross bars under which pedestrians can climb and certain vehicles even can pass, are practically useless in that form. The present style should be abolished and one substituted which, when shut, should be non-negotiable by any kind of traffic. Overhead bridges and subways are by far the best form of protection.

A tendency was shown during the recent parliamentary discussion respecting industrial accidents, for the Minister of Labor to place the responsibility upon the industries concerned. That is a right view only after parliament has enacted stringent laws, and, more important still, has seen that they are enforced. The standard of public safety to which we are supposed to adhere is too low. It must be raised by our legislators and we must act up to it. After that, workmen's compensation is largely a matter for the railroad or other industry involved in lengthening the list of killed and injured.

These figures do not make good advertising for Canada, but idle boasting of our progress without self-examination of our weaknesses ultimately will only work to our own disadvantage. The public are demanding speed. They are being given it. The price paid is shattered nerves, human life and limb. In the meantime, legislators remain idle in face of duty.

EDITORIAL COMMENT.

In an editorial on "Sanitary Engineers Needed," one of the daily papers of Ottawa states: "The people are coming to realize the reason for the unsatisfactory results obtained from the public health service in charge of medical doctors. They are beginning to see that the public health to be adequately protected must be looked after by sanitary engineers, rather than by general medical practitioners. There are still some, however, who hold the opinion that a Federal department of public health would correct the shortcomings of the existing provincial and municipal health departments. This proposal, however, as at present outlined, could only result in increasing the number of general medical practitioners in the public health service, and the chief cause for the unsatisfactory results would thus be left untouched, if, indeed, not increased." We are glad to note that the public are beginning to appreciate the difference between the practical methods of the engineer and the visionary schemes of many of the medical profession.

LETTER TO THE EDITOR.

Sir,—The following is a simple method for determining voids in sand. I don't know whether this has been used before, but if you have no record of it, I would be glad to have you publish it. I would also like to have the opinions of the various engineers upon this method.

For convenience, use a glass cylinder graduated to 200 c.c. Fill with water up to the 100 c.c. mark and then pour in 100 c.c. of sand. There will be no necessity of measuring the sand before hand, as the cylinder containing the water will also measure the sand. When the 100 c.c. mark is reached, the water will have risen a certain amount, subtracting this reading from 200 will give the percentage of voids in sand, without any weighing.

This is obvious, due to the fact that there were 100 c.c. of water to start with, and if there are, say, 62 c.c. of water above the sand, there must be 38 c.c. filling of voids in the sand, and as there are 100 c.c. of sand, the percentage of voids would, therefore, be 38%. Taken another way, the total reading in this case would be 162 c.c. which, subtracted from 200, would equal 38.

L. S. BRUNER,
Manager of Publicity,
Canada Cement Company, Limited.

BIG BEND WATER POWER DEVELOPMENT OF THE FEATHER RIVER IN CALIFORNIA.

One of the largest hydro-electric power developments in the West has been partially completed by the Great Western Power Company, of San Francisco, Cal. The development is on the North Fork of the Feather River, a branch of the Sacramento River, which rises in the Sierra Nevada Mountains in the Northeastern part of California. The power house is at Big Bend, 18 miles above Oroville, and 160 miles from San Francisco, where most of the power is used.

At Big Bend, as the name would indicate, the river makes a long detour of a horseshoe shape; the distance around the bend is about 11 miles, but the distance across the neck of land is only 3 miles. The natural fall in the river in this distance is 413 ft. By means of a dam at the upper end of the bend the flow of the river is diverted into a pressure tunnel 3 miles long, across the neck of land, to the power house at the lower end of the bend where the total fall in this length of the river can be obtained. Here there are at present 4 units installed, each of 15,000 horse-power or 60,000 horse-power in all. The station is only one-half the size to which it will ultimately be built, but the tunnel is large enough for 4 more units.

In a paper before the Brooklyn Engineers' Club Mr. H. P. Rust describes the Big Bend power development in detail. An abstract of the paper follows:

Big Bend Development.—The development consists of a concrete diverting dam 40 ft. high, which will finally be raised to 130 ft. in height above the original water level. This dam turns the flow through a concrete lined pressure tunnel three miles long. Part of this tunnel is an old mining tunnel, formerly used to drain the river bed around the bend, which has been enlarged and lined. At the outlet there is a riveted steel header pipe securely concreted into the end of the tunnel. This branches into four smaller penstocks down the side of the canyon and connects with each of the four turbines in the power house below. The end of the harder pipe is turned up the hillside to a level 35 ft. higher than the crest of the dam and forms a surge pipe, or vent, and prevents any excessive pressure of water hammer in the tunnel due to quick closure of the turbine gates. The problem of the development was a peculiar one and there are several conditions which make it unlike any other in the West. First, there was the old mining tunnel which had to be used. This had a steep grade and a fall of 70 ft., too much to be wasted by using a gravity tunnel, so this necessitated a pressure tunnel. A new tunnel or extension was necessary from the exit of the old one in Dark Canyon to the main river, 3,400 ft. long, to obtain all the head available with the shortest possible head-race. With a pressure tunnel and pipe lines, all enclosed, the quantity of water flowing could be quickly changed, thus allowing for changes in the load on the generator without having to waste water over spillways, as would be necessary with a gravity conduit, in which the flow would have to be constant nearly all the time.

The pressure tunnel allowed the use of a high dam at the intake to increase the head and to form a balancing reservoir to carry daily peak loads or store water over Sunday. With such a reservoir no water need be wasted on account of any load factor which may be obtained for the plant, and the average flow during the day could be stored when the load was light and used when the demand for power was at its greatest. By means of the reservoir and pressure tunnel the amount of water which could be obtained from the low flow in the river is increased from 50 to 60 per cent.

The chief disadvantage of a pressure tunnel in such a case is the difficulty of taking care of the water hammer and providing for close regulation, but by special precautions afterwards described this may be safely taken care of.

This design necessitated engineering and construction work of a high character, much more so than is customary with most power plants in the West.

In order to get the plant started as soon as possible and cheapen the first cost, only half the power was first built and the high dam has been deferred. But the tunnel has been made large enough and all connections provided so that the power house may be doubled and four more units installed without interfering with the operation of the first installation.

Construction Plant and Camps.—The main problem before the railroad was completed, as far as the work, was transportation. This had been promised for early in the summer of the first year's work, but the railroad engineers also had their trouble and it was not in operation as far as the power house until the following spring. During this time all supplies and plant had to be hauled 20 miles from Oroville. About 25 miles of new roads were built into the different camps and the saw mills.

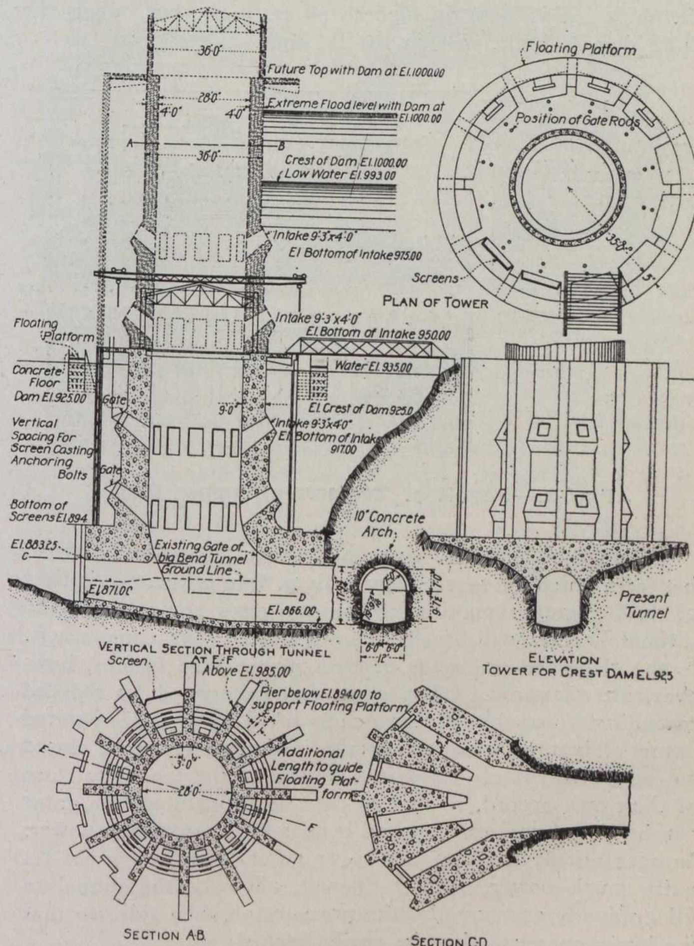


Fig. 1.—Details of Tunnel Intake Tower.

Work was started in the fall of 1906, and the weather during the first winter was very bad. There was a great deal of rain and snow and the roads were almost impassable. However, sufficient plant, boilers, compressors and supplies had to be hauled in to start the tunnel excavation. At the intake there was a camp (Camp No. 7) accommodating about 300 men. Besides the concrete plant here, there was a 1,250-cu. ft. steam-driven compressor and boilers, etc.

The principal camp (Camp No. 3) was in Dark Canyon, at the exit of the old tunnel. Here there were accommodations for about 600 men and the principal repair shops, etc. The camp at south portal above the power house (Camp No. 4), had accommodations for about 300 men. Besides these, there were two saw mills, Camp No. 6, and Camp No. 8, each with a capacity of 10,000 ft. of lumber per day; and also the headquarters, Camp No. 1, and the various storehouses, commissaries, etc.

As the work was carried on shortly after the San Francisco fire, labor was very scarce and of poor quality. The maximum force was about 1,600 men and it averaged 1,200 most of the time. No contractor could be found who would undertake the work at a reasonable price, as all who were asked to bid seemed afraid of the inaccessibility of the site, so all the work at Big Bend was carried on by the engineers by day labor. Among other troubles, there were two severe floods, the first of which washed away most of the buildings in the headquarters camp, and one bad forest fire which burned over a large portion of the company's property at Big Bend and endangered the camps and equipment.

Intake Tower.—In order to control the water entering the tunnel at all levels at which the water might stand in the reservoir, and also to provide access to the tunnel from this end, a concrete gate tower has been constructed. It is of somewhat unusual construction (Fig. 1) and is a massive piece of work. It consists of a heavy hollow concrete cylinder 28 ft. in inside diameter, with walls from 12 to 7 ft. thick; it is now finished to 76 ft. high, but, when the high dam is built, will be 163 ft. high.

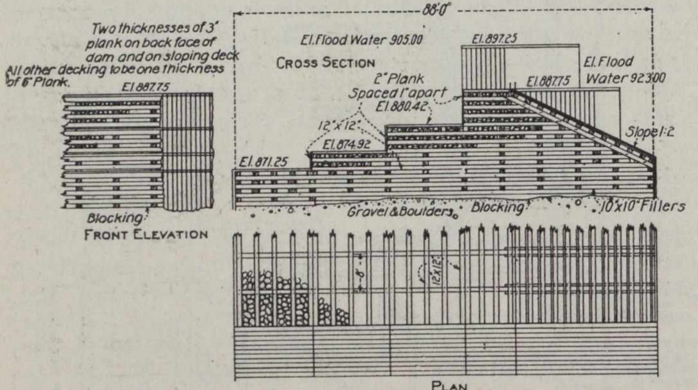


Fig. 2.—Details of Temporary Timber Dam.

Around the outside there are 12 buttresses 3 ft. thick, between which there are now 2 tiers, but ultimately 4 tiers of 12 flap gates; making in all 24 gates now in use, and ultimately there will be 48. They are each 3 ft. 4 ins. x 4 ft. in the clear and are made of steel plate. The frames, however, are cast iron. The gates can be opened by the rod extending up to the floor, which is lifted by a hand-operated crane. Their principal advantage is that they can be closed so easily; by simply releasing the rod at the top, they close of their own accord, so that in case of accident all the gates can be closed very quickly and it does not require any power. In opening them one of the upper gates, which does not require much power, is first opened, allowing the tunnel to fill gradually and equalize the pressure on each side, so that the lower ones can then be easily opened.

Outside the gates and between the buttresses are the screens. These are made up of 2½-in. x ⅜-in. flats, spaced 2 ins. apart, and slide into C. I. grooves bolted to the side of the buttresses. They are arranged to be raked from a floating platform fitting between the buttresses.

This arrangement allows water to be taken from nearer the surface and insures freedom from sand, silt or debris. It also gives large rack and gate area with a minimum of masonry.

In order to start the plant before the dam was finished, 4 temporary openings were left through the bottom of the tower. These were controlled temporarily by steel and redwood gates, motor operated. But since the completion of the dam they have been closed permanently and will not be used in the future.

During construction of the tower access to the tunnel had to be allowed for as it was being enlarged and lined at the same time. A crushing and concrete mixing plant was erected near the tower and concrete was mixed here for both the tower and for lining this end of the tunnel. A quarry of hard trap rock was opened up just upstream. There was also a compressor located here of 1,250 cu. ft. per min. capacity to supply compressed air to this end of the tunnel.

No sand for concrete could be obtained nearby, so 2 sets of 24-in. crushing rolls were installed in the crushing plant to crush rock fine enough for use as sand.

There was not room for a camp and quarters near the river, so this was located about 350 ft. higher up the canyon side, above the tower, with accommodations for about 300 men.

Timber Dam.—In order not to interfere with work in the tunnel and protect this end of it from a higher water level, the intake tower had to be practically finished before the diverting dam could be started. Work on the tower could not be rushed without interfering with work in the tunnel, so that it required all the first working year to complete the tower and the dam could not be started until the second summer.

In order to get the plant started as soon as possible, this left only one season in which to build a dam and it would have been impossible to put in the foundations and build a masonry dam in one summer, only about six months. So it was decided to build a temporary timber dam (Fig. 2) sufficiently high to turn the water through the lower sluiceways of the intake tower and build the masonry dam later.

The timber dam was located just above the site for the masonry dam, and built so it would later act as a cofferdam for the masonry dam. It is about 700 ft. downstream from the intake tower. Also, as the Western Pacific R. R. was not finished as far as the intake, the cost of cement and sand would at that time have been excessive for the construction of any large amount of masonry. The timber dam is shown in plan and cross-section. It has a slope of 2 in 1 on the upstream side, a level crest 10½ ft. wide, and three steps on the downstream side, each 16 ft. wide. It was arranged so 8 ft. of flash-boards could be added on the crest. The crest is 22 ft. above the tunnel invert at the intake. It is about 18 ft. above the original water, or about 26 ft. above the river bottom, and is about 280 ft. long. The dam is built of 12-in. x 12-in. square timbers bolted together with ⅞-in. drift bolts 26 ins. long. Additional longitudinals and rakers are spaced 4 ft. apart to support the deck. This is made of two layers of 3-in. plank on the upstream face and of one layer of 6-in. plank on the crest and the downstream face.

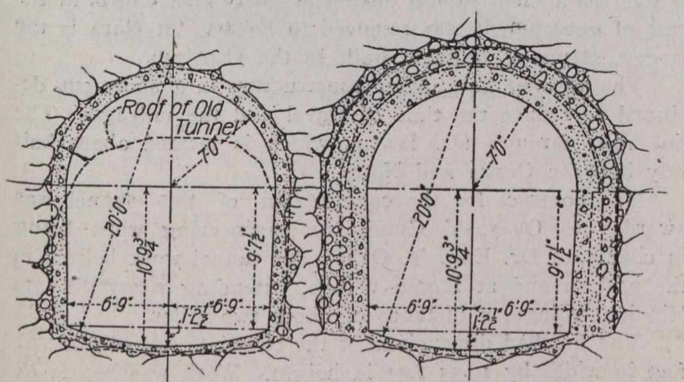
The dam was built in the dry between two cofferdams. It is founded on solid rock, at each end, but in the centre of the river rests on the boulders and hard pan of the river bottom. A row of timber sheet piling was driven along the upstream face to prevent leakage under the dam. During the first winter it successfully withstood a flood of 95,000 sec. ft., about three-fourths the maximum expected in the river. This overtopped the crest about 22 ft. No leaks developed, except one at the end, through a crevice in the rock, and the pond above was filled with so much silt it made the dam quite tight. However, the large amount of silt in the water caused a sand blast action, which wore away the decking in some places from 2 ins. to 4 ins. The timber for the dam was all obtained from the company's property near Camp 8, on the east side of the Bend, and was sawn at the mill there. It is mostly pine.

Permanent Dam.—The masonry dam was not started for a year after the timber dam was finished, and has just been finished up to El. 920. It is about 300 ft. long on the crest and is 50 ft. high above the river. It is high enough to turn the water through the gates of the intake tower and to form a regulating reservoir to store water for the daily peak loads and enable the station to operate at any load factor without wasting water. It has a gravity Ogee section of cyclopean concrete masonry, and is very broad at the base on account of the severe floods. The maximum flood will overtop the crest about 23 ft. The foundation is a very hard and tough diorite rock, locally called greenstone. The bottom of the river was covered with large boulders and gravel, which had to be excavated. The lowest point of the foundation is 45 ft. below the original water level. In constructing the dam a new camp and quarters were built. Four Lidgerwood cableways were used and a large new rock crusher plant and concrete mixing plant installed. Of course, it is intended, as explained before, that this dam will ultimately be built 90 ft. higher.

Tunnels.—As was shown on the map, the old tunnel of the Big Bend Mining Co. only discharged into Dark Canyon, and did not go completely across the neck of land to to the main river below. This old tunnel has quite an interesting history. It was started in 1883 at the time placer gold mining was booming in that part of California, the idea being to divert all the dry season flow of the river through the tunnel of 12,300 ft. long to Dark Canyon, and leave the river around the bend dry, thus allowing the company during the summer to work the gravels and sand in the river bed and extract the gold which was supposed to be there.

The tunnel was started from the Dark Canyon end, and required three years to complete. It was about 8 ft. high by 13 ft. wide, and had a grade of 5 per 1,000. The progress was rapid, 400 ft. being made one month. A timber diverting dam was built across the river just below the intake, but when the water was turned through the tunnel it was found that unfortunately the tunnel had not been made large enough, and would not take nearly all the summer flow. It was then enlarged, requiring another year, by taking 4 ft. more from the roof of the tunnel, making it 12 ft. x 13 ft. in cross-section. The cost of the complete tunnel was then $750,000.

Work was started prospecting the river in 1888, but with poor success. The next year the company spent $100,000 to obtain about $40,000 worth of gold, hardly a paying proposition, so the project was abandoned. The tunnel then lay idle until purchased by the Great Western Power Company to be used as part of their development.



Cross Section In Solid Rock Timbered Section

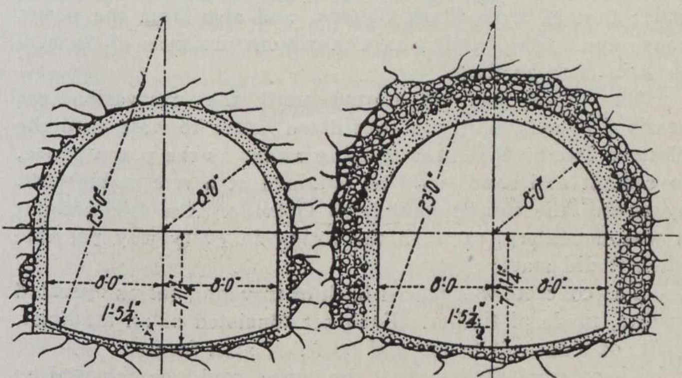
Fig. 3.—Typical Sections of Enlarged Tunnel.

The maximum flow required in the tunnels is 2,500 sec. ft. The maximum allowable velocity decided on was 11 ft. per second, so the net cross-section was made 220 sq. ft. inside the concrete lining. The old tunnel measured about 12 ft. x 13 ft., so it had to be considerably enlarged. It was made of a horseshoe section 18 ft. high x 14 ft. wide inside the lining, or 20 ft. by 16 ft. outside the lining, Fig. 3. The enlargement was made by taking from 5 to 6 ft. from the roof and by trimming 2 to 4 ft. from one side. This is the reason for making the section so high in comparison with its width, as it was considered more economically in making the enlargement to take as much from the roof as possible.

The 3,400 ft. extension, or new tunnel, being entirely new, could be made a better section. As shown, Fig. 4, it is 16 ft. wide x 16 ft. high inside the lining, horseshoe shape, but the same net area.

The concrete lining is intended to be 12 ins. thick. The minimum allowed on the sides and arch was 6 ins., and 4 ins. on the invert. From careful cross-section taken with a sunflower the actual thickness averaged 21 inches.

At the intake the invert is 54 ft. below the present crest of the dam; throughout the new tunnel and in the header pipe about 120 ft. below. When the dam is raised to its final height, the header pipe will be 200 ft. below, and the tunnel has to withstand the internal pressure due to this.



Cross Section In Solid Rock Timbered Section

Fig. 4.—Typical Sections of New Tunnel.

The ground is solid rock throughout. The new tunnel and both ends of the old tunnel are through shale, but about 6,000 ft. in the middle of the old tunnel is through a very hard and tough blue trap, really a diorite.

The surface of the ground is mostly from 400 to 1,500 ft. above the tunnel and all rock. The few springs encountered in the tunnel or appearing along the canyon side, tended to show that the ground water level was much higher than that necessary to counteract the internal pressure in the tunnel. On this account weepers (2-in. diam. pipe) were placed in the lining to relieve any pressure from the outside, one for each 100 sq. ft. of lining, and extra ones where any springs were encountered. However, the tunnel was very dry, and none were struck which gave more than what a 1-in. pipe would carry.

There were, however, three exceptions where all weepers were omitted and the lining was made at least 24 ins. thick. First, for about 200 ft. in from the intake. Second, for about 400 ft., where the new tunnel branched off from the old and ran under Dark Canyon. At one point here there is only 80 ft. of rock overlaying the tunnel. Third, for about 373 ft. in from the header pipe or to a point 500 ft. away from the portal above the power house. Great care was taken at these places to secure dense concrete closely packed against the rock.

In the other parts of the tunnel the rock is depended on to take the pressures, and the lining is considered merely as a means to obtain a smooth tube with small hydraulic losses. In fact, one engineer seriously proposed lining the tunnel with planed red-wood timbers supported on concrete cradles.

The proportions of the concrete mix were 1:3:5. Puddling stones were embedded in the concrete where possible, keeping them 6 ins. from the face. Very little timbering was necessary except at each portal. At the intake end and throughout the tunnel the timbering was all left in place; but at the portal above the power house it was removed, before the lining was placed.

The exit into Dark Canyon was closed by a concrete bulkhead 25 ft. thick. Two 12-in. pipes fitted with gate valves were left through this to drain the tunnel and act as sand traps.

The excavation from the roof of the old tunnel was carried on from heavy traveling timber platforms 24 ft. long. The rock was blasted directly onto these, then mucked into the cars below, and hauled away by electric locomotives. There were generally three platforms for each gang of miners drilling being done on one, while mucking from a second and moving the third ahead. Twenty travelers, or jumbos, were required in all, a number being broken in the hard trap rock. The progress varied according to the hardness of the rock, from 10 ft. per day to 3 ft. per day per gang of men.

The new tunnel was driven with a full width heading followed by a single lift bench. It was worked from both ends; that is, from Dark Canyon, and also from the power house end. The result was a maximum progress of 64 ft. a week in each heading.

The lining was not started until the excavation was nearly finished, as it was considered better to wait until the Western Pacific R.R. was running as far as the power house, so cement and sand could be obtained at a reasonable cost, by saving the wagon haul from Oroville. On this account it was necessary to rush the lining in every way possible when it did start.

The concrete was placed back of traveling forms operated in sets, made of timber. Each set consisted of an air hoist, 60 ft. of side wall forms and 60 ft. of arch forms.

These were arranged so the forms could be released as soon as the concrete had set and the carriage run ahead on rails to its new position. A 60-ft. form could be released, run ahead and set up again in from 3 to 6 hours by a small gang of men.

One gang operated two sets of these forms and would fill one while the concrete was setting behind the other. From four to five gangs, both day and night, were employed, and the record progress was the equivalent of 860 ft. of complete lining in one week.

The concrete was all mixed outside the tunnel and was hauled in by the electric locomotives.

There were three mixing plants, one at the intake, one above the power house and one in Dark Canyon. Each consisted of a No. 5 rock crusher and two ½-cu. yd. Smith mixers. There were two sets of 24-in. crushing rolls at the intake to crush rock fine for use as sand. Sand for the other plants was obtained from Marysville, 46 miles down the river on the Western Pacific R.R.

At Dark Canyon was located the principal camp and equipment. It was crowded and inconvenient, as there was practically no level ground on which to place anything. There were accommodations here for about 600 men. There were three air compressors with a capacity of 3,500 cu. ft. per minute, eleven 50-horse-power boilers, machine shop, blacksmith shop and the concrete plant. Cord wood was used for fuel until most of that in the district was burned, and then crude oil was used. Three hundred horse-power of electric power at 30,000 volts was also obtained from the Oro Water, Light & Power Co. from a small station on the West Branch, seven miles away.

CARE OF BOILERS.

In his annual report to the Montreal board of control, Mr. E. O. Champagne, city boiler inspector, claims that while the necessity for legislation looking toward the installation and care of boilers was dealt with in his last annual report no action has as yet been taken by the corporation.

DRIVING A DOUBLE-TRACK TUNNEL IN JAPAN.

The Japanese people have given us many evidences of their progressiveness, but nothing emphasizes their spirit of progress more than the work which they are now doing in building a double track, wide-gauge electric railway, between Osaka and Nara. Mr. W. L. Saunders describes some of this work in a recent issue of the Mining and Engineering World, from which we have abstracted the following:

Osaka has been called the Pittsburg of Japan. It is the commercial metropolis, with 1,000,000 inhabitants, covering an area of more than 8 square miles, intersected from east to west by the river Yodo, and with numerous canals running through it, Osaka is admirably situated for a manufacturing city. Its principal trade is with China. On arriving at Osaka one is impressed by its industrial activities as illustrated by the large number of chimneys. Old Osaka has left its monument in the great castle built by Taiko Hideyoshi in 1583. Little remains of the old castle but the ruins, and principally the walls of the moat. These walls contain huge blocks of hard granite, some of them measuring 40 feet in length and 16 feet in height.

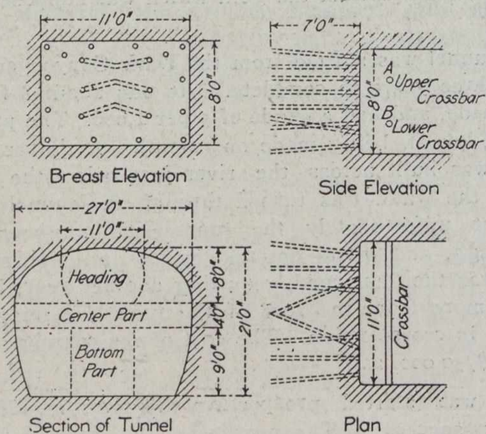


Fig. 1.—Scheme of Drilling Heading.

From Osaka to Nara is from new to old Japan, for Nara is in every respect representative of what Japan used to be. It was the ancient capital during seven reigns, and until the seat of government was removed to Kyoto. At Nara is the largest statue of Buddha, built in the year 746.

The railway now under construction is a short cut designed to reduce the time of travel and the mileage. The line runs through Mt. Ikoma, which is located about half way between Osaka and Nara.

The contract for the construction of this tunnel was awarded to Obayashi Gumi, the engineering work being in charge of Dr. Eng. T. Oka. The tunnel work begins in the eastern end at Ikoma village, extending westwardly to Hineichi village, a distance of about two miles.

The finished dimensions of the complete tunnel are 22.2 feet in width by 19.35 feet in height. Work was begun on July 3, 1911, and is now being prosecuted from the two portals.

Fig. 1 shows the methods pursued in this work. The upper sketches represent the heading, one being an elevation showing the breast, and the other representing a vertical section, or elevation, through the heading.

The lower sketch to the left in Fig. 1 shows a section across the tunnel, illustrating the entire width and height, and showing the heading in the upper central part, with the centre prism separating the heading and the bench, or bottom part.

To the right and to the left of the heading, and to the right and to the left of the bench, are sections which are excavated by the use of stoping drills. The centre prism is also removed in the same manner.

The plan immediately to the right of this section illustrates the cross-bar used for mounting the drills in the heading. The heading is 8 feet high and 11 feet wide; the centre part is 4 feet high and 27 feet wide, and the bottom part or bench is 9 feet high and 8 feet wide.

In the heading a bar 5 inches in diameter and 10 feet in length is fixed horizontally across the tunnel. Jack screws, located in each end of this bar, serve to adjust it to proper lengths, and to fix it rigidly against the walls. Three water Leyner drills are mounted on this bar, and the upper holes are first drilled. Then the bar is lowered to a point nearer to the bottom of the heading, and the lower holes are drilled.

Because of the use of these light-weight drills, which do not kick hard against their mounting, it is possible to employ this bar in place of the usual columns. Columns with arms are mainly used in America, because drills of the percussion type require a very rigid mounting. It is obvious that the use of the horizontal bar facilitates the

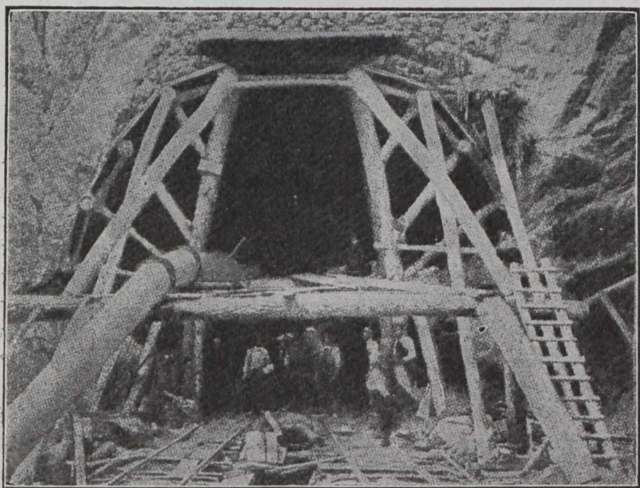


Fig. 2.—Tunnel Portal.

handling of the drills, and makes it possible to set up after a blast quicker than by the use of columns. The whole thing with the drills mounted is handled readily by a gang of men, who climb up over the muck, placing the bars in position and drilling the holes, while the muckers are at work below them.

The centre, or cut holes, are drilled to a depth of 8 feet, all the other holes being 7 feet in depth. Blasting is done by time fuse, which is admitted nowadays to be the best practice. Gelatine is placed in the bottom of the hole next the primer, over it is placed some gelatine and then 60 per cent. dynamite. Clay is used for tamping. Where the rock is hard, from 22 to 26 holes are drilled in the heading, but in softer rock this number is reduced to 16 holes in some cases, and in others as low as 12 holes. The rock in Mt. Ikoma is granite, usually hard, especially in the east end.

Progress in this tunnel has averaged over 10 feet of heading per day. Records have been made of 20 feet in 24 hours, single heading. This was on the west side where the rock is of moderate hardness. It usually requires 5 hours to drill 20 holes, 6 to 7 feet deep. The work of loading, firing and taking out the rock consumes about 3 hours, or a total shift of 8 hours. The work is done by the miners in 6-hour shifts, working day and night. One superintendent is in charge of each heading, with three drillers and three helpers.

Mine cars made of wood are used, carrying a capacity of 30 cubic feet, track 30-in. gauge, 25-lb. rail, the train of 10 cars being hauled by an electric locomotive.

For ventilation 50-h.p. Root blowers exhaust through a 20-in. stack. Ingersoll-Rand air compressors of 115-h.p. each furnish the compressed air at 100-lbs. pressure, the air being conducted to the heading through a 5-in. pipe.

The holes drilled are usually of about 2 ins. in diameter, and the progress of the drills is from 7 to 12 inches of hole per minute. Although water is fed into the bottom of the hole, the discharge of the cuttings is really effected by compressed air, which is forced in with the water, the minimum amount of water being used, and only for the purpose of laying the dust.

Power at the portals of the tunnel is transmitted electrically as a distance of 16 miles at 3,500 volts; 16-candle-power electric lamps are used for lighting.

Up to May 31, 1912, an advance was made in the east end of 2,127 feet, and in the west end 1,917 feet, or a total progress of 4,044 feet. The tunnel is to be lined with brick, about 1,000 feet being already completed.

WORKMEN'S COMPENSATION IN ONTARIO

In connection with the Royal Commission appointed by the Ontario Government to consider the question of compensation to injured workmen, the commissioner, Sir William Meredith, is visiting England and the continental countries to investigate on the ground the systems in operation in these countries.

A plan may be proposed by which all workmen sustaining personal injuries by accident, arising out of and in the course of their employment, will receive compensation, irrespective of who was to blame. A Workmen's Compensation Act of such a nature would be only similar to those adopted in the other Provinces throughout the Dominion, as well as in England.

There is a suggestion in the interim report of the Commissioner that the manufacturers of Ontario are favorable to a scheme of State insurance. The details are not disclosed, but the scheme would probably be operated on an assessment plan.

Commenting on this, Mr. Alex. MacLean, manager and secretary of the London and Lancashire Guarantee and Accident Company of Canada, says: "State insurance is a movement towards paternalism of government, more far-reaching than any economic measure heretofore proposed. The adoption of such a plan commits one to a principle, which, if carried to its logical conclusion, means that any or all commercial industries may properly be conducted by the government to the exclusion of private enterprises.

"It is for the government to decide as to what form of legislation to place on the statute books in respect to compensation to injured workmen. That is one thing, but for the government arbitrarily to fix the rates that the employer must pay for his protection is taking away the inalienable right to purchase insurance, or protection, at the lowest possible cost.

"Any legislation that will eliminate law costs and provide adequate compensation to the injured workmen will be gladly welcomed by the insurance companies. Let the government pass such an act, and if necessary see that the liability companies are subject to the closest government inspection so that no injustice will be done the employer in the fixing of rates. It will be found that there will be a better feeling between the employer and employee than if arbitrary rates are fixed by the government under a system of State insurance and injured employees are compelled to look directly to the government for compensation."

CANADIAN PACIFIC EAST-BOUND RATES AND EMPTY CAR MILEAGE

An official of the Canadian Pacific Railway, in speaking of the freight rate situation, high eastbound rates and general traffic conditions, says: "Nearly 40 per cent. of our freight trains moving westward are made up of empty cars, and it costs nearly as much to haul an empty car as it does to haul a loaded one. This empty movement is one of the largest shown by an important division of any great railroad company, and it practically means that the rates on eastbound tonnage, in order to protect the company, must be high enough to cover the eastbound haul, and also the expense of returning the empty cars to the Pacific coast.

"The bulk of this traffic," he says, "consists of lumber, and for this are used principally the ordinary box cars, which are suitable for the haulage of grain or general merchandise. It is only the long timber that is hauled on flat cars. If the cars which now return empty could be loaded with grain or merchandise, the cost of the westward trip would then fall on the latter and the burden removed from the eastbound traffic.

"In the United States, roads that show an empty car mileage of about 20 per cent. are considered expensive to operate, and in our traffic we have an empty car mileage of approximately 40 per cent." He also points out that the Canadian Pacific has probably invested more money in roadbed and equipment than any other road moving a high percentage of empty cars The line from Calgary to the coast has not yet become a profitable investment, but it was necessary to build the line in order to reach the large lumber sections and mineral deposits of British Columbia and to furnish an outlet for Canadian products to the Pacific coast.

On this division there is almost a total absence of local traffic, whereas it is on heavy local traffic that railroads principally depend for profits. The cost of road, he points out, is about $100,000 per mile, equipment included, through the Rocky Mountain section, and yet the traffic developed up to the present time is considerably less than on most roads costing not more than about $60,000.

Pacific coast extensions have proved a somewhat expensive necessity without an adequate return of profit, but it is in keeping with Canadian Pacific policy that this work is undertaken, for this road has always built far in advance of traffic demands. At present, Canadian Pacific is spending about $2,500,000 for a new station and office building at Vancouver, and also a new pier at Vancouver Island.

A large westbound traffic in wheat, which may be reasonably expected in time, will have the effect of lowering rates on eastbound freight and incidentally enable manufacturers to extend their markets in Alberta, Saskatchewan and other eastern provinces.

THE UPPER ATHABASKA REGION.

The rapid linking together of the Grand Trunk Pacific to form a new transcontinental highway across central Canada opens another hinterland for the tourist. It makes easy of access a vast new section of the Rockies in central Alberta and the sunset province, and of all this area it is doubtful if there is a more interesting and inviting region than that embraced by the upper watershed of the Athabaska River and its several southern tributaries. The natural starting point for tourists intending to visit any of this country is Fitzhugh, a picturesquely situated frontier town in Jasper Park, some two hundred and fifty miles west of Edmonton.

How little of this region has been actually trodden by white men is evidenced by the fact that only four short summers ago the largest sheet of water on the entire east slope of the Rockies was found in its recesses. This beautiful mountain lake, some seventeen miles in length, and lying between green wooded slopes, forms a broad expansion of the Maligne River, and resembles a Scotch tarn in its far-melting vistas of water and crag. This lake is some thirty miles south-east of Fitzhugh, and twenty miles farther south is another large lake, where the trout fishing is excellent. The latter body of water forms the chief source of the Brazeau River. To the west of it, in Alpine grandeur, lies the region of wild, lofty peaks, dominated by Mount Alberta, where enormous glaciers give birth to the Athabaska and North Saskatchewan Rivers.

This region is also a noted game country. It lies far enough north to have escaped in part, during recent years, the far-searching reach of the Stoney Indian; bears of all kinds are still fairly numerous; the sheep (and more especially the goat) hunting is good, while scattered moose, deer, and even elk, may be occasionally seen.

Meantime, the crying need of the district, for tourist and fire-ranger alike, is the need for more and better trails. Hence, to provide a good and adequate system of trails will be the first and constant effort of the Dominion Forestry Branch in carrying out its recently assumed duty of administering this region, so as to protect its forests from fire and make every auxiliary resource contribute its part to the public welfare. During the present season the rangers in charge made a good start on this work, and next year it will be again pushed with vigor. Already, between Laggan or Morley, on the Canadian Pacific Railway, and Fitzhugh, an old through trail is in existence, a trail which promises to be a very popular Alpine tourist route when improved. It traverses the Brazeau, Clearwater and Bow River, forests, and everywhere its improvement will be promptly undertaken by the Forestry Branch.

The scenery in this upper Athabaska country is varied and beautiful in its color effects, and specially so in early autumn. From the deep green carpet of pine and spruce on the valley floor the eye passes to intermingled belts of blushing gold poplar and light green lodgepole, fringed above to timber line by sombre masses of Alpine fir. Higher still, the warm reds and ochres of disintegrating ferruginous rocks form a Joseph's coat of many colors, while over all loom the background of summits wrapped in their eternal snows.

THE AUSTRALIAN TRANSCONTINENTAL RAILWAY.

At Port Augusta, South Australia, on September 14th, the interesting historic ceremony of breaking the first sod in the construction of the Transcontinental Railway was performed by the Governor-General (Lord Denham). A large number of legislators and others interested in the work were present. This new line, to connect the State railway systems of South and Western Australia, will be 1,063 miles in length, and the gauge is the standard of 4 feet 8½ inches. The highest point on the line is an elevation of 1,354 feet and the steepest gradient 1 in 80. It is estimated that the work will be finished in from three to four years at a cost to the Commonwealth of, approximately, $20,000,000.

The completion of the railway will open direct communication (independent of the existing steamer services from Adelaide, S.A., to Fremantle, W.A.), from the eastern states with Western Australia, which is the largest state in the federation, comprising an area of 975,920 square miles, with the present limited population of about 420,000.

LIGHT COMPRESSION MEMBERS.

On March 11th, 1912, the Western Society of Engineers held a meeting at which a topical discussion of the design of light compression members was taken. The discussion is given herewith:

Horace E. Horton: I have just one thing to urge in connection with the details of compression members—not necessarily light members, but all members. The error I discover is that the principal part of our discussion turns on the radii length, while it has developed, with the built-up members universally used, that the composition of the section has more to do with its efficiency than its radii length.

Our knowledge of column design has been evolved from laboratory experiments on solid rounds and small pipe, made approximately eighty years ago. The laws of flexure for rolled sections were fairly well developed by these early tests; in fact, we have repeated examples justifying the laws of flexure as set forth in the formulae. In the evolution of things, however, we have come to build compression members that are not rolled but are composite structures, usually of plates and angles. We may use channels or we may use beams, but practically speaking, the members are built up of plates and angles. There are specifications in general use that allow a greater compressive than tensile stress per unit section of the same material. It was this error that culminated in the Quebec disaster. Compression members of forty radii were used with as great a unit stress as that allowed for tension, and in some cases a still higher unit stress was allowed on these compression members. As a matter of fact, the compression members of that structure failed with one-quarter the unit load that the material would have sustained in tension. Now, it failed how? Not by flexure, but by the wrinkling of the component elements.

Another engineering society started, some years ago, to gather all available statistics with reference to compression members. The committee of that society concluded that laboratory tests were of no value and they found, altogether, 268 recorded tests of large compression members, 184 of which were of iron and almost obsolete, except as illustrating general laws. A second group of 52 tests were made on rolled sections, namely, pipe and **H** sections. The tests of this second group undoubtedly show the maximum efficiency possible in a compression member. Each one of a third group of 32 built-up members failed by wrinkling of the parts. Not one of them yielded by flexure. In other words, none of the tests of which we have record shows a built-up member which was so designed as to reach its maximum efficiency.

We are left with the question: Suppose two, or three, or four times as many rivets had been driven through the angles and plates; or again, suppose that rivets of twice the area had been used. Would the members have sustained a greater load? Would we have obtained a greater efficiency from the material by using more or larger rivets?

What we want instead of 32 is more than 1,000 tests, varying the constituent elements such as radii length, size, and number of rivets. It happens that the members of this third group of built-up members represent about 65% efficiency, as compared with the rolled sections, at their point of failure. The loss is 35%, and it is here that experimental research can point the way to better design. We will have to have a large number of tests to give us the knowledge necessary to design to the best advantage.

Because the cost of a sufficient number of tests of full-sized members is prohibitive, I am personally inclined to think that laboratory tests are all that we can hope to get in sufficient number. Suppose we use a built-up section of two plates, 4 by ⅛ in., four angles ¾ by ¾ by ⅛ in., varying the size of the lacing and the size and number of rivets as the research advances. This section would have a gross weight of, say, 8 lb. per lineal ft., would have a radius of gyration of 1.5 and a sectional area of 1.42 sq. in. The length for $24\,\frac{l}{r}$ would be 3 ft., and for $240\,\frac{l}{r}$, would be 30 ft.

If we should make tests of five members of each of these lengths and eight intermediate lengths, we should have 100 tests which would undoubtedly point out many valuable facts. By making 1,000 tests in all, it would probably be possible to discover the spacing and size of rivets to make the material fail by flexure rather than by wrinkling.

The Pennsylvania Lines (Panhandle) not long ago made elaborate tests of six large members about 40 ft. long, each nearly 100 sq. in. in cross section. The material for these tests alone represented some 80,000 lb., or about the equivalent of the material required for the 1,000 tests suggested above.

I believe that we are safe in concluding that there is no mere mental analysis that will ever show us the required relations. Physical tests are required. We have only 32 tests of full-sized steel members in all the years that have gone. These members were all designed on the theory that they would fail by flexure. They all did fail by wrinkling. Failure by wrinkling invariably indicates a low efficiency and a poorly designed member. Sections such as I have indicated can readily be handled in our university testing machines. At the University of Illinois, as at other engineering colleges, there are ambitious professors and active students. Give them a chance. I believe that if this society would become interested in the subject, it would be possible to actually devise means whereby 1,000 such laboratory tests could be made, thereby adding more to our knowledge of the compression member than we could hope to obtain in any other way.

F. E. Davidson: In this discussion I trust some one will take up the question of a rather long compression strut with light loading, and show us how he would build an economical strut out of ordinary stock sections. That is a problem that architects and engineers have to meet constantly. The requirements of our revised building code with regard to compression members are very rigid compared to what could be done a few years ago. There are certain credits given to steel that is encased in concrete under certain conditions; that is, one can use a higher stress in certain types of columns than in other steel shapes with the same amount of concrete fireproofing.

When I was with the Illinois Steel Company I often used, in struts between roof trusses, a light channel with a plate riveted to one flange. For instance, with a 7-in. channel I would use a 7-in. plate and run the plate about three-quarters the length of the channel, simply to stiffen it sidewise. It is true I do not know of any case in which this section was used where the unit stress in the steel was over 3,000 to 4,000 lb. per sq. in. That was not economical; it was wasting steel; but it was the best we could do. I have used a 5-in. I-beam with a 4-in. channel riveted to the web. The channel has no office to perform, whatever, except to stiffen the I-beam section. The latter takes the entire loading. This section of a column is one that can be put in an ordinary 4-in. partition in an apartment building.

Recently the Lally column has come into use, which is nothing but a steam pipe filled with concrete, and it is my opinion that it might as well be filled with sand. The star-shape section, made of two angles, is very weak in one direction, on account of the very small radii.

To-day we are confronted with the proposition that we have not, nor can we build, an economical rigid section for very light loads. Take, for instance, wind bracing. It is easy enough to provide a suitable section for heavy loads, but with light loads it is a different matter. In our building designs of to-day, for instance, the columns in the top story of any building, a 5-in. **H** section would support every load, but you cannot get it and what will you use in its place? As a matter of fact, I doubt if the manufacturers of steel have kept pace with the demand for economical sections along these particular lines. I understand that the Illinois Steel Company are developing these sections, and are making rolls for a new set of beams throughout; also that they are developing some very small, light sections, and are changing the moments of inertia and the weights of standard beams from 8 to 24 in.; so that very soon we shall have a new series of steel structural shapes to figure on. This is all right for floor construction, but what I am after is something that we can use for columns and struts, which is economical; where the steel can be actually stressed up to a working limit of, say, 10,000 lb. per sq. in. Heavy column sections may be built out of a number of structural shapes, but in the light sections we are compelled to waste material, no matter what we use.

Albert Smith: I am quite unequal to suggesting any section that would be thoroughly economical in the case which Mr. Davidson mentions. We use channels, light channels, with angles at the bottom in an endeavor to make the actual fiber stress come as near as possible to that permissible in such a case. It has sometimes occurred to me that it would be possible to use a pipe section in cases of that kind. If we could get pipes 18, 20, or 24 ft. in length of thin material, and could manufacture a standard detail for the end, to be threaded onto the pipe, we might be able to carry these very light loads economically. I think we are too much afraid of doing shop work, in general; we think a little too much of the cost of coping and of blacksmith work. With us, with the very excellent machinery that we use, he cost of shop work cannot be anywhere near as great as with English manufacturers. I refer especially to the small compression members of a bridge brace—those which we now make of single angles. English designers use T-bars almost exclusively for such struts, cutting off the outstanding leg, and I think such members could be used economicallv in our trusses. The cost of coping would not be great and we should avoid, in most cases, the gusset plate. Nine times out of ten two rivets are sufficient for a connection, and the two rivets could be driven through the remaining leg of the T-bar into the top chord.

In regard to large compression members—those to which Mr. Horton has referred—I wish that such tests could be made by the government, and that when they are made they would parallel the case of the members in the field—for instance, the vertical posts of railway bridges. It seems to me they would be better if tested in connection with the floor beam, and it does not seem impossible to put bending in that floor beam while the test is being carried on. It should be braced with a knee brace at the other end in just the way the bridge in actual service is braced, and then we might find an answer to a question which is as yet entirely unanswered in specifications or in practice: What constitutes free length? I have in mind a set of specifications which permits three definitions; fixed at both ends, fixed at one end and free at the other, and free at both ends and allows the free length to be made one-half, two-thirds, or the whole of the distance between connections on that basis. I do not know what constitutes a fixed-end connection in an actual structure; it seems to me it would be very hard to determine, and also very hard for anyone to say in a given case that he is willing to take one-half the length between connections as the free length of his member. There are so many things that enter into the stiffness of the member, in the connection, the yielding of the support, the rigidity of the attachment, that it seems as if a test, which would simulate actual conditions and show the actual value of the compression member under those conditions, would be very valuable. The difference in the permissive fiber stress is likely to run as high as 25% or 30%, according as you vary the free length—that is, supposing you use the ordinary formula, 16,000 minus 70 $\frac{l}{r}$, and 30% is a rather important amount in the design of your member.

I have no suggestion that bears directly upon the subject that the chairman has in mind.

Henry E. Vanderlip: In listening to Messrs. Horton and Smith, a few things have occurred to me. First, in regard to the question of wrinkling referred to by Mr. Horton. I have seen columns with that wrinkling between rivets, produced by heavy loading. There would seem to be a bulging out between the rivets, and yet the rivets had been spaced according to the so-called practice, which ordinarily is that no ¾-in. rivet—which is the standard rivet used in bridge and building construction—shall be placed at a greater distance than sixteen times the thickness of the thinnest outside piece of the member. This would mean that a ⅜-in. plate would be the minimum thickness where 6-in. spacing could be used, and a 5/16-in. plate, according to the rule, would permit not greater than 5-in. spacing. Yet, if you use that same 6-in. spacing with a ⅜-in. plate under some conditions of loading, you will get a bulging or wrinkling of the plate. According to the formula, it should not bulge. That is one of the peculiar things in the construction that nobody has ever seemed to explain.

The subject that the chairman brought up, about the advisable form of column for light loads and long lengths, is one which has not often been brought before the engineering profession. We might consider two forms: First, a post or column under four points supporting a water tank—a gravity tank—placed 25 ft. (approximately) above the roof of one of the standard warehouses as they are built in Chicago. There are all kinds of forms of columns used, and it does seem as if the engineers should agree on some standard form that seems to be the most economical for that purpose. You will see a dozen different forms to carry, say, a 25,000-gal. water tank. I have known of cast iron being used for that purpose, but personally I would not select it. I have seen two channels used so as to form, with cover plates, a box-shaped column. Then I have seen four angles with a single web plate, which we all know has unequal radii of gyration on the two axes. Then I have seen star-shaped forms, and the star may be formed by using two or four angles—two angles of sufficient area to take a light load—and increasing those two angles in thickness and in the size of the leg of the angle until we reach a point where good judgment would say you should use four angles as the load increases. I think this is a very good form of column for that purpose, for the reason that a water-tank tower is essentially a wind-braced structure. Therefore, since it is a wind-braced structure, one can arrange the position of the wind bracing horizontally and diagonally so that the question of the radius of gyration does not really enter into it. Another thing, the gusset plates can be arranged in between the angles, and the connections, from a bridge shop point of view, are about as good as can be obtained.

The other form I have in mind is a long column. Imagine a column, say 40 ft. long, in the middle of a large and high room, with an upper floor and roof of the building carried on that long column. According to the building ordinance, if the column is to be fireproofed with tile where the tile did not aid in stiffening the column, then the radius of gyration of that column should be 1/120 of that length; or, 40 ft. being 480 in., there would be a radius of gyration of 4 in., and the engineer would select a form of column where he would have a radius of gyration of 4 in. The form is a matter of preference. Probably in a case like that the average engineer would select a box-shaped column, as it is easier and cheaper to get a radius of 4 in. with the box shape by using channels and cover plates.

J. Norman Jensen: It might be advisable for me to review some of the features of the ordinance in regard to columns. As you probably know, the ordinance formula for the allowable stress is $16{,}000 - 70\frac{l}{r}$, and if the column is filled with concrete, and also encased with concrete, so that there is at least 3 in. of concrete outside of the metal, there is permitted an allowable stress of $18{,}000 - 70\frac{l}{r}$, but not to exceed 16,000 lb. In the first formula referred to, the limiting stress is 14,000 lb. These are the highest stresses that can be used, and the limiting length of the compression member is 120 times the least radius of gyration. You will find, if you want to use an I-beam column, as is sometimes advisable, say a 6-in. I-beam, you could not use a length more than 7 ft. 2 in., and if you had an ordinary ceiling height of 10 ft., or a little more, you would have to use a 15-in. I-beam, 42 lb. per ft. This 15-in., 42-lb. I-beam would be insisted on, even for the top floor of a building where there is only a light roof load, because we have only the ordinance to go by, and that is the requirement of the ordinance. In order to meet the condition for slender columns, the Lally and the Acme columns have grown into use under the protecting wings of the ordinance. Where you would have to use, say, a 15-in. I-beam, 42-lb., you could use a Lally column or an Acme column 4½ in. in diameter, and satisfy the requirement as to length. Probably most of you know that these columns are merely pipes filled with concrete under pressure. In the city of Chicago there are two types—the older form called the Lally column, and another form called the Acme column—a recent competitor. While, of course, we cannot show any preference, we find that the details of the Acme column are considerably better.

The reason for bringing up this topic of light compression members, and the cause of this discussion about the limiting length of compression members, is that in apartment-house work in particular we want a column to fit inside of a partition. A 15-in. 42-lb. I-beam will not go inside of that partition, and so the architect and the engineer are compelled to use these round forms of columns, in order to comply with the rule in regard to limit of length. We would like to see the ordinance changed. We would like to see the limiting length increased from 120 to 150 times the least radius of gyration. This would allow the use of I-beam columns which are now practically excluded in buildings. The average round pipe column is of rather flimsy construction. There is no stiffness or rigidity about it. The use of an I-beam column for light loads will give something that is fairly stiff, and will be a section to which an I-beam can be riveted or bolted.

Tests at the Watertown arsenal, and other places, show that the radius of gyration has practically nothing to do with the strength of the column. The recent tests at Watertown arsenal show, for the lengths tested (from 25 to 175 times the least radius of gyration), that there was practically no difference in the strength. The one at 25 was just about as strong as the one at 175 times the least radius of gyration. So it seems that we are placing altogether too much emphasis on the theoretical considerations, and that we must come back to common-sense ideas and realize that in a compression member we want a good sturdy member, a member all of whose parts will work together, and not a highly theoretical member where the metal is in thin sections widely spread.

I spoke of the building ordinance and my hope that it would be changed to allow the use of I-beam columns in buildings. If such a change were made I would also suggest that the wording of the limiting length of cast-iron columns be changed. At present it reads: "The limiting length of a cast-iron compression member shall not be more than 70 times the least radius of gyration." The average layman and the person who has many other things to think about does not want to figure out the "70 times the least radius of gyration." The way that rule was obtained was this: They took the old rule of thumb of limitation of the length of a cast-iron column to 24 times its least diameter and translated it into 70 times the radius of gyration.

I do not know particularly what columns are referred to as freak columns. Sometimes we run across water-tanks carrying very heavy loads with supporting columns of single angle sections. Of course, theoretically that would seem to be all right, but it does not always look right. Outside of that I do not know of any particular instance just now.

Mr. Vanderlip: May I ask a question? Mr. Jensen remarked about the radius of gyration not having much to do with the strength; this made me think of the form of column that is used in a long boom—some of these modern long booms for derricks, 50 or 60 ft. long. They make those out of four angles, and near the ends where the blocks and pulleys are fixed they come down to possibly 8 in., back to back in both directions. Then as they go toward the centre they bow them out so that they are perhaps 16 or 18 in. wide. Would that not seem to indicate that the radius of gyration is a very important thing in there. The farther out they bow, the larger becomes the radius of gyration to take care of the bending tendency of the column.

Mr. Jensen: The point I wanted to bring out is that theoretical considerations lay large stress on the radius of gyration, but actual tests show it does not make any difference, as is shown at the Watertown arsenal—I am referring to this in particular. They took a certain type of column, and varied the ratio of $\frac{l}{r}$ from 25 to 175., and they found, so far as the load-carrying capacity of the column was concerned, that the ratio of $\frac{l}{r}$ seemed to make no difference; a long column would carry just as much as a short one. Some recent tests at the University of Illinois indicate that this radius of gyration—a thing that has troubled us ever since our student days—really has no right to trouble us. It has not much to do with the strength of the column. We have to make some allowance for it, in a way, but we should not lay as much stress on it as we do.

These tests also bring out another fact. According to the formulae for long columns, we ought to get the higher stress in the middle of the column. When the column is tested, that highest stress is not necessarily at the middle. It may be there or somewhere else.

I do not wish to discredit theoretical considerations, by any means, but to me it is more important to be guided in all these things by actual tests, and if these tests show that the radius of gyration has not much to do with the strength, we ought to throw overboard the radius of gyration.

Mr. Davidson: Mr. Jensen brought out one point that has troubled me somewhat, and that is how to make rigid connection between a floor beam and a Lally or Acme column. He also brought out in his remarks the advisability of using the I-beam. With an I-beam with floor beams riveted to it, there is rigidity to a building. In the other case there is a little steel or iron pipe filled with concrete, set up on a little cap, with no rigidity to it at all.

H. J. Burt: With reference to using I-beams for columns and also other light members, where the load is small in comparison to the section that is required on account of the rule limiting the value of $\frac{l}{r}$, I have resorted to this expedient: I have figured the radius of gyration of only the outstanding metal; that is, the flange of the I-beam. That permits one to go to a longer length for a good sized member and seems to me to be altogether permissible, provided there is enough metal in the flange to carry the load specified.

W. L. Cowles: It seems there can be no question about the cylindrical section. Probably the strongest—it must be the strongest—is the pipe section, and evidently such a form of section has been used for building construction recently, but I should imagine that it might be quite difficult to make satisfactory connections. I am not familiar with the dimensions and what the connections may be. I recall that pipe sections—in fact, actual gas pipes—were used quite extensively by the Brown Hoisting Machinery Company some years ago. The sections were prepared by putting them in the blacksmith shop and straightening out or flattening the ends. They were used in a riveted connection, and for compression members so far as they were available; also for the posts of bridges—the chords, however, being made of channels—and for lateral struts.

I have never seen this method of construction used anywhere else, and in many places it might be considered a difficult or uneconomical one as to shop work, but the Brown Company was equipped for that kind of work, and the results seemed to be very good. The pipe section certainly proved economical in construction and served the purpose very well.

I do not know whether the Brown Company is still using that section or not, but if these pipes can be utilized economically they will naturally make the best section for the purpose.

Mr. Horton: It seems to me that the necessary thing to do in this matter of light column work is to take off the limitation as to radii length of the member. If there is any reason why the limitation should be 120, it has not been disclosed—only the mere fact that is happens there. The tests show 200 radii lengths doing just as good work essentially as 100. For many years I have said that a circular column, if we could make the connection rigid, is the ideal thing as far as cost and everything else is concerned, the difficulty being in the connections.

C. S. Pillsbury: Two small channels make a good section for light horizontal struts with no particular load, such as struts in water towers. In such a member the channels have their webs vertical and are laced horizontally. This design seems to work out very well as regards connections and is a fairly stiff and economical section. I have also seen the box shape, made of four angles with lacing on the four sides, used for very long horizontal struts. The difficulties with this last section seem to be that the lacing is too large a portion of the total weight of the section and that the shop work cost runs up considerably.

The fact brought out in regard to large columns—that they failed by wrinkling and not by flexure—is a most important point which is not always given the consideration that it merits. If composite members fail by wrinkling of the parts at 65% of the load that a pipe or **H** section will stand, then 35% of the maximum efficiency is lost. By spacing the rivets closer or by changing the proportion of the different parts, it may be possible to make built-up members approach nearer the strength of a solid section of equivalent area. Mr. Horton suggests that a large number of tests be made of small-sized members with variations in the relative sizes of the flange and web elements, and in the numbers and sizes of rivets. It might then be possible, from the results obtained, to recover some of the 35% lost efficiency.

Olin H. Basquin: In regard to pipe sections, I recollect that tests were made at the Watertown arsenal not long ago, perhaps within three or four years, in which Mr. Howard showed that pipe sections of moderate lengths fail practically always at their elastic limits when tested as columns. He also showed the same thing for these **H** sections, the form used by the Bethlehem Steel Company. These sections were used with square ends and were loaded very carefully. One would not expect to get such a result in actual practice because they could not be loaded as carefully in a structure as they were in the laboratory. That is one difficulty with all tests that have been made on columns, because the load which the column will stand depends very largely upon the care used in loading it, and the degree of accuracy used in getting that load at the centre of the column section.

The theory of columns is generally thought to be in a very unsatisfactory condition, but this is due to the fact that people do not pay attention to the theory that is already fairly well developed. About thirty years ago Professor S. W. Robinson, of the Ohio State University, published a paper on the strength of wrought iron bridge members, and that paper has been republished in No. 60 of Van Nostrand's Science Series. In that he gives the correct formula for maximum stress in a column, which is based on the same assumptions that are ordinarily used in the beam theory. This formula was rediscovered by Professor Marston, now of the Iowa State College, then a student at the University of Wisconsin, and was published in the Proceedings of the American Society of Civil Engineers, in connection with a paper by Dean Johnson, but Dean Johnson warned the public that this was a very dangerous theory to use in practice —for just what reason I do not know. This theory has crept into the German text-books and has been used there for a long time, but you will find it in a rather subordinate position in the better American text-books of the present time.

This theory depends upon the load on the column being a little out of centre; that is to say, it is the theory of eccentrically loaded columns and it is the true theory for ordinary columns; but in order to apply it, we must know where the load is; in the ordinary column, of course, we do not know where the load is; it may be an inch out from the axis of the column; so, in using an ordinary column formula, we are guessing how far the load is from the centre of the column. Of course, that is a short way and a convenient way of estimating columns in practice, but I want to call attention particularly to the fact that the theory of columns, in so far as columns are well built, is not on a particularly unsatisfactory basis. This theory was taken up by Professor Tetmyer, who published a book on columns and made a great many experiments on eccentrically-loaded columns of rather small size. He took, particularly, a couple of angles, fastened together, and loaded one of the legs, and found that the deflection and failing load corresponded closely with the values which one gets from calculation.

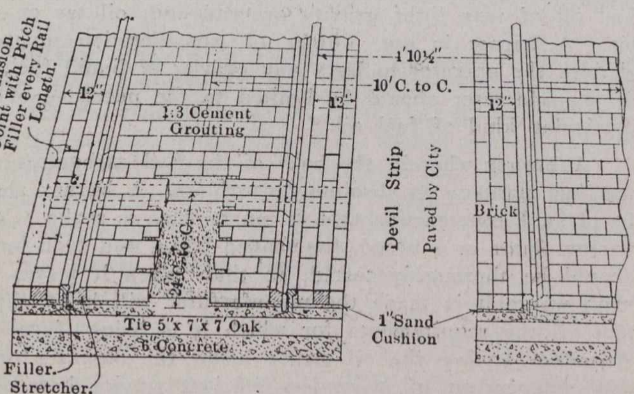
Three or four years ago—perhaps a little longer—Mr. Buchanan published a series of tests made for one of the eastern railways—I think it was the "Panhandle." In some of those tests, which were made on the top chords of bridges loaded on the pins with a certain eccentricity, the deflections which he gives will be found to correspond almost identically with those calculated, but those columns did not fail at the maximum stress which was calculated. Why? Nearly all of them, I think all of them, failed in the details, particularly at the end plates; and I think that is true of nearly all tests of full sized columns made up of riveted shapes. They do not fail at the maximum stress figure, but they fail in the details.

What is needed is more experiments like those recently performed at the University of Illinois, in which they were testing the strength of riveted joints. As far as the columns are concerned, it does not seem to me that there is much need of testing a great many columns in the laboratory until we know how to make the details properly, and then it is not at all certain that the tests will be of any great value, because the failure of a column depends upon how carefully it is fabricated and just how the load is applied, and to apply the load very carefully in any one position in practice is almost impossible. We cannot duplicate in practice the conditions of the laboratory, so that the results which are obtained in the laboratory will not correspond to those obtained in practice.

STREET RAILWAY CONSTRUCTION.

The Des Moines (Ia.) City Railway is using for standard track construction in paved residence streets having ordinary traffic the combination of materials shown in the accompanying drawing, a description of which appeared in a recent issue of the Electric Railway Journal.

The foundation for this track consists of 6 in. of concrete below 5-in. x 7-in. x 7-ft. oak ties spaced 2-ft. centres, with 2 in. of concrete above the ties and a 1-in. sand cushion for the paving. The rails, which are the Lorain 80-335 section, 7 in. high, with 6-in. base, 2½-in. tread and 7/16-in. web, are connected every 6 ft. by 5/16-in. x 2-in. tie rods. The interesting feature of the paving is the use of the Nelsonville (Ohio) Brick Company's filler and stretcher blocks in connection with the T-rail. The filler blocks are 2 in. x 5 in. x 9 in. and the stretcher blocks 3¼ in. x 4 in. x 9 in. in size. Pitch filler is used for the joints between them. The other paving used on the street is of cement-grouted brick, 4 in. deep, as shown in the illustration.



T-Rail with Filler and Stretcher Block, as Laid in Des Moines, Ia.

NEW WESTMINSTER'S HARBOR

Seeing that a bill will shortly come before parliament to make New Westminster a national port; that most extensive plans for the development of this port have been drawn up and the first work is being carried out; and that the development of the Pacific Coast ports is of importance to the whole of Canada, the following authoritative facts concerning New Westminster and the Fraser River, which can be relied on, are of much interest:

New Westminster is situated on the Fraser River, 18 miles from the sea.

The harbor extends from the head of Douglas Island (about 28 miles from Sandheads Lightship) down the north arm to salt water, south to the international boundary and up the south arm to Douglas Island. The length of the main deep-water channel (or south arm) is 28 miles, and 14 miles is the length of north arm for log towing and small vessels. The depth is 14 feet at low-water, and 26 feet O.S. high-water at Sandheads. When the Dominion government's work at the Sandheads is finished these depths will be 25 feet at low water and 37 feet at high-water. Along 1.7 miles of municipal waterfront there is an average depth of 40 feet.

There is 12 feet of tide at the Sandheads and 5 feet at New Westminster. Marine growth dies and falls off in the river water in ten days or so. The water is good for boilers.

Pilotage fees are $1.00 per foot of vessels' draught and 1 cent per registered ton each way, half charges if no pilot is employed.

Harbor dues are chargeable as follows on vessels of

	50	tons and under	....	$ .50
over	50	tons and not over	100......	1.00
"	100	" "	200......	1.50
"	200	" "	300......	2.00
"	300	" "	400......	2.50
"	400	" "	500......	3.00
"	500	" "	700......	4.00
	700			5.00

Dock dues are not charged; wharfage amounts to 50 cents a ton. The railway makes no charges on freight delivered from or to their own trains. One dollar a day berthage is charged where any charge at all is made.

The principal wharves are those of the Canadian Pacific Railway, 340 feet long; Canadian Pacific Navigation, 700 feet long; British Columbia Transport, 600 feet long; British Columbia Electric Railway; Great Northern Railway, and that of the Canadian Northern Railway at Port Mann, 1,000 feet long, and many other privately leased wharves. The railways, the Canadian Pacific Railway, Great Northern Railway and British Columbia Electric Railway, parallel the waterfront and run on to the wharves. The land and waterfront lend themselves to unlimited development along these lines.

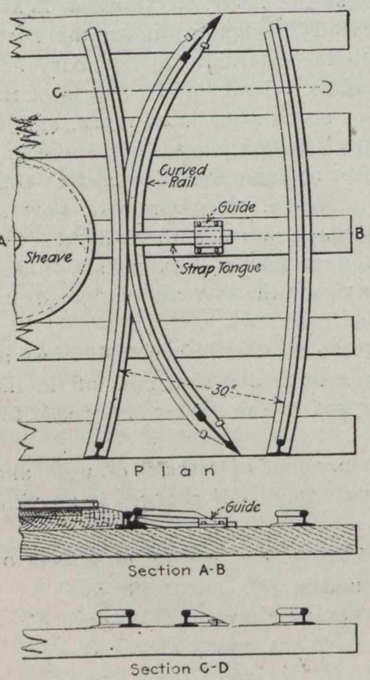
Towage is unnecessary except for sailing vessels, when charge is a matter of bargain. Large vessels coal at Vancouver Island points, as they do when calling at any British Columbia port. Small supplies of coal are to be had locally. Locks are unnecessary on the river.

There are good machine shops and boiler works in New Westminster, capable of carrying out any repairs. The Dominion Government dredge "Fruhling" is at work at Sandheads, King Edward, on north arm. The municipal dredge will soon be at work improving the city waterfront by filling Front Street and carrying the harbor line further out to an unbroken quay over a mile in length.

The Dominion government's contract for the first 6,900 feet of three-mile jetty will be completed by April 1st, 1913, and forms part of LeBaron scheme, which will give 25 feet at low-water from the Pitt River to the Gulf of Georgia.

GUIDING ROPES ON CURVES.

A rope incline which contains many curves sometimes occasions trouble by the rope catching under the rail head, when rounding the curve, and thus being thrown off the sheave. Joseph Daniels proposes an ingenious method of avoiding this trouble in Coal Age, August 24, 1912. It is as follows:



Sketch of Guide Arrangement for Use on Curves.

A section of rail, usual weight 30 lb., has its ends tapered to a wedge and is bent into a curve having a middle ordinate of 5 in. in a chord of 6 ft. This rail is placed so that its centre touches the main rail at one point and its ends are then spiked to the ties, leaving this middle point free to move. A piece of strap iron is fastened to the rail flange at the middle point and slides in a guide which is also spiked to the tie as shown.

The action of this arrangement is as follows: The cars going up or down the incline spring the curved rail away from the point of contact, thus permitting the trip to pass and immediately spring back to place after the last wheel flange has passed.

The rope at this time is approximately in the middle of the track, but its tendency will be to side over toward the short cord of the adjacent curve. In doing so it is carried from the middle of the track over the wedge point of the curved rail past the main rail to the sheave. In this way the rope is prevented from getting underneath the head of the main-track rail.

TOWN-PLANNING FROM AN ENGINEERING ASPECT.

A paper on the above subject was read by Mr. Ernest R. Matthews, Assoc. M. Inst. C.E., F.G.S., before the Society of Engineers recently. It was divided into two main headings—(a) town-planning in a residential district, and (b) town-planning in a manufacturing area, the former being illustrated by a brief description of Bridlington town-planning scheme. The author stated that, in his opinion, one of the principal points to be considered in the preparation of a scheme was the direction, width, and method of construction of main arterial, secondary, and subsidiary streets. He did not agree with making the foundations of a roadway in a subsidiary street less substantial than that in a wider street. He deprecated the practice of putting in heavy kerbing and flagged footways in residential districts, and thought that grass margins and asphalt footways not only effected a saving of cost, but presented a more rural and pleasing appearance. He thought that the road requirements of our by-laws were unreasonable, and resulted in houses being built with a narrow frontage and deep back, instead of a wider frontage and shallow back, which he considered much preferable. Open spaces should be left for parks, tennis courts, bowling greens, children's playgrounds, garden enclosures, sites for public buildings, &c. The sewerage scheme and sewage disposal were also very important matters. In a manufacturing area town-planning was different from that of a residential area, some of the points to be considered being:—(1) The position of the proposed industrial area, (2) its proximity to railway sidings, (3) the facilities for vehicular traffic to and from the area; (4) the necessity for constructing any new roads leading to this area in a substantial manner, so that they would carry the heavy traffic likely to come upon them; (5) the area to be occupied by workmen's dwellings; and (6) the supply of electrical energy for power and lighting purposes. In addition to these there would be questions of water and gas supply to be considered, and the disposal of sewage, storm-water, &c.

OIL FUEL BURNERS.

At the October meeting of the New York Railroad Club a paper on the subject of liquid fuel was presented by W. N. Best. Mr. Best stated that one of the greatest abuses of liquid fuel is the fact that it is often used with burners that do not thoroughly atomize the oil and evenly distribute the heat throughout the firebox or the charging space of the furnace. A burner should really form a flame to fit the length and width of a furnace as evenly as a blanket covers a bed. It should be capable of atomizing any gravity of fuel procurable in the open market without either clogging or carbonizing, no matter whether it be fuel oil of very light gravity or crude oil, oil tar or coal tar. A burner is not worthy of consideration unless it enables the operator to burn any gravity of liquid fuel, for no manufacturer should be limited to the purchase of one particular kind of fuel oil.

A burner wherein the base of the fuel carbonizes over the fuel passage is absolutely worthless. A burner should be of such construction that it can be filed to make a long, narrow flame or a broad, fan-shaped blaze, and each burner should be thoroughly tested, so that when it leaves the shop where it is made the manufacturer will know that it will fill the requirements for which it is being furnished. A burner having the oil orifice below the atomizer orifice and independent of it renders efficient service because of there being no liability of the oil solidifying or carbonizing over the atomizer slot at the nose of the burner.

A combustion chamber of adequate proportions for the uniting of the air requisite for perfect combustion with the atomized fuel before it reaches the furnace proper should be used on furnaces. This prevents oxidization of the metal charged in the furnace. It also aids in forming a blanket of flame to cover the entire charging space, thus insuring the even distribution of the flame and heat. Steam or compressed air should be used to atomize the oil and distribute the heat in the furnace, the pressure varying in proportion to the size of the furnace. Air at from 3 oz. to 5 oz. pressure admitted independently below the burners will aid in furnishing the oxygen requisite for perfect combustion.

COAST TO COAST.

Regina, Sask.—The building permits issued in this city for the month of October last have a total value of $462,725. This is over $200,000 less than the total value issued in the same month last year.

Vancouver, B.C.—Mr. P. Welch, who recently secured the contract for the construction of the Pacific and Great Eastern Railway, is making arrangements for the transportation of his supplies and equipment into the country over snow roads that are to be kept open all winter.

River St. Lawrence.—The Admiralty Court of London, England, reversed the recent judgment on the placing of the responsibility for the collision between the Canadian Pacific Railway liner "Empress of Britain" and the collier "Helvetia." By their decision the owners of the smaller vessel must assume seven-twelfths of the damage.

Toronto, Ont.—A general survey of Ontario, dealing particularly with water supply, sewage and drainage of every city, town and village except in centres of over 50,000 population is to be made by the provincial authorities through the district health officers. The latter have practically completed their preparatory work in Toronto and will start the survey about November 15th.

Moose Jaw, Sask.—Word comes from this point to the effect that contractors are experiencing considerable difficulty with workmen in their employ who claim the various Balkan States as their native land. It is thought that the return of these men to take up arms against the common enemy will be a serious drag on the completion of several contracts now being rushed.

Ottawa, Ont.—D. H. Ross, Canadian trade agent in Australia, advises the Trade and Commerce Department that though a special effort was made to interest Canadian rolling mills in regard to the supply of 146,000 tons of steel rails and fish plates for the new transcontinental railway in the Commonwealth, no tender was received. The strong domestic demand precluded Canadians from submitting offers.

Ottawa, Ont.—At a meeting of the International Joint Waterways Commission to be held in Washington on November 18th, the matters to be dealt with will include the questions of the level of the Lake of the Woods and the pollution of international waters. It is expected that both these important problems will be advanced a stage. It will be some time later, however, before either matter reaches a finality.

Big Sandy Island, Man.—A barge in tow of the tug Minerva, became waterlogged and sank at this point, which is 200 miles north of Selkirk. The cargo consisted of two cars of dynamite and one car of black powder and is a total loss. It was the property of Macmillan Bros., sub-contractors on the Hudson Bay Railway, and was to be used in the construction of the railway. High winds had prevailed for several days on the lake.

Ottawa, Ont.—An order-in-council has been passed providing that in future school lands in the three prairie provinces may be leased for the purpose of extracting fire clay therefrom. These leases will be for an annual rental of one dollar per acre, but shall not apply to school lands within a city, town or village, unless specially provided for. The term of the leases will be for 21 years, and they will be renewed for a second term of a similar period.

Wallace Harbor, N.S.—The Livingstone bridge, the longest bridge in Nova Scotia, which spans Wallace Harbor, was formally opened for traffic recently. The bridge consists of seven spans, having a total length of the steel work, with the abutments, of 771 feet. In addition to this the approaches are 2,200 feet long, making a grand total of 2,971 feet for the length of the bridge. The cost of the bridge, which was built by the local Government, was $65,000.

St. Lawrence River.—Everything is in readiness for the floating in of the first of the four huge spans which will complete the building of the double-track bridge over the St. Lawrence River at Highlands, a work which is costing the Canadian Pacific Railway $3,000,000. It will be another twelve months before the work is finally completed, despite the fact that only four of the spans have to be swung. Each of these four spans are four hundred and eight feet long.

Springfield, Man.—Henry Hudson, Pine Ridge, Springfield, has discovered an immense bed of cement rock on his 240 acre farm. The deposit is 140 feet beneath the ground surface and extends to a depth of 250 feet, the quantity being almost unlimited. The material has been tested by local experts, whose report shows it to be an excellent ingredient for the manufacture of Portland cement. Above the deposit is also an immense bed of valuable clay for brick and tile making.

Montreal, Que.—The drydock "Duke of Connaught," recently described in *The Canadian Engineer*, arrived at its final resting place in Maissoneuve Friday morning, November 1st, after a rough journey across the Atlantic. During the trip the hawsers by which it was being towed broke several times, and a great storm nearly threw the dock on the rocky shores of Cape Breton. The dock was escorted to its position by a string of tugs, bearing representatives of the Harbor Commission and the cities of Maissoneuve and Montreal.

British Columbia.—That lumbering should properly be regarded as a science and as a profession is the substance of resolutions recently adopted by the British Columbia Lumber and Shingle Manufacturers' Association and by the Canadian Forestry Association, favoring the establishment of a course in logging engineering at the new University of British Columbia. The success which has attended the agricultural colleges of Canada and the United States in equipping the farmers' sons with a scientific knowledge of husbandry, is evidence of what might be expected from similar courses devoted to logging engineering.

Ottawa, Ont.—The construction of a $200,000 bridge over the Richelieu River, in Ottawa division of the G.T.R., has just been completed. It will connect Coteau with St. Alban's, Vt., and will result in the elimination of a number of light engines now used on the local division and the substitution of heavier ones. The old Richelieu bridge was of wooden construction and could therefore not be used by heavy locomotives, which were sent around by Montreal. The new structure, however, is of steel with concrete piers and is 1,100 feet in length. It will be formally opened for traffic on November 10th.

Toronto, Ont.—Three hundred and fifty-six new members were received by the board of directors of the Ontario Motor League at their regular monthly meeting on October 31st at the National Club, Toronto. This is the largest number of members ever enrolled in one month by the association. The total membership is now considerably over the two thousand mark. The movement for good roads will continue to be furthered vigorously by the league. The directors will personally inspect the roads in the vicinity of Toronto, and they will hold a special meeting shortly for the purpose of discussing road problems and will invite as guests, W. A. Maclean, provincial highway engineer; E. A. James, York highway engineer; Mayor Hocken, and a representative from the Board of Trade. The board decided to co-operate with the Canadian Motorcyclists' Association in all matters affecting the common interests of both bodies.

St. Catharines, Ont.—A serious accident and break in the Welland Canal occurred about two o'clock November 1st, when the steamer "Samuel Marshall," owned by the Central Canada Coal Company, of Brockville, carried away the four gates of lock 13, and badly damaged the bridge crossing the canal a short distance below the lock. The Marshall was bound up, light, and on entering the lock rammed the two head gates, throwing them apart and letting the waters of the upper level rush through, tearing the upper and lower gates from their sockets and forcing the steamer back against the bridge which crosses the canal. The working gear of the bridge was badly wrecked and the bridge thrown out of position, blocking all travel along the road. Fortunately the level above is a short one, and there was comparatively little damage to the canal banks or surrounding country. The steamer escaped without any serious damage. The pontoon, with new gates, from Port Dalhousie, was at once hurried up to the break. There has been an unusual number of accidents this season on the canal, this being the fifth time gates have been carried away. It is said the high wind was partly responsible for the latest accident.

Grand Trunk Railway.—In regard to the block signal system at present being installed on some portions of the Grand Trunk Railway System for the additional safety and control of train moremements, it has been decided by the company to place all construction work incident thereto, as well as the after maintenance of such, under the direct charge of one official, known as the signal engineer, who will report to the chief engineer. The signal engineer will also have similar charge of the signal and interlocking plants, on the lines of the Grand Trunk System. In a circular issued recently by the chief engineer, Mr. Charles A. Dunham is appointed to the office of signal engineer. Mr. Dunham was born in Hamilton, Ont., 46 years ago, and has had a long experience with the various systems of block signalling in use by the larger trunk lines in the United States. To meet the needs brought about by the great development of its train service in general, the Grand Trunk has been extending the use of such safety appliances on some of its lines, and it has in view the substantial increasing of such use, in order to keep pace with the needs of its railway development.

SEPTEMBER RAILWAY EARNINGS.

The net earnings of the Canadian Pacific Railway in September, according to the monthly statement, showed an increase of $332,857 as compared with the same month last year. The increase while smaller than that reported in either July or August of the current year compares with a gain of only $5,847 in the same month last year over September, 1910. The gain in net for the month was equal to 8½ per cent. and net earnings for the three months show an increase of nearly 15 per cent. The September statement follows:

	September, 1912.	July 1st, to Sept. 30, 1912.
Gross earnings	$11,579,733.98	$35,883,848.43
Working expenses	7,329,430.13	22,467,442.02
Net profits	$ 4,250,303.85	$13,416,406.41

In September, 1911, the net profits were $3,917,446 80, and from July 1st to September 30th, 1911, there was a net profit of $11,696,046.14. The gain in net profits over the same period last year is therefore, for September $332,857.05; and from July 1st to September 30th, $1,720,360.27.

Canadian Northern gross earnings for September were $1,671,500, an increase of $95,100 over the corresponding month in 1911. The net earnings showed an increase of $4,100 for the same period, making those for 1912 to date $193,200 in excess of last year.

The Grand Trunk September statement shows net profit as follows:—Grand Trunk proper, increase, £21,550 sterling; Canada Atlantic net profit, decrease, £3,400; Grand Trunk Western net profit, increase, £4,250; Grand Haven net profit, decrease, £4,900; total net profit, whole system, increase, £17,500; one working day less.

RAILROAD EARNINGS.

The following are the railroad earnings for the week ended September 21st:—

	1911.	1912.	Increase or Decrease.
C.P.R.	$2,218,000	$2,549,000	+ $331,000
G.T.R.	1,018,506	1,101,588	+ 83,082
C.N.R.	373,600	390,200	+ 16,600
T. & N.O.R.	44,592	28,146	— 16,446

The following are the railroad earnings for the week ended September 30th:—

	1911.	1912.	Increase or Decrease.
C.P.R.	$3,061,000	$3,457,000	+ $396,000
G.T.R.	1,330,952	1,464,732	+ 133,771
C.N.R.	506,000	526,600	+ 20,600
T. & N.O.R.	58,381	36,650	— 21,731

The following are the railroad earnings for the week ending October 7th:—

	1911.	1912.	Increase or Decrease.
C.P.R.	$2,396,000	$2,765,000	+ $369,000
G.T.R.	985,730	1,058,587	+ 72,857
C.N.R.	460,500	471,700	+ 11,200
T. & N.O.R.	42,582	25,019	— 17,563

The following are the railroad earnings for the week ended October 14th:—

	1911.	1912.	Increase or Decrease.
C.P.R.	$2,510,000	$2,957,000	+ $447,000
G.T.R.	995,600	1,063,161	+ 67,561
C.N.R.	480,900	523,700	+ 42,800
T. & N.O.R.	49,492	33,170	— 16,362

Aggregate traffic receipts of the Grand Trunk Railway Company for July, August and September were £2,952,240, against £2,701,975 in the same three months last year, an increase of £250,265.

NEW FOREST RESERVE RECOMMENDED IN PRINCE ALBERT DISTRICT, SASKATCHEWAN.

The Forestry Branch of the Department of the Interior has again, during the past summer, had parties out examining the timber on some of the regions still in the hands of the Dominion Government, with a view to reserving from settlement lands more suitable for forest growth than for farming. Some of these parties have finished the work assigned them and have made their reports.

Mr. C. H. Morse made an examination of a district north-west from Prince Albert lying between the Shellbrook branch of the Canadian Northern Railway (on the west) and the third Dominion meridian (longitude 106 degrees), and recommends that the tract between the meridian on the east and the Sturgeon River on the west should be made a forest reserve. This land is not pure sand, but has some stretches of sand among lands of better quality; none of it, however, can be classed as good agricultural land. At the present time this tract carries, in places, a good stand of spruce, as good a stand as will be found anywhere in the country. The reproduction of the forest is good, and this should make one of the most valuable forest tracts in the west. The rate of growth is good. As it is calculated that the present stand of timber, which is held under license, will be cut out in ten years, it will be seen that the necessity for looking for a future supply is close at hand.

RAILWAY AND OCEAN TERMINALS FOR HALIFAX.

The Dominion government will build new railway and ocean terminals nearly two miles south of the present terminals at Halifax.

The new docks are to extend for one and a half miles from the Lumber Yard to Point Pleasant Park, and will consist of six piers, 1,250 feet long and 300 feet in width, with capacity sufficient to dock at least thirty ships. There will be one bulkhead loading pier, 2,000 feet in length, at which the ocean greyhounds will land. This pier will be equipped with immigration buildings, sheds and a grain elevator.

A new union passenger station will be erected at the end of Hollis Street, just north of the docks mentioned, which will be of ample size and suitable architecture.

The new terminals will be approached by a double-tracked railroad, which will branch off the main line at the Three Mile House and extend southerly through the low divide between Bedford Basin and the head of the northwest arm. It will then skirt the arm in such location as will do the least damage to property in that vicinity, avoiding all level crossings, and for the most part passing through deep cuttings so as not to mar the beauty of that district, and finally reaching the terminals by passing under the lower end of Young Avenue. The streets in the residential district where the railway is submerged will be carried over the cutting on artistic bridges in keeping with the present surroundings.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

Professor C. H. McLeod, secretary of the Canadian Society of Civil Engineers, has sent out the list of nominees for officers and members of the council for the year 1913, as submitted by the Nominating Committee of the Society. It will be observed that with the exception of the nomination for president, two members are proposed for each office. There are three vacancies in District No. 1, and one in each of the other districts. The extra vacancy in No. 1 is caused by the resignation of Mr. Phelps Johnson, who has been nominated for the office of president.

FOR PRESIDENT—Phelps Johnson.
FOR VICE-PRESIDENT—H. G. Kelley, F. C. Gamble.
FOR COUNCILLORS—

District No. 1—R. J. Durley, J. M. R. Fairbairn, W. J. Francis, Geo. Janin, F. H. Pitcher, J. M. Robertson.
District No. 2—F. A. Bowman, T. C. Burpee.
District No. 3—A. R. Decary, W. D. Baillairge.
District No. 4—S. J. Chapleau, A. A. Dion.
District No. 5—H. E. T. Haultain, C. H. Mitchell.
District No. 6—E. P. Fetherstonhaugh, W. A. Duff.
District No. 7—H. E. C. Carry, T. H. White.

PERSONAL.

MR. R. J. FULLER, B.A.Sc., has been appointed to the staff of the city architect's department in Toronto.

MR. T. AIRD MURRAY, consulting engineer, has returned to Toronto after an extended trip through the West

MR. W. J. ELMENDORF is in charge of the property of the Portland Canal Tunnels, Limited, in the Portland Canal district, British Columbia, as general manager.

MR. ROBERT D. HEDLEY, formerly manager for the Canadian Mining Operators, Limited, Vancouver, B.C., has opened an office in Vancouver as consulting engineer.

PROFESSOR WALLACE P. COHOE gave an address on "The Function of the Chemist in the Industrial Development of Canada," before the Society of Chemical Industry in Toronto on October 31st.

PROFESSOR R. J. DURLEY, M.Inst.C.E., of McGill University, Montreal, Que., has been awarded the Crampton prize of the Institution of Civil Engineers of Great Britain for a paper presented during the 1911-1912 session.

MR. D. H. McDOUGALL, assistant general manager of the Dominion Coal Company, has been appointed to the general managership of that company, which position has been rendered vacant by the resignation of Mr. J. Butler.

MR. H. P. BELL, late of London, England, has opened an office in Toronto as consulting chemical engineer, with temporary quarters at 409 Kent Building. Mr. Bell will undertake inspections and reports on industrial processes and plants.

MR. F. A. DALLYN, B.A.Sc., of the Ontario Board of Health, is at present taking samples of water from Lake Huron, the River St. Clair and Lake St. Clair. It is understood that the results of the analyses will be used before the International Joint Commission when the Provincial Board of Health present their arguments regarding lake pollution.

MR. HARRY DIX, for the past two years in charge of the heating and ventilating department of the Douglas Milligan Co., Limited, has severed his connection with that firm to join the engineering staff of the Canadian Domestic Engineering Co., Limited. Mr. Dix is a Boston man who came to Canada for permanent residence several years ago and has a number of friends in and around Montreal. He is well fitted for the responsibility of his new position and the connection should prove mutually beneficial.

MR. C. A. DUNHAM, who has been appointed signal engineer for the Grand Trunk Railway System, received his earlier education in Hamilton, Ont., which was supplemented by educational work at Scranton, Pa., and Chicago, Ill. He entered the railway service in 1884, since which time and up to 1886 he was with the mechanical department Chicago, Burlington and Quincy Railroad, at Chicago; April, 1886 to 1887 in bridge department, New York, Chicago and St. Louis Railroad; in 1887 he was for several months with the U.S. Rolling Stock Company at Hegeswich, Ill., following which he became connected with Grand Bros., railroad contractors, serving in this capacity until January, 1890. From January, 1890, to September, 1892, was in the operating department of the Chicago, Burlington and Quincy Railway. September, 1892, to March, 1896, with the Union Switch and Signal Company, and the National Switch and Signal Company; March, 1896, to March, 1901, inspector of signals, Illinois Central Railroad; March, 1901, to June, 1905, signal engineer same road; June, 1905, to date, signal engineer, Great Northern Railway.

OBITUARY.

PETER H. HUME, C.E., one of the best-known structural engineers in America, and business associate of Michael Connolly, of Ontario, died at St. John, N.B., on November 3rd last after a long illness during which he had kept at work. He had supervised the construction of great docks at Hong-Kong, Buenos Ayres, New York and the subway in Philadelphia. His widow and one daughter, Mrs. C. E. Duggan, of St. David's, Ont., survive.

COMING MEETINGS.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Monthly Meeting will be held in the Rooms of the Society, 413 Dorchester Street West, Montreal, November 7th. Paper on "The Protection of the Foreshore at Dallas Road, Victoria, B.C.", by Mr. G. N. Duncan, Jr., C.S.C.E. will be read. Discussion on the effect of sea water on Portland Cement Concrete Structures will follow the reading of the paper. Chairman, Henry Holgate.

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

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—7th Annual Convention, November 14th, 1912. City Hall, Toronto. Secretary, Francis Dagger, 21 Richmond Street West, Toronto.

THE CANADIAN INSTITUTE.—198 College Street, Toronto. Saturday Evening Lecture, Nov. 23rd, at 8 o'clock. "The Prevention of Sewage Pollution relative to Water Supply," by T. Aird Murray, C. E., Toronto. Secretary, J. Patterson.

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

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

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

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

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

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

ENGINEERING SOCIETIES.

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

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

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

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

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

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

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

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

MUNICIPAL ASSOCIATIONS

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

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

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

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

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

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

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

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

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

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

CANADIAN TECHNICAL SOCIETIES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CANADIAN STREET RAILWAY ASSOCIATION.—President, 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, J. E. Ritchie; Corresponding Secretary, C. C. Rous.

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

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

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

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

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

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

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

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

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

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

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

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, T. B. Speight, Toronto; Secretary, L. V. Rorke, Toronto.

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

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

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.

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.