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THE TROLLHÄTTAN HYDRO-ELECTRIC POWER STATION, SWEDEN.

The Trollhättan Falls are situated in the Göta River, which connects Lake Vänern, the largest lake in Sweden, with the sea. The Vänern covers an area of 5,570 sq. km. (2,180 sq. miles), and it is the largest of the European lakes but two. The aggregate difference in level between the sea and Lake Vänern is about 44 m. (144 ft.), of which some 33 m. (108 ft.) occur in the Trollhättan Falls, which comprise a series of cascades. The legal position as to the ownership of the water rights was exceedingly complicated at the time their value began to dawn upon the people, but in the year 1901 the Swedish State became the undisputed owner of the greater portion of Trollhättan's vast water power. Through subsequent purchases the State has acquired the waterfalls at Vargön, between Lake Vänern and Trollhättan Falls, and those at Ström and Lilla Edet, below the Trollhätten Falls, so that the State now controls the entire water power of the Göta River. The present low-water volume is 320 cub. m. (11,520 cub. ft.) per second, and the high-level volume of water is about 900 cub. m. (32,400 cub. ft.) per second. Through the regulation of Lake Vänern, the low-level volume of water, however, can be materially increased, and for the future the States may reckon on having at its disposal in its falls in the Göta River an aggregate of not less than about 200,000 horse-power, and this, too, in a district having excellent means of communication and at no great distance from Gothenburg, the leading commercial centre on the west coast of Sweden, and in the midst of a populous part of the country. The State power-station at Trollhätten is constructed for the exploitation of 250 cub. m. (9,000 cub. ft.) water per second, representing 80,000 turbine horse-power. This important installation, which is located on the eastern bank of the river, was taken in hand towards the end of 1906, and occupied some four years in construction. A description of this development appeared recently in London "Engineering," from which these notes have been abstracted.

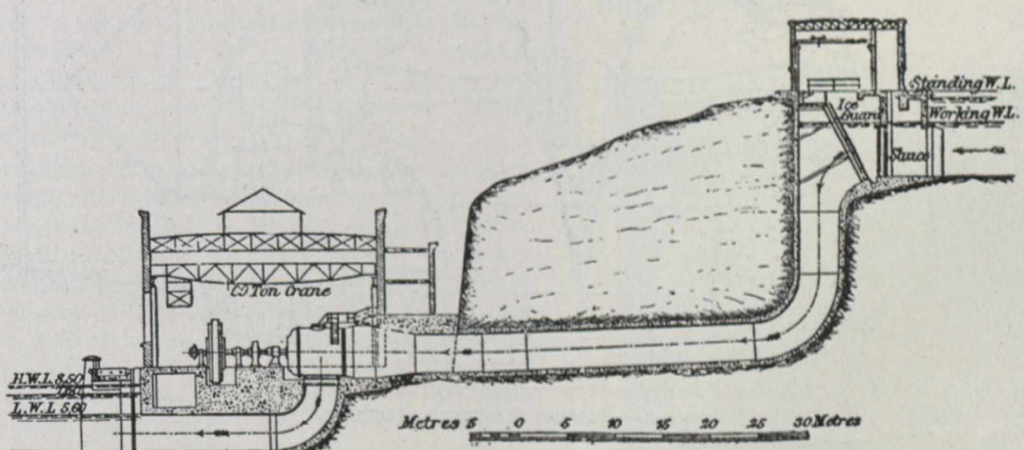

Fig. 1.—Section Through Penstock and Power House.

The regulating dam across the river, is situated at the threshold of the upper fall on the firm rock. The dam is constructed with four openings, separated by piers of granite. The two central openings each have a free width of 20 m. (65⅝ ft.), and are closed by means of bear-trap or roller-dams. The most westerly opening, which was first constructed, and which is placed at the side of the river course proper, is 19.7 m. (64 ft. 8 in.) wide, and is closed by means of five sluices, 3.7 m. (12 ft.) wide, which are constructed of iron with wooden boarding; these sluices are divided in two, in the direction of their height, and can be drawn up or let down at will. They are not fitted with anti-friction rollers. The eastern outlet is 3.4 m. (11 ft. 2 in.) wide, and is fitted with a similarly constructed door. Both the roller-dams and the sluices can be operated by electric motors as well as by hand-power, and all the outlets can be closed for repairs by means of steel needles or tube-pins, resting partly against the bridge-way on the pillar and partly against the sill. This construction of the dam has been chosen on account of the quantities of ice which, during the winter, are carried down by the river. If there be ice when there is plenty of water in the river, the ice makes its escape through the fully-opened central outlet. With lower water-level the ice is led away under the partly raised rollers or through the sluices.

The intake of the water to the power-station lies about 120 m. (394 ft.) above the dam, and consists of six openings, 12 m. (39 ft. 6 in.) broad, separated by brick piers. In front of the openings is placed a securely anchored floating ice-guard, which is made of strong timber and fitted with a screen commencing 90 centimetres (36 in.) below the surface of the water. As there is no loose floating timber in the river, there consequently is no risk of any timber diving under the guard; no wreckage guard will, at first, be erected, as a guard always gives trouble when coated with ice, and the ice-guard is expected to yield sufficient protection.

Should, however, a wreckage guard subsequently prove necessary, there will be no trouble in attaching one. The inlet openings can be closed by a form of sluice, consisting of loose doors, about 4 m. (13 ft. 2 in.) wide. The fixing and removal of these sluices, as well as of the steel tube-pins, is effected by means of a portable crane on wheels. The intake is calculated for a volume of water of 350 cub. m. (12,600 cub. ft.) per second, which volume, in all probability, after the regulation of Lake Vänern, may be reckoned as available for power purposes under all circumstances throughout the 24 hours. The speed of the water at the inlet is about 1 metre (3 ft. 3 in.) per second. The intake canal is about 1,300 m. (1,418 yards) long, and through its entire length is blasted in rock or lined with brickwork. The portion nearest the intake is proportioned for the same volume of water as the inlet, or 350 cub. m. (12,600 cub. ft.) per second. About 350 m. (1,148 ft.) from the intake the section of the canal is reduced so as to correspond with a volume of 250 cub. m. (9,000 cub. ft.) per second. When the regulation of the Vänern has been completed, another canal, of 100 cub. m. (3,600 cub. ft.) of water per second, m. (115 ft.), has smooth vertical sides, faced with bricks below the water, and with heavy granite at the water-line. When the turbines were tested, the measurement of the water-flow was taken by means of the well-known method invented by Professor E. Anderson, of Stockholm. Three bridges lead across the canal, two of which are iron bridges, and the third of reinforced concrete. The canal walls are partly built of granite in cement up to a height of from 6 m. to 7 m. (20 ft. to 23 ft.), and partly of concrete at greater heights than 7 m. (23 ft.). The concrete walls are made of concrete of the following mixture:—1 cement, 5 sand, 7 stone. Nearest the rock, however, there is a layer of a mixture of 1 cement and 1 sand, and then a 10-cm. (4 in.) layer of fat concrete (1 cement, 2½ sand, 2½ broken stone), and outside this cement rendering up to 4 m. (13 ft. 2 in.) from the top of the wall. Behind the tight surface of the wall are inserted 50-mm. (2-in.) brick drain-pipes at 0.5 m. (1 ft. 7½ in.) distance from each other, besides requisite collecting-pipes, so that the wall will not be subjected to water pressure from below. The surface, by means of a 0.5-m. (1-ft. 7½-in.) coating of stone set in cement, is protected against the wear and

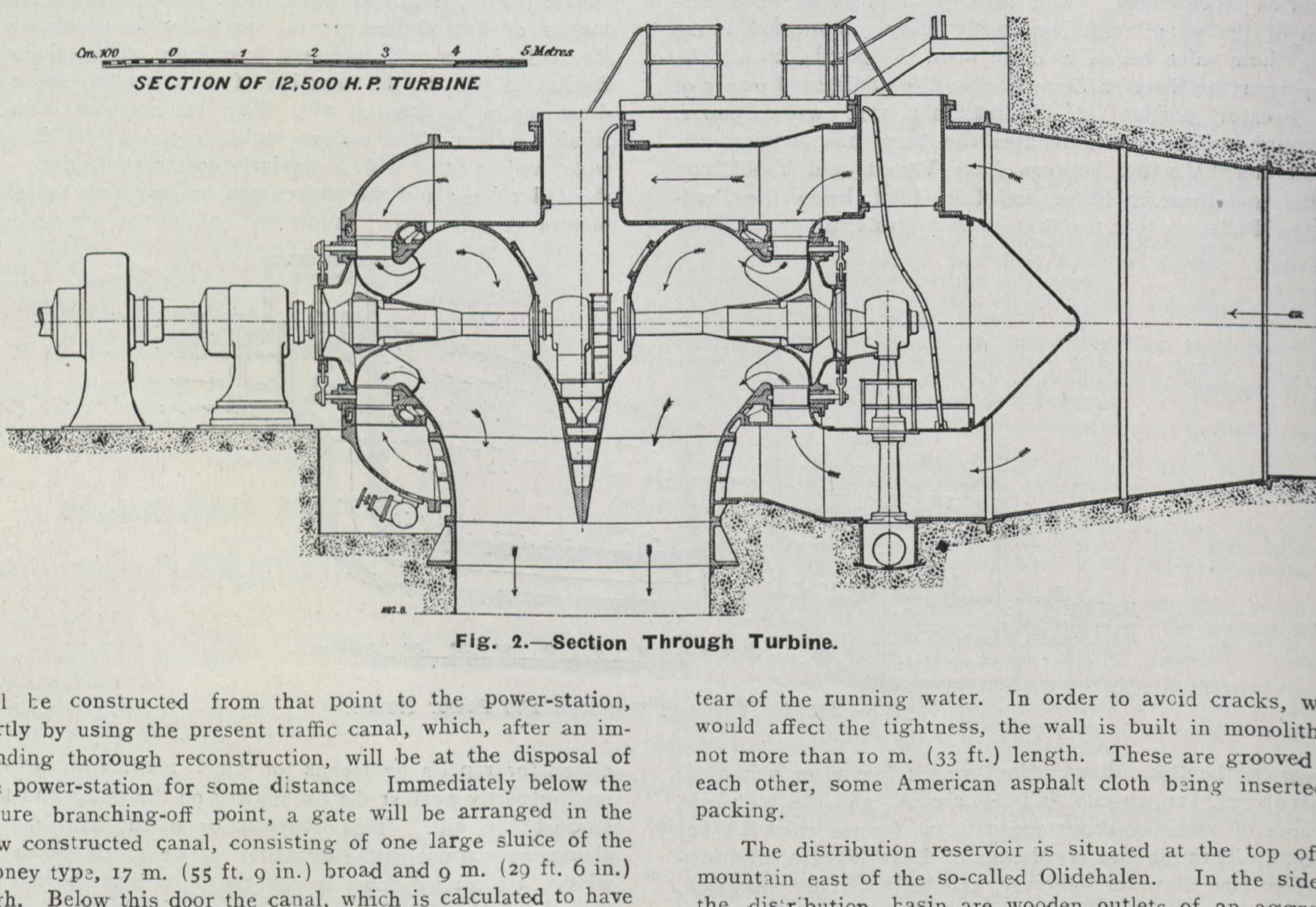

Fig. 2.—Section Through Turbine.

will be constructed from that point to the power-station, partly by using the present traffic canal, which, after an impending thorough reconstruction, will be at the disposal of the power-station for some distance Immediately below the future branching-off point, a gate will be arranged in the now constructed canal, consisting of one large sluice of the Stoney type, 17 m. (55 ft. 9 in.) broad and 9 m. (29 ft. 6 in.) high. Below this door the canal, which is calculated to have a speed of water of 2.2 m. (6 ft. 7 in.) per second, has a sectional area of 114 sq. m. (1,225 sq. ft.) below low water. The form of the section, however, is somewhat variable; generally it is shaped with the view of obtaining a maximum of hydraulic average depth, corresponding to a bottom breadth of 14.2 m. (46 ft. 6 in.) and a depth of 7.7 m. (25 ft. 3 in.); but for a portion, where space is very limited and the natural rock surface is high, the bottom width has been re-(33 ft.). The change from one section to another takes place duced to 10.5 m. (34½ ft.), with a depth of water of 10 m. gradually, whereby the formation of whirlpools is avoided.

At the deepest point of the canal is a discharge opening, which is closed by means of a tightly fitting door. The latter portion of the intake canal, over a distance of about 35 tear of the running water. In order to avoid cracks, which would affect the tightness, the wall is built in monoliths of not more than 10 m. (33 ft.) length. These are grooved into each other, some American asphalt cloth being inserted as packing.

The distribution reservoir is situated at the top of the mountain east of the so-called Olidehalen. In the sides of the distribution basin are wooden outlets of an aggregate length of 72 m. (236 ft.), to provide an outlet for the water flowing through the canal, and thus to prevent an inundation of the power-station, in case the majority of the turbine regulators should be simultaneously closed. The water is led in tunnels from the above-mentioned outlets into the river. Besides the inlets to the conduits there is further an ice-escape at each end of the distribution reservoir. The doors and the guards in front of the conduit inlets are under cover of a building constructed of granite and concrete. A separate tube leads to each turbine, proceeding from a separate chamber, with a double closing arrangement. Within the chamber is the ice-guard, which, if the chamber be closed, can be cleaned independently of the other guards. The sluice of the Stoney type has a width of 8 m. (26 ft. 3 in.) and is supported by the grooves in the wall, and by two intermediate supports in addition; it is operated by means of an electric winch or by hand-power. The lowering of the door can be promptly effected by means of an electric arrangement in the switchboard-house. The speed of the water through the free opening of the ice-guard is about 1 m. (3 ft. 3 in.) per second; and in order to incur the smallest possible risk from ice-coating, special types of ice-guards have been designed. Fish which reach the ice-guard through the inlet canal can, by means of a passage in the bottom, immediately in front of the ice-guard, go through the tubes to a collecting-groove running along the distribution reservoir, and from there again to the river. From the intake building the water is led to the power-station through eight large and three smaller

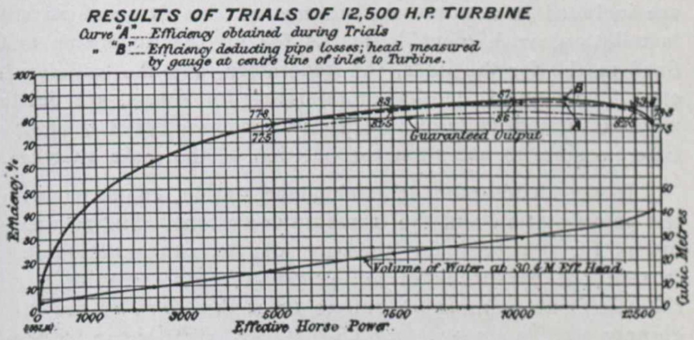

Fig. 3.—Results of Test of Turbine.

tube-conduits. The former, which have a diameter of 4.25 m. (14 ft.), lead to the eight large turbines, and the latter, which have a diameter of 1.2 m. (4 ft.), to the three exciting turbines. The tube-conduits are placed in tunnels in the rock, lined with sheet-iron, and encased in concrete. Each tube-conduit has a length of about 60 m. (197 ft.).

The power-station (Figs. 6 and 7) contains the turbines and the generators, which are direct coupled. The arrangement of the power-station will be understood from Fig. 1, which is a vertical longitudinal section through tube-intake, tube-conduit, machine-house, and outlet tunnel. Fully equipped it can yield 100,000 horse-power under the existing condition of water, and when Lake Vänern has been regulated, as already mentioned, a considerably larger power. The turbines are the so-called twin turbines with horizontal axles direct coupled to the generators. They have rotors of the ordinary Francis type and are fitted with adjustable bearings. Each turbine with a head of water of 30.4 m. (100 ft.), and with a speed of 187.5 revolutions per minute, has a capacity of nominally 10,000 horse-power and a maximum capacity of 12,500 horse-power, measured at the coupling to the electric generator. A vertical longitudinal section through the turbine is shown in Fig. 2. The turbines are enclosed in cylindrical cases of steel, and are directly connected with the tube-conduits, so that the water, without any alteration in its direction, is led from the tube-conduits on to the turbine-wheels. The smallest interior diameter of the surrounding cases is 5 m. (16 ft. 6 in.), and the largest diameter is 5.5 m. (18 ft.). The thickness of the plates varies from 22 mm. to 23 mm. (about 15/16 in.). The turbines may be seen in perspective in course of erection in Fig. 4 and Fig. 5.

In the construction of the turbines the greatest care, in the first place, has been bestowed upon making the casing of the turbine as smooth as possible inside. Most parts, especially those exposed to the severest strains, are made of steel, as are also all the cast parts, which by riveting are connected with the casing. Each turbine has been tested at 75 metres (246 ft.) water pressure. The turbine shaft is of nickel-steel, made in three parts, which are connected by means of couplings, forged on the shaft. It is supported by three bearings, with ring lubrication; two of them are placed against the turbine-case and are accessible for inspection by means of vertical pits. All the bearings are water-cooled, and fitted with thermometers, which indicate the temperature at a convenient place outside the turbine-case. The rotors, which have a diameter of 1,800 mm. (6 ft.) on the inlet side, are made of cast steel and are very securely attached to the shaft.

In order to obtain a construction with combines the greatest possible reliability in working with easy management and durability, all the parts belonging to the governing mechanism have been located outside the turbine-case, so that all the journals can be lubricated and inspected during working. Special interest attaches to the construction adopted in these turbines, which makes it possible to take out each guide-blade separately without causing any serious disturbance beyond the removal of the box belonging to the blade in question, and the uncoupling of the small chain between the crank and the regulator. The guide-blades are of steel, and cast in one piece with their respective shafts.

The governor, which is worked by belting from the turbine shaft, together with the pressure bell, is placed in a cast-iron box, fixed in concrete, which also serves as an oil receptacle; pipes, 100 mm. (4 in.) in diameter, connect the governor with the servo-motor, which acts upon the middle of the governor shaft. The oil-pump is worked by belting from the turbine axle. The brake intended to bring the turbine to a standstill is hydraulic, and is worked from the starting platform.

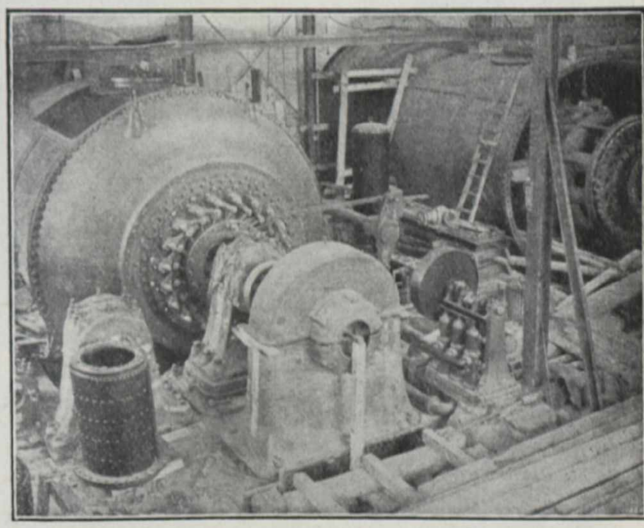

Fig. 4.—View of Turbine During Erection.

In order to give some idea of the large dimensions of the turbines, we append the following particulars of weight:

	Kg.	Tons.
The front ring, of steel..........about	12,000	(12)
The suction-case parts ....about	14,000	(14)
The turbine-wheels, of steel, each weigh ....about	5,000	(5)
The turbine-axle, of nickel-steel about	14,000	(14)
The cast-iron upper parts of the suction-case ....about	32,000	(32)
The front portion of the suction-case, with part of suction-case....about	28,700	(28¾)
Conical portion of case.........about	10,200	(10¼)

The diagram, Fig. 3, shows the satisfactory results of the tests undertaken at the instance of the buyer.

At the tests, which were carried out with the greatest care, the quantity of water was measured by means of a floating screen in the inlet canal, and the effective height of fall was ascertained by the difference in level between the upper and the lower water surfaces. The generator was loaded with a water-resistance, and the effect was measured by means of two precision watt-meters. In the results are included the loss of efficiency arising in the inlet-tube, and the influence of this is shown in curve B, which shows the efficiency that would be registered if the head were measured through a manometer placed in the turbine-case or in the way such tests are generally carried out.

The generators produce three-phase current, 25 periods, and 10,000 volts. They are entirely encased so as to obtain efficient cooling. The generator rotors draw by suction the cold air through spacious conduits, which pass within the walls of the power-station and underneath its floors. The air, heated in the generators, is also led away through conduits; during the winter it is used for warming both the generator-station, the tube-inlet building, and the switchboard building; in the summer it is led away, so that the attendants shall not be inconvenienced by it.

For exciting the generators, for lighting purposes, and for power to the auxiliary machines, there is a continuous-

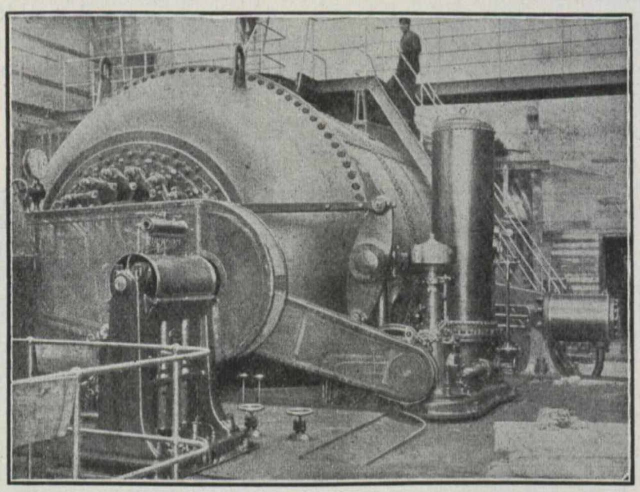

Fig. 5—Completed Turbine.

current installation for a voltage of 220 volts. This is worked by the three 500-horse-power turbines already referred to, which are placed in the centre of the power-station. Each turbine is direct coupled to a continuous-current generator of 350 kilowatts for 220 to 300 volts. Parallel with these generators is an accumulator battery of a capacity of 4,800 ampere-hours, which serves as a reserve and for counteracting the voltage variations. The switchboard for this installation is placed on a balcony in the centre of the power-station, close to the generators in question.

The regulation of the generator excitation does not take place in the ordinary manner, by means of main-current regulators, but by direct-coupled additional machines or boosters; and the voltage, with separate excitation, can vary from —220 to + 110 volts. By this arrangement the exciting voltage of the generators can be varied from 0 to 330 volts. The alternate current is conducted from the power-station through a tunnel to the instrument house. The tunnel is divided into four separate passages, in each of which there is room for the cables from two generators. It was originally planned to place the instrument-house in the immediate vicinity of the power-station, but various considerations have led to the adoption of the present location, which is some 200 metres (653 ft.) distant from the power-station. The instrument-house contains transformers, which transform the alternate current from 10,000 volts to 50,000 volts. The building further contains main switches, laboratory, lightning-dischargers, and all other appliances for the handling and distribution of the energy. In the centre of the house is the room from which the controlling and working of the station is carried on. In this room, on marble switchboards and desks, are placed all the instruments necessary for ascertaining the load distribution within the alternate-current system, as well as all the requisite signal and warning appliances. The voltage of the current is regulated from the controlling-room. From here, too, the oil-switch of the alternate-current installation is worked electro-magnetically by means of auxiliary switches. The auxiliary switches on the switch-desks are included in a miniature scheme of the alternate-current installation, with movable marks for all the apparatus and fixed marks for the lines, the generators, and the transformers. The movable marks, or miniature apparatus, are partly worked automatically and partly by hand, so that it is at any time possible to ascertain the position of the main switches.

In the switch-room is a telephone station, connected with the power-station and the transformer-stations. The requisite orders for the ordinary working of the power-station are transmitted by means of an electric machine telegraph, as the telephonic connection suffers from the noise of the machinery. The upper story of the instrument-house is used for a repair-shop for the transformers, for laboratory, store-rooms, &c. This portion is entirely separated from the high voltage installations.

The transformers are placed in a series of rooms on the north-western side of the instrument house, four cells on each side of the central part. Each cell is calculated for one transformer group, and each transformer group consists of three one-phase transformers, each 3,670 kva. maximum capacity, thus corresponding with a three-phase generator. The transformers are all insulated and water-cooled. In order to minimize the risk of fire, which can never be fully removed from the use of oil-insulated transformers, the rooms are entirely closed in, and arrangements are made for the free escape of oil. In order to maintain the water-cooling there are signal contacts in the cooling-water pipes to each transformer. These signal contacts give an alarm as soon as the cooling water ceases to circulate. As soon as the temperature in any of the transformers exceeds the permissible limit the thermometer placed in the transformer gives an alarm. The water for cooling the transformers is circulated by pumps in the cellar of the instrument-house. This installation consists of four pumps worked by electric motors. They lift 1,500 litres (333 gallons) per minute to a height of 15 m. (49 ft.) respectively; and 500 litres (111 gallons) per minute to a height of 25 m. (82 ft.). These pumps are also used for the extra voltage precaution appliances, of which more will be said later. Only two pumps are required for the maintenance of the working. The other two are reserve. Two water-tanks of an aggregate capacity of 50 cub. m. (11,250 gallons) serve as an additional reserve for the cooling of the transformers, and one tank of 10 cub. m. (2,250 gallons) capacity as a reserve for the extra-voltage protective appliances. There is a special pipe system for conducting the oil into the transformers, and for emptying them; there are also tanks for the reception of the used oil from the three one-phase transformers, and also for supplying clean oil, as well as appliances for cleaning and drying the transformer oil.

The energy is distributed from the instrument-house partly at 10,000 volts and partly at 50,000 volts. The long-distance lines are generally calculated either for the output of a complete generator or half generator; in the latter case they are in pairs. This makes it possible for each generator, with or without transformation of the voltage, to supply energy for a fixed number of lines, and to work independently of the other generators. In other words, the installation can be divided into several systems independent of each other, which fact, to a very great extent, increases the safety. The switchboards are constructed with a special view to this arrangement. They are therefore also divided into eight compartments, each of which corresponds with a generator. The different units, by means of oil-switching, can be switched into collective systems for 10,000 volts, and also into a collective system for 50,000 volts. This makes it possible, at will, to switch any long-distance line on to any transformer

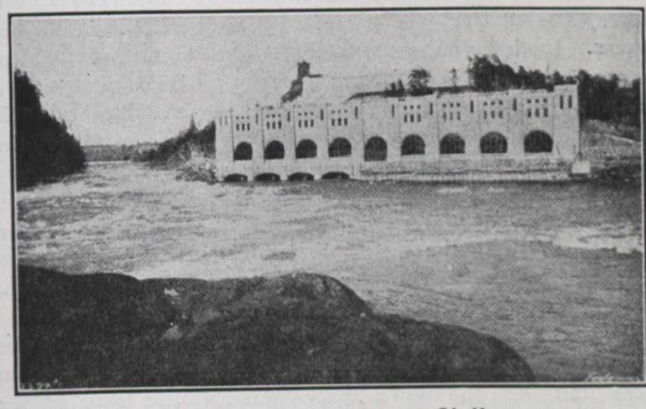

Fig. 6.—View of Power Station.

or generator. All the switches intended for on-and-off switching of the generators, the transformers and the long-distance lines, are fitted with starting rheostats and dimensioned for the temporary current which might arise from a short-circuit, when all the eight generators work in parallel. The machines and the long-distance lines are protected against overloading by means of relays, which are built on the principle of the induction motor.

The extra-voltage projection for the long-distance lines consist of water-jets for the dispersal of the static charge and of horn lightning-dischargers with two horns switched in series with a resistance formed through running water as a rough protection. For smaller quantities of energy there are horn lightning-dischargers with oil-resistances switched in series, and there are roller lightning-dischargers as a finer protection for high-frequency extra-voltage with smaller quantities of energy. Apart from the cables in the tunnels between the power-station and the instrument-house, the high-voltage lines for 10,000 volts are arranged as bars, and those for 50,000 volts as tubes on insulators. The different phases are separated from each other by fire-proof intermediate walls, which principally consist of concrete plates, set in iron grates. The distance between the lines and the constructive parts connected with the ground amounts to 200 mm. (8 in.) for the 10,000-volt system, and 400 mm. (16 in.) for the 50 000-volt system. The cables in the cable tunnels are each placed separately in a brick channel, and covered with sand.

The various high-voltage rooms are separated from each other by fireproof material. The lines are, therefore, carried through by means of through-insulators. Special attention has been bestowed on the cells for the oil-switches which are made in concrete. They are entirely closed, and fitted with drain-pipes, which, should an explosion in an oil-switch occur, quickly lead away the oil. The current, as already mentioned, proceeds from the instrument-house, partly with a voltage of about 10,000 volts for places in the vicinity of the station, and partly with a voltage of 50,000 volts for more distant places. The 50,000-volt current, however, is not supplied direct to the consumers, but is led to large transformer-stations (secondary stations) which belong to the State, and are situated at convenient distances apart. In these stations the energy is again transformed down to a more convenient voltage. This is generally 10,000 volts, and only in isolated cases current of 3,000 or 6,000 volts is supplied. The energy of this low voltage is supplied from the secondary stations to the surrounding consumers. The State provides the lines as far as the place of consumption, but the consumers must themselves defray the cost of the requisite transformation from high voltage to a serviceable voltage. In more populous districts energy of such serviceable voltage, however, is distributed by the same means as are used by municipal electric stations. All 50,000-volt lines are of copper, generally six copper lines and one iron line for earth connection. Lines of 50,000 volts were first installed to Skara, Gothenburg, and Allingas. On the Skara line (the one first completed), the copper lines were laid on support-insulators of porcelain; on the other lines suspended insulators have been adopted, except on the tightening-masts, where support-insulators are used.

The insulators are attached to iron trellis poles placed on concrete foundations. The poles are partly tightening-poles and partly support-poles. The former are constructed very strongly and are placed at a distance of 1 km. from each other. Between two tightening-poles are placed as many support-poles as is economically advantageous for each respective section of the line. The support-poles are designed with due regard to the weight of the line and the wind pressure. The number of poles per kilometre is four for 70 sq. mm. (0.112 sq. in.) line, and six for 16 sq. mm. (0.026 sq. in.) line. For 35 sq. mm. (0.06 sq. in.) line the normal span is 170 m. (557 ft.). Of the 10,000-volt lines, those intended for very large currents are made of aluminium, those for smaller currents of copper wire. The insulators are support-insulators or porcelain. The poles, where it is a question of large currents, are trellis masts of iron, built on the same principle as those for the 50,000 volt lines; whilst creosoted wooden poles are used for the smaller currents. The secondary stations are arranged on the same principles as the instrument-house.

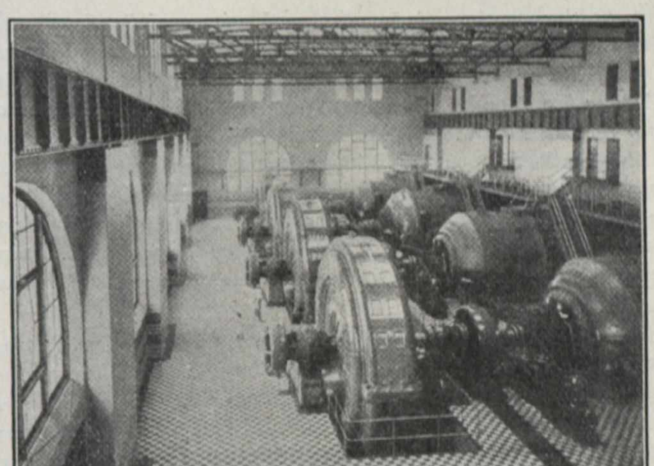

Fig. 7.—Interior View of Power House.

A portion of the energy having been reserved for railway traction, the remainder is sold to municipalities and private concerns, and has met with a very lively demand. There has even been a question of disposing of a considerable quantity of the energy to Copenhagen. The plan is considered quite practicable, but has not yet passed beyond a preliminary stage. As the cost of the Trollhättan power-station, etc., is unusually low—11,500,000 kr., $3,100,000 for 80,000 turbine horse-power—and as the State can obtain money at a small rate of interest, and be content with a moderate profit, the price for the energy has been fixed at an unusually low figure. Amongst the first to contract for electric current were the towns of Gothenburg, Skara, Sköfde, Allingas, etc., including several smaller places and amongst the customers of the Trollhättan power-station are also a number of industrial concerns. The State provides suitable sites at Trollhättan, at the canal or the railway, for such industries as require electric energy at a particularly low price, and which therefore, so as to avoid the cost of transmission over a distance, should be located quite close to the station.

The greater portion of the plant for the power-station at Trollhättan has been supplied by Swedish manufacturers. Thus two of the large turbines which were first installed were made at the works of Nydqvist and Holm, Trollhättan; the particulars given in this article, as well as the illustrations, refer to the turbines from this firm. The other two large turbines came from the Kristinehamn branch of the Karlstad Engineering Company, Karlstad. The generators and the greater portion of the instruments have been supplied by the General Swedish Electric Company, Västeras.

The management of the State waterfalls in the Göta River, as well as of the Trollhättan Canal between Lake Vänern and the sea, which is Sweden's most important waterway, has hitherto been vested in a special local board, domiciled at Trollhättan; but, on the formation of the Royal Waterfalls Board, which has the management of all other State waterfalls in Sweden, the Trollhättan Falls were also transferred to this board.

WIRE ROPES AS APPLIED TO MINING.

At the meeting of the Mining Institute of Scotland, held at Glasgow, on the 11th inst., Mr. Robert M'Laren (H.M.I.M.), president, in the chair, Mr. Dugald Baird (Lugar Iron Works, Cumnock) read an interesting Paper on "Wire Ropes as Applied to Mining." At the outset he said although Parliamentary Blue-books showed that for the ten years 1898-1907 inclusive only 13 fatal shaft accidents, causing 32 deaths, took place in Great Britain, yet no apology was needed for bringing this subject before the mining public, especially as shafts were becoming deeper and loads heavier.

Proceeding, Mr. Baird said it was his intention to treat the subject from a practical standpoint and in such a manner as to be of use in everyday experience, so that his observations could be put into daily use and be of service to everyone who had to deal with ropes from day to day. The various qualities of rope from which a selection may be made, he continued, beginning from the lowest and going upwards in quality and price are:—(1) iron wire, (2) Bessemer-steel wire, (3) patent-steel wire, and (4) plough-steel wire. There is no fixed standard for these different qualities, and herein lies the difficulty of getting exactly the quality of the wire specified; but this may, in a manner, be overcome by stating the tensile strength of the quality wanted, thus:—

Description of wire	Tensile strength in tons per sq. in.
(1) Iron wire	30 to 40
(2) Bessemer-steel wire	45 to 60
(3) Patent-steel wire	65 to 90
(4) Plough-steel wire	95 to 125

Let it be supposed that offers are invited from, say, three firms of good repute for a winding-rope, and that the same form will suffice, whether it is for a shallow pit with a light load or a deep one with a heavy load. The weight to be lifted (including the weight of the rope), the diameter of the drum and pulley-wheels, and the speed of winding will be specified, and the makers will be asked to send a full specification of the rope offered, with their guarantee as to tension, torsion, and bending. After the rope is ordered, made, and received, three feet can be cut from the end of it, and from this piece sufficient will be got for the three tests advised by the writer of tension, torsion, and bending. These tests will be entered into the rope-book for future reference, and, if the wires do not come up to the guaranteed figures, the matter will necessarily be taken up with the makers. If the results are seriously under the guarantees, a new rope will be required. It may be taken that only a few managers have the necessary testing-machines at their command, and so the majority cannot very well conduct the tests. This being so, he (the speaker) suggested that some responsible engineering firm should, through the Institute, be approached with a view to having a rope-testing station added to their establishment, where ropes could, at a moderate rate, be tested with accuracy and expedition, without being sent to London or to other distant centres.

In the absence of a machine suitable for testing the rope as a whole, the next best course is to take the rope to pieces and test the wires individually. The sum of the breaking-strains of the several wires, less a percentage for combination, gives the breaking-strain of the rope. This percentage deduction varies with the size and construction of the rope from 5 per cent. with a six-strand seven-wire rope to 17½ per cent. with a six-strand thirty-seven-wire rope; but the average may be taken at 10 per cent. Makers' tables, so far as the writer can ascertain, are based on the aggregate breaking-strain of the individual wires, and 10 per cent. should be deducted from the total breaking-strain in order to reduce the results to the actual breaking-strain. The testing of a rope, after the testing-machines and the tables necessary to guide in the results have been obtained, is the simplest part of the whole matter. What is more difficult is laying out the engines, drums, pulley-wheels, and keps or shuts, so as to give the rope the best chance of doing a large amount of work before it requires to be taken off. Each of these and several other points would lead to a long series of remarks, which in this Paper at least, would be cumbersome and undesirable. It will, however, be necessary to enumerate the more important of these, and offer a few practical remarks on them without pursuing them to their scientific conclusions.

(1) The drum should be at such a distance from the shaft that the angle of the lead of the rope should be under two degrees when the cage is at the top, otherwise the side-wear on the rope will be excessive.

(2) The drum should be of sufficient width to admit of the rope being only one course deep. If, in certain circumstances, this is impossible, then a simple step-up should be provided for the rope where it mounts for the second course.

(3) The diameter of the drum and pulley-wheels should not be less than a hundred times the diameter of the rope, and a thousand times the diameter of the thickest individual wire in the rope.

(4) A rope lasts longer if there are no shuts or keps at the pit-bank, and it is better for the cage at the pit-bottom to have (if resting) no slack rope, for it has been proved beyond doubt that six inches of slack doubles the strain on the rope when the load is lifted. This is a very important matter.

(5) The pulley-wheels should be so proportioned and of such material as shall prevent them remaining stationary when the rope is let out, or is continuing to revolve after the cage comes to the bank. There is nothing so detrimental to a rope as this, and its prevention is a problem that, so far as the writer knows, has not yet been properly solved.

(6) All winding-ropes should be made Langs lay, unless where locked-coil or other specially constructed ropes are in use. A longer life will thus be ensured.

(7) Where the drums are lagged with wood, it is desirable to have a groove turned all the way along, so that the rope does not rub on itself as it coils on and off the drum. The pitch of the groove thus formed should be such as to have a space of about three-thirty-seconds of an inch between the coils of the rope. This is always a good arrangement, but it is indispensable when the drums happen to be too close to the pit, otherwise the rope will be apt to ride on its neighboring coil before the outer edge of the drum is reached.

(8) In all cases the wires of the ropes should be as large as possible, consistent with the sizes of the drum and wheels, so that they may take longer to wear through.

(9) Should winding-ropes be galvanized? This question has been often discussed, and every user has his own opinion of it; but the writer's experience has satisfied him that, unless in very favorable situations where a thick coating of preservative can be put on and maintained, so that scarcely any of the wires can be seen (which is itself a drawback for examining purposes), all winding-ropes should be galvanized.

(10) How long should a winding-rope be kept on? This is another question that is rather difficult to answer in a few words. It depends, of course, upon the conditions under which the rope is working; but the life of a winding-rope, if of the proper quality, size and construction for what it has to do, will vary from 1½ to seven years, and the writer's experience is that a 50 per cent. longer life can be got with galvanized ropes than with bright-wire ropes.

Ropes for sinking purposes are, or should be, of non-rotating construction, and can be obtained from almost any maker. These ropes are constructed of two ropes, one inside the other, and laid in the opposite direction to each other. When they are taken off a reel and put on the drum, care should be taken to prevent them from turning, as they are liable to get out of the twist and so bring about what is called "bird caging." If properly handled at the first, they are not likely to give any trouble. Such ropes are most useful for sinking purposes, but it is doubtful whether they are to be recommended for ordinary coal-winding. Flat ropes for winding purposes are sometimes used. They consist of six or eight small ropes, ½, ⅝, ¾ or 1 in. diameter, according to the strength wanted, and are stitched together with Bessemer wire. They are more expensive than round ropes, and usually give trouble by splitting asunder, and in such a case need to be re-stitched. The only point in their favor is that they give an ideal scroll-drum movement, similar to that of flat hempen ropes, so that engines of smaller size will do the same work as larger engines would do with a parallel drum. Everything considered, they are, in the writer's opinion, not to be recommended, as they do not give a long life. Even with moderate winding, from two to three years is a fair average life. In conclusion, the writer said he raised other two questions in his paper, chiefly for the purpose of drawing forth the experience of others as to the life of winding ropes.

(1) Whether the rope coming off the top of the winding-drum or the one coming off the underside of it has the longer life? The general accepted answer is in favor of the top rope, as both of the bends it makes are in the same direction, whereas the lower bends first one way and then the other. So far as the writer's experience goes, it is found that the difference, if any, is not pronounced.

(2) Whether a rope running on a wood-clad drum lasts longer than one running on iron or steel cleading? The writer has no recorded experience on this point, but he understands that the difference is very much in favor of wood, and this fact ought to be better known than it is at present.

SHOP FLOORS.*

By Leonard C. Wason.†

No floor surface is perfect from every point of view. The question of what floor to adopt for a shop is therefore always a choice between different combinations of good and less good qualities. While the factor of cost is apt to be considered the dominating one, there are many situations in which cheapness is not the most important item in the choice of a floor; or, to put the matter a little differently, it is sometimes economy to discard the floor that is cheapest in first cost for a different floor of higher cost, which will justify this higher cost because of its better adaptation to the particular kind of service required of it. Therefore, although I have been asked to speak particularly about granolithic floor surfaces for shops, I am not in the attitude of advising granolithic floor for any and every service under any and all conditions. The granolithic surface has good qualities of great importance, and I shall give these qualities due weight. But I shall also point out some of the circumstances under which it may be better in particular cases to put in wood floors.

In first cost the granolithic floor surface has the advantage over a wood floor, the cost of such a surface laid in the best manner being about equal to the cost of seven-eighths maple flooring delivered at the work. Besides this advantage in cost, the granolithic surface is fire-proof and waterproof, and will not decay or disintegrate under washing with water, which is one of the weak points of the wood floor.

There are other considerations involved in a decision between granolithic and wood floors concerning which it is unsafe to be very dogmatic without first defining very precisely the conditions of each particular case. Taking first such a matter as the wear of these two types of floor, it is easy to see that a wood floor is more easily repaired than a granolithic surface, and that repairs to a wood floor can bring the floor to its original maximum efficiency. A granolithic surface also can be repaired so that the new patches will be quite as good as the original surface, but the time and care required is much greater than with a wood floor. In repairing a granolithic surface it is necessary for best results to cut out the broken or defective portion down to the slab, leaving the cut with vertical edges. Next, the slab must be cut with a sand blast or acid until the aggregate stands out sufficiently to give a good bond for the new surface. Then the slab, and edges of the cut, having first been well wetted, must be grouted with neat cement mortar, on which the new finish is laid before the grout has set. Finally, the patch must be kept wet, and protected from use for at least a week. It is rarely possible to satisfy all these necessary conditions, and it is therefore true that under average

*Abstracted from a paper presented at New York, October meeting of Am. Soc. M.E.

†President of Aberthaw Construction Co., Boston.

practical conditions the repaired portions of granolithic floors are inferior to the original surface in wearing quality.

In this contrast between wood and granolithic floors we have to deal with the question of workmanship. With a maple top floor the difference in wearing quality between a floor laid by a first class carpenter and the floor laid by a merely average carpenter, is comparatively slight; but with the granolithic finish, ignorant or hasty work is disastrous almost from the outset. The granolithic finish, to give good service, must be laid according to the right theory and every step in the workmanship must be first-class. It is not at all difficult to get a first-class granolithic surface if one starts out with a determination to have it. Good work costs very little more than poor work. It must be admitted, however, that a great many granolithic floors have been unsatisfactory. Poor workmanship and wrongly chosen materials are the reasons.

Among objections which have been raised to the granolithic surface, one of the most prominent is the bad effect of the concrete floor upon the health and comfort of the operatives who stand upon it. There seems to be little doubt that long standing in one position on a concrete floor is not good for the operative. The reason for such ill-effects as occur is not the excessive hardness of the concrete floor, as is so generally supposed, but its great heat absorbing power. Wood is a poor conductor, a poor radiator, and, therefore, in general a pretty effective insulator. But when an operative stands for hours on a concrete floor the heat of his body is conducted from his boot soles into the concrete rather rapidly. In consequence of this drawing away of the body heat, feet and legs become more or less chilled, the circulation in the legs is slackened, and pressure on the skin of the feet, coupled with this sluggishness of circulation, due to the loss of heat, may easily give rise to sore feet and to various pains which are commonly classed under the head of "rheumatism." That these bad effects do occur has conclusively appeared in investigation of the whole question made by the Aberthaw Construction Company about a year ago. For operatives who are moving about while at their work, or who wear thick-soled boots, this excessive extraction of the body heat by the concrete floor is a negligible matter. For men working steadily at the machines in one position, some insulation is required. It is the practice in many machine shops to give the men foot boards or gratings of wood on which to stand. These do away altogether with any ill-effects from the concrete floor.

Granolithic floors have been attacked as not sufficiently durable under the rough usage of machine shops and foundries. Here again we have to take into consideration the all-important items of materials, workmanship, and theory of construction. Nothing but the hardest natural stone in the way of a masonry floor can long withstand the wear of heavy trucking. The usual form of truck is provided with small diameter wheels having a flat tread and sharp edges, and such wheels with the tilting or slewing of trucks that is always in evidence in turning corners, will gouge and dig into any kind of floor. But the granolithic finish can be so made with such a high percentage of tough, elastic aggregate, that the wear of trucking is borne almost exclusively by the aggregate itself. Nothing but steel and granite can outwear such a floor. It is the part of wisdom in laying granolithic floors over which there is a heavy truck traffic along certain lines to provide steel plates or gratings properly set in the concrete to form lanes or tracks for the heavy trucks.

The nature of the tools, possesses and products in a given shop bear on the decision between granolithic and wood floors. An edged tool dropped edge down on a granolithic floor would be damaged by the impact, while the same tool dropped edge down on a wood floor would dig into the wood and probably suffer no damage. Also, a manufactured product consisting of delicate metal pieces would be much more damaged by falling on a cement floor than on a wood floor. Still further, the dust produced by the wear of some granolithic surfaces has proved harmful to delicate machinery in some shops. The wood floor does not of itself produce a dust capable of any visible action as an abrasive. It is possible, however, by glueing battleship linoleum to a concrete floor to get many of the advantages of a wood surface. Tools and small manufactured articles are as little likely to break by falling on a linoleum surface as upon wood. The linoleum is without the innumerable cracks of the wood floor and therefore is much more easily kept perfectly free from dust. Linoleum is also an efficient insulation against loss of body heat to the concrete floor.

High resistance to wear of every sort and practically complete dustlessness, that is to say, freedom from the production of abrasive dust, can be secured in a granolithic surface properly made. It is always better that a granolithic finish should be laid on the floor slab while the latter is still green. A better bond between the finish and the slab can be obtained in this way than is possible after the slab has fully set. Unfortunately, the conditions governing the erection of concrete buildings usually put off the laying of the floor finish until all the rest of the building is practically completed, and this involves the need of using great care in cleaning and roughening the slab surface so that the granolithic finish laid upon it will get the best possible bond with the slab. Ordinarily the finish need not be more than three-quarters of an inch thick. Both for wearing capacity and for the avoidance of dust through abrasion of the concrete, the granolithic finish should contain the highest possible proportion of tough stone aggregate.

For the most durable and most nearly dustless flow my rule is this: First, it is better to use no sand; sand grains are brittle, are easily broken by the abrasion of feet, and cause dustiness. Use for an aggregate a stone suitable for macadam road, taking the sizes that pass through a half-inch round mesh screen, and nothing smaller than that passed by a 20 mesh screen. Mix the concrete dry of the consistency used in making blocks, so that considerable tamping will be required to bring to the surface enough water for trowelling. Finally, do the trowelling before the mortar sets. It is practicable in this way to get a surface that is 90 per cent. hard stone; the mortar, of course, wears more quickly, but its small area makes the results of this wear unobjectionable. Prolonged trowelling of a wet mixture brings to the top the "laitance" of the concrete, which is the part incapable of a true set. A top layer of laitance is therefore porous and wears down quickly. Even the fine particles of good cement should not be brought to the top, for they form a layer which is weakly bonded to the rest of the concrete, and which wears away quickly, appearing in the air as dust.

LARGE CHIMNEYS IN THE NORTH-WEST.

The new concrete chimney under construction at the power plant of the British Columbia Electric Company, Vancouver, B.C., will soon loom up alongside its brother chimney, which has been in use several years. The chimney is 252 feet high, with a 6-foot flue, and cost $16,000.

The chimney on the Guggenheim smelter at Tacoma and on the smelter at Butte are the only ones in the Northwest which are larger.

GRAND TRUNK PACIFIC ELEVATOR AT FORT WILLIAM, ONT.

The Grand Trunk Pacific, the latest of the three Canadian railroads to begin construction, is in its conception the greatest of the transcontinentals. This undertaking surpasses in magnitude and importance any railway ever planned and under construction at one time. When completed, it will have a main line, extending from Halifax on the Atlantic, to Prince Rupert on the Pacific, with a number of important branches to Port Arthur, Toronto and Montreal. It is proposed, ultimately, to extend to Hudson Bay and thus open a short ocean route to European markets. These three railroads, modern to the last degree, are yet inadequate to handle the vast amount of traffic which they have created. In some sections, before the original track was ballasted, double tracking had already been carried out. The Canadian Pacific is now double tracked from Winnipeg to Fort William, and it will undoubtedly be necessary for the other roads in the near future to duplicate their tracks on some important sections. Every line speaks of absolute utility and efficiency and one is reminded of the clean-cut lines of a thorobred. Of such an appearance is the Grand Trunk Pacific Terminal Elevator at Fort William, illustrated on the following pages.

Preliminary sketches of the elevator were made in 1905 and were further elaborated during 1906 and 1907 by the railroad engineers. In 1908 the Canadian Stewart Company, Limited, prepared designs for the elevator, and a contract was let to it on its plans and specifications.

Grain elevators in general features are quite similar to one another, yet differ in many essentials on account of local conditions. From the small country elevator, receiving grain from wagons and loading into cars is a far cry to the huge terminal elevators of the Great Lakes or Gulf of Mexico and Atlantic Ports. These also are differentiated. Ocean going vessels carry miscellaneous cargoes of package freight as well as grain and loading is usually a matter of some days. In order that loading of all classes of cargoes may be done at the same time it is necessary to construct long conveyer galleries to transport grain to vessels which may lie at warehouse docks a considerable distance from the elevator.

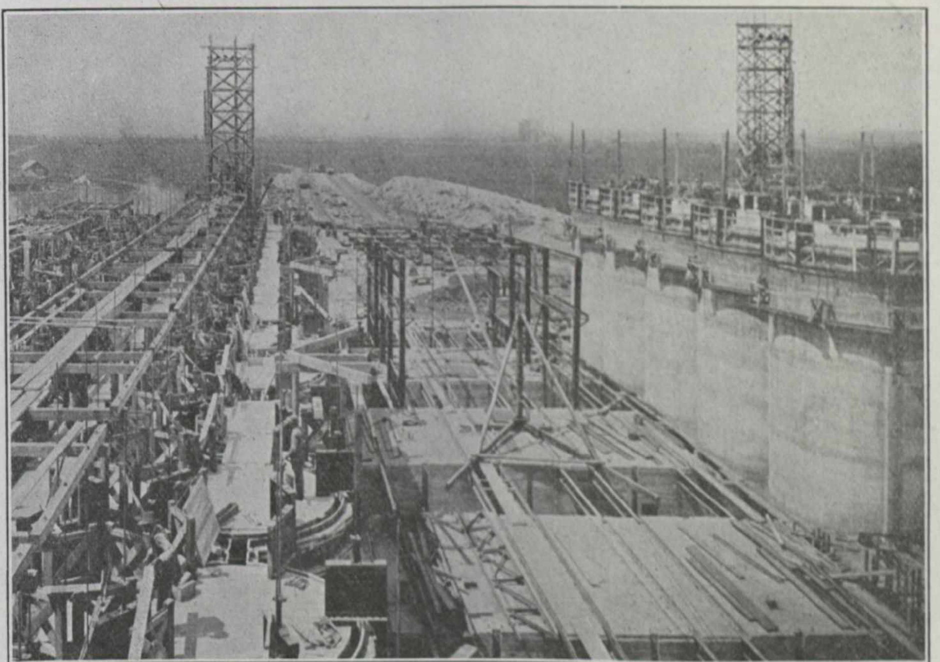

Fig. 1. Receiving Pits and Bins of Grand Trunk Pacific Elevator in Course of Construction.

The Grand Trunk Pacific Railway, with its usual foresighted policy, planned to construct what will be the largest grain handling terminal in the world. Its terminal elevator system at Fort William is designed in four units of 10,000,000 bushels capacity each; and the first section having a capacity of 3½ million bushels has just been completed. In order to take advantage of lower freight rates on the Great Lakes, wheat in the autumn months is rushed from threshing machines through country receiving houses to terminal elevators on Lake Superior and there loaded into lake vessels. For the prompt and efficient handling of the Western crop, unusual facilities are necessary at the head of the lakes.

To the layman, a grain elevator seems to be an unsightly structure whose walls look so blank and bare that further investigation seems uninteresting. In the past that picture was true enough, but to-day with the introduction of steel and concrete as building materials, a great elevator reared against the sky has a rugged aspect which invites attention.

On the Great Lakes, where grain generally forms an entire cargo, the vessels lie directly in front of the elevator and by means of spouts discharging through a series of deck hatches are loaded in a few hours. Another feature distinguishing marine elevators at the head of the Great Lakes from those on the Atlantic and Gulf Coasts is the ample and elaborate cleaning facilities provided. Nearly all grain received from the West at Duluth or Fort William is carefully cleaned before being shipped, and for this purpose extensive and elaborate batteries of warehouse separators, for wheat, oats, flax and screenings are installed.

By reference to the illustrations an idea of the general lay-out of the Grand Trunk Pacific Elevator may be obtained. The plant consists of a working house with a capacity of 750,000 bushels, a four-track receiving shed, a dryer house, a boiler house, a switchboard room and a transformer house.

In front of the working house a concrete dock 337 ft. long was constructed for the accommodation of vessels receiving their cargoes of grain. It is essential that the various factors in any grain elevator form a compact system, as on this depends to a great extent the efficiency of the plant. In the Grand Trunk Pacific Elevator, excellent judgment has been shown by the designers in arranging the various structures so that they form a harmonious unit.

The working house, facing the slip through its entire length, is admirably suited for the rapid shipment of grain. It consists essentially of 75 circular concrete bins, having an inside diameter of 12 ft. and rising to a height of 79 ft. They are arranged in five rows of 15 bins each, forming 56 interstice bins, and making the working house 69 ft. wide by 237 ft. long. These bins are supported by a series of octagonal columns forming a working story 20 ft. high. Surmounting these bins is a structural steel cupola 83 ft. high, sheathed with corrugated steel and roofed with concrete.

Between the working house and storage annex is located the track shed, a steel framed structure 68 ft. wide by 240 ft. long, having a concrete foundation and roof. It contains four tracks with pit and shovel accommodations for twenty cars which may be unloaded at one time. Under normal conditions 200 cars may easily be unloaded in ten hours and under stress 500 cars may be unloaded in 24 hours.

For the storage of such immense quantities of grain the problem arose as to what would be the best size and arrangement of tanks for the storage annex. As built, the annex consists of 70 circular concrete tanks arranged in ten rows of seven tanks. They have an inside diameter of 23 ft. 3 inches and are 95 ft. high. Fifty-four interstice bins formed between the circular tanks are also utilized for storage. The tanks are supported on a concrete mattress and walls. The cupola over the annex is of steel construction and is roofed with concrete. Five overhead bridges connect the storage annex with the working house and provide passageway for the conveyers. Steel galleries and cross walks were built over the storage tanks in the annex with open areas between; thus making it possible to heap the grain above the top of the bins.

The preliminary work entailed by an undertaking of such magnitude as the construction of the Grand Trunk Pacific elevator may be realized by an examination of the plans. Fifteen men were employed at the Walkerville office of the contractors for many months, designing, drawing and tracing, and $20,000 was spent on this item alone. Every little detail to the last rivet and rope sheave was drawn out before being used for construction. The designing and drafting was carried out under the direction of Mr. R. H. Folwell, Chief Engineer, and the work of construction was superintended by Mr. W. R. Sinks, General Manager of the Canadian Stewart Company, Limited. The owners were represented by Mr. John S. Metcalf, who approved the plans and inspected the construction of the work.

The actual work of construction began on November 21st, 1908, the Mayor of Fort William turning the first sod on that date in the presence of over three thousand invited guests. From that date excavation for foundations was vigorously pushed under weather conditions which were far from ideal. With the thermometer registering as low as 55 degrees below zero, it required pluck as well as perfect organization to perform without interruption the task of removing 60,000 yards of frozen clay and sand. A steam shovel and the operation of trains of dump cars over 6,000 feet of track, necessary to waste the excavated material, presented an animated scene.

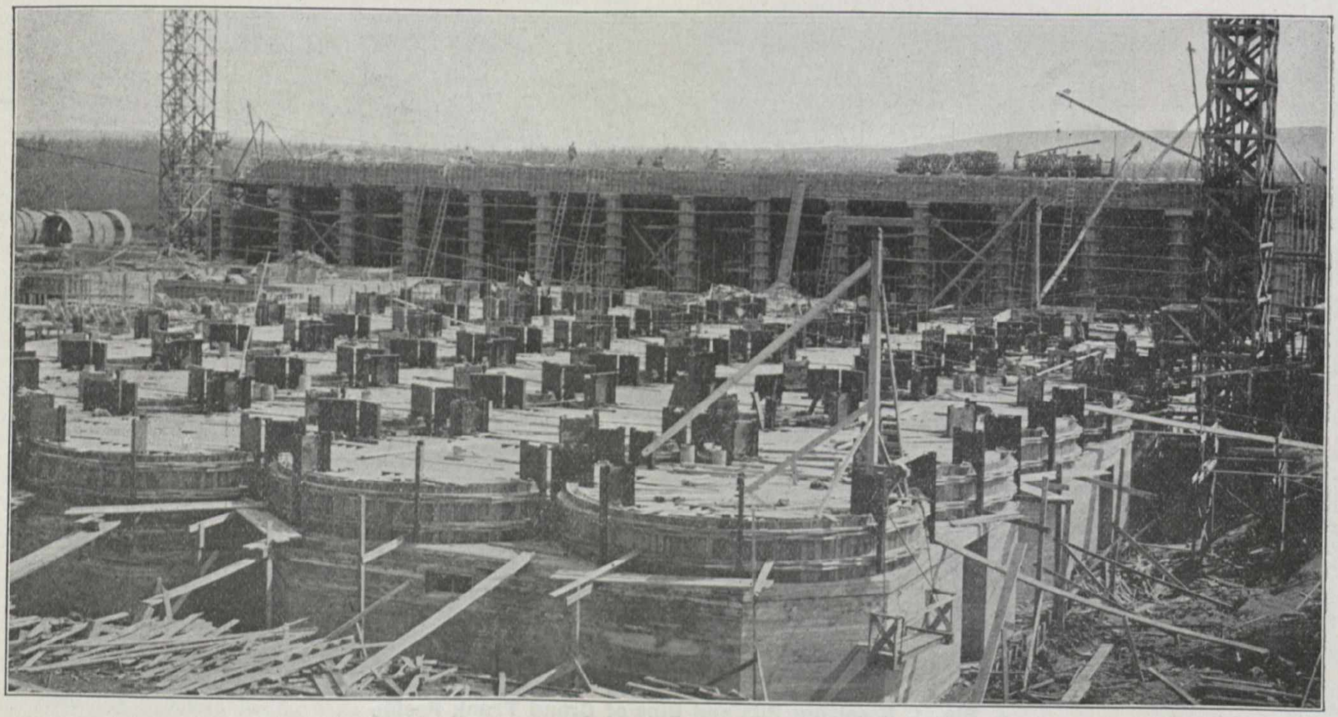

Fig. 2. Foundation and Substructure Grand Trunk Pacific Elevator, Fort William, Ont.

Pile driving closely followed the commencement of excavation. The piling, consisting of 12,000 sticks of timbers 60 feet long, was driven to rock, which was done by two drivers working night and day for ninety days. With the advent of spring, the site was in readiness for the concrete foundation proper.

The methods of handling and placing concrete in the foundation did not differ much from the general practice in such work, but it is noteworthy to remark the rapid progress made. While the first concrete was laid in March, the foundations were completed to the top of the bin supporting floor in May. During the time the foundation work was being done, the circular tank forms were made and when the bin supporting floor was laid, the tank forms were in readiness for placing. These forms, embodying the experience of years of concrete grain elevator construction, are an evolution from the crude methods first employed on circular bins. An absolutely smooth surface without breaks or unsightly rings and offsets is obtained by their use. The laying of concrete is practically continuous from the placing of the bottom until the top of the tank is reached. The forms in general consist of an inner and outer wall section four feet high which are held apart by yokes, a sort of steel clothes-pin made up of plates and channels and supported by special lifting jacks.

Though there are a number of other kinds of jacks for movable forms in use, yet this jack has special advantages which are apparent to all who have had experience in the use of movable forms for concrete walls. The essential element of the invention is a hollow jack screw through which is inserted a vertical rod and upon which the jacks are made to climb and thereby raise the forms. In operating the jacks, a workman inserts a bar in a socket, causing a screw to turn. By turning to the right the forms are lifted, and by turning to the left the jack itself climbs the rod while the forms remain stationary, being supported by the adjacent jacks. By reason of the rod passing through the jack, the load is applied concentrically and thus any tendency for the forms to bind is eliminated. Another great advantage of the device is that it does not have to be dismantled when a new length of rod is inserted. By this system the position of the horizontal reinforcing rods may be marked on the jacking rods, which is a matter of great convenience; also daily progress of the work may be accurately observed and the forms are kept level throughout the entire work, by reference to the marks.

The forms of the separate tanks though constructed in sections are tied together by an arrangement of rods attached from yoke to yoke, making a united system and providing an ample floor space for workmen. For each tank eight yokes and jacks were used, operated in sequence, one being turned a little at a time. The annex walls were completed on August 15th. In the meantime the working house bins were rising and the final concrete was placed August 31st. Immediately after the final completion of the tanks, the erection of the steel cupola framing was commenced. Fifteen hundred tons of steel was used in the construction. In December, 1909, the framing for the cupolas had been erected and enclosed and the floors and roofs were completed. All floors and roofs are covered with five-ply composition pitch felt and gravel. Sheet metal window frames glazed with quarter-inch wire ribbed glass and steel-clad doors completed the construction of buildings, which are fireproof to the last degree.

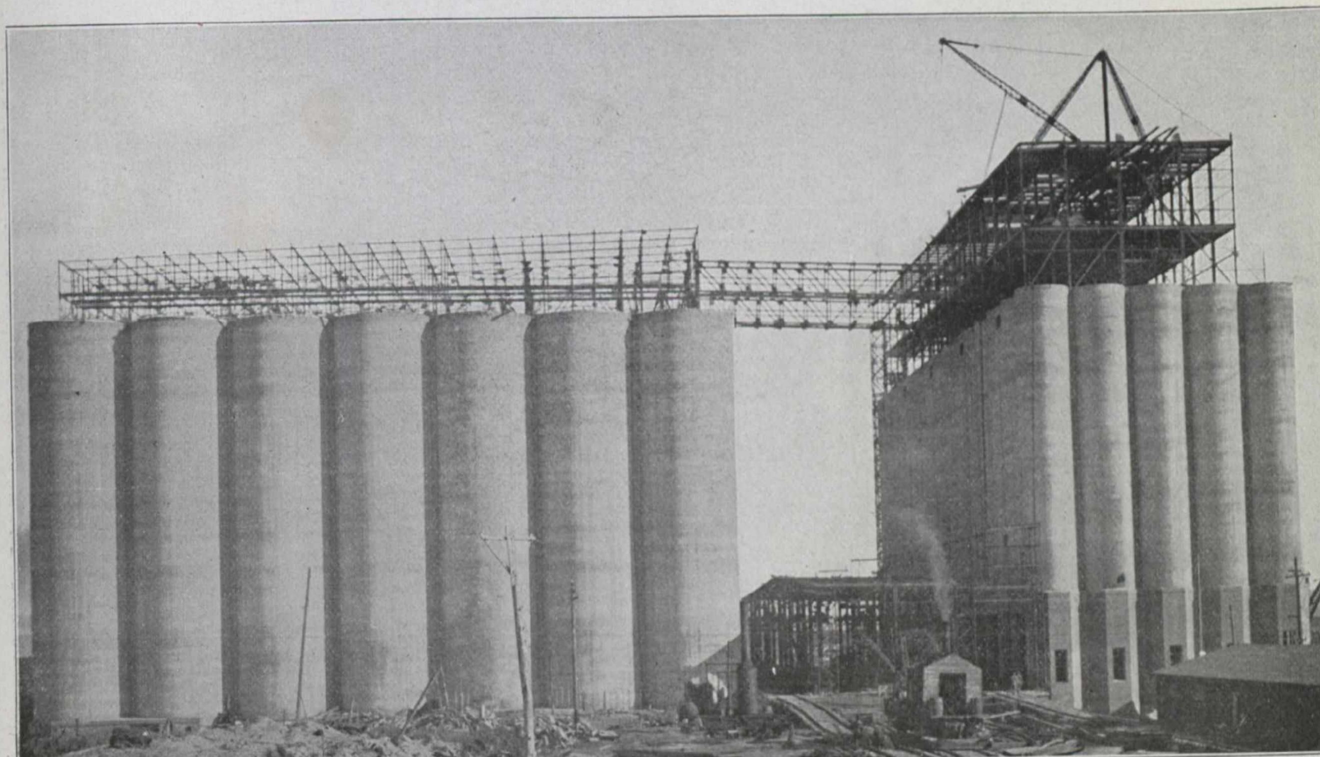

Fig. 3. Completed Bins and Steel Frames of Track Shed and Cupolas, Grand Trunk Pacific Elevators, Fort William, Ont.

Other features that added to the rapidity of construction were well-equipped machine, blacksmithing and wood-working shops. Here were installed power lathes, drill presses, bolt threaders, band and circular saws, planing mills and borers; so an immense amount of manual labor on the wood forms was eliminated and quick repair of equipment was made possible.

Portland cement arrived in Fort William in large cargoes and it was necessary to provide ample warehouse facilities to hold it until wanted on the work. A cement shed capable of storing 12,000 barrels of cement was connected with the various cement mixing plants by means of railroad tracks on which Vulcan locomotives and dump cars were operated. Sand and gravel for concrete was dredged from Lake Superior and unloaded from barges at a temporary dock 2,000 feet long by clam-shell derricks. Traveling hoppers received these materials from a whirley and in turn loaded the trains of side dump cars. The concrete mixing plant consisted of four No. 2½ Smith Mixers and Lidgerwood hoisting engines located in two batteries at each end of the elevator. Four hoist towers and hoppers were constructed and necessary track was laid early, so that when the work was ready for concreting to begin, the mixing plant was completely installed. This plant handled during the course of construction 60,000 cubic yards of concrete and its efficiency is evidenced by the fact that as much as 800 yards was mixed and placed in a single day. As is well known the item of lumber is one of the chief factors entering into the cost of concrete work. In this instance 2,000,000 feet of pine lumber was used for forms and moulds. The steel bars for reinforcing concrete in various parts of the work amounted to 2,500 tons and of quality demanded by the Steel Manufacturers Standard Specifications. Round bars were used in girders and floor slabs. Horizontal reinforcing in the concrete tanks consisted of flat steel bands and, in placing, sufficient lap was allowed to develop the necessary strength of the joints. In the concrete columns supporting the working house bins spiral reinforcing was used, which was made of ½-inch steel wire forming a helix of 41 inches diameter.

Grain Handling Facilities: If the lofty structure rising high in air has interested the layman, the intricate machinery and complicated equipment, the very life of an elevator, must hold a still deeper interest for the engineer and operator. To watch the belt conveyers with their rushing streams of grain, to hear the purring of the motors and then to note how few employes are to be seen is to realize how nearly automatic modern science has succeeded in making the immense plant.

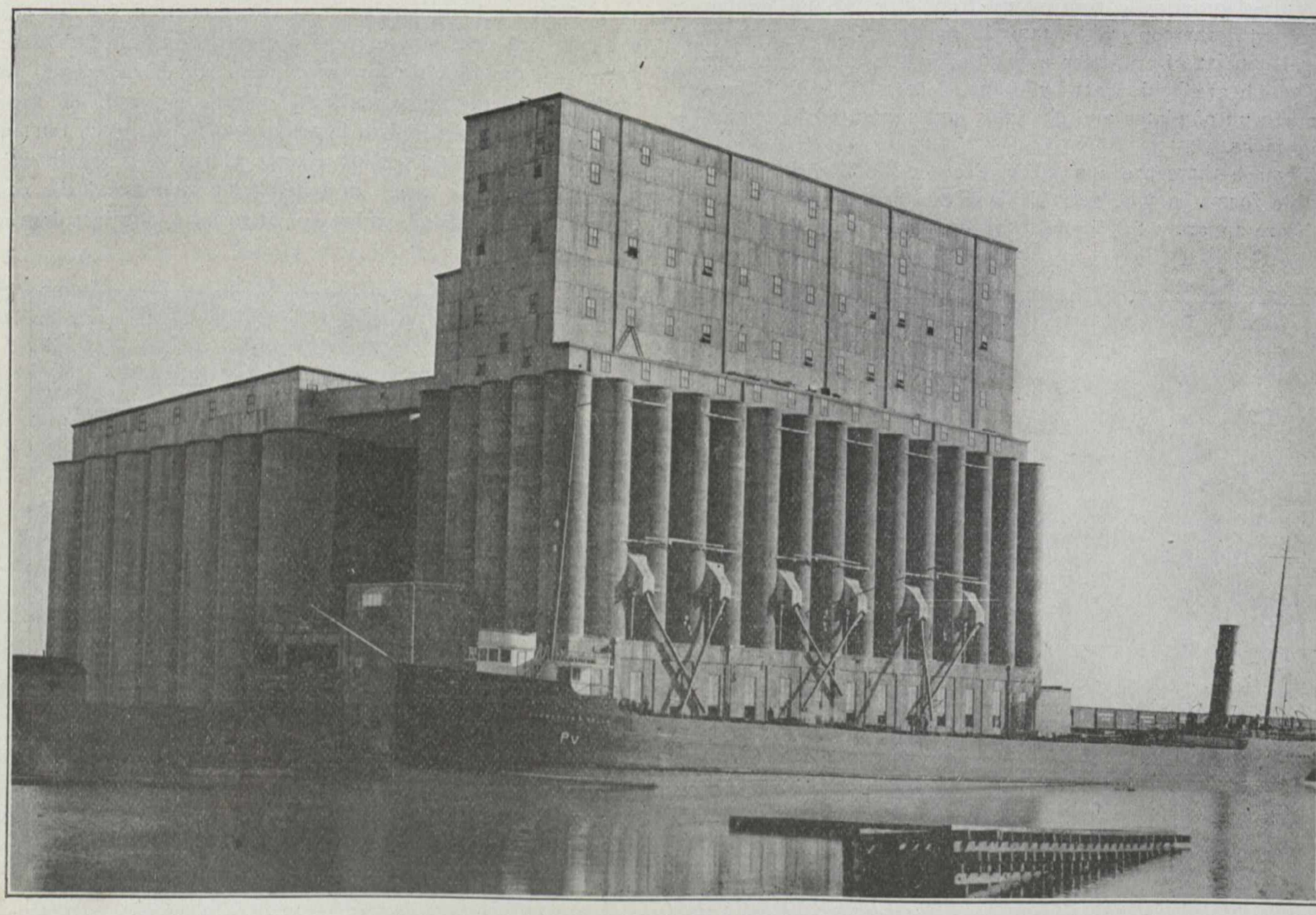

Fig. 4. First Section of 40,000,000 Bushels Grand Trunk Pacific Elevator, Fort William, Ont.

TREATING RAILROAD TIES.

While some railroad systems have resorted to creosoting for the treatment of railroad ties, the Southern Pacific has engaged in a different sort of experiment for the same purpose. It has just removed from the Great Salt Lake 10,000 ties that have been in pickle in that highly mineralized body of water for three years. These have been shipped to Hazen, Nev., and will be placed in a roadbed of the Hazen cut-off for test purposes.

The experiment is not altogether new, for there are ties in the old Promontory line of the Southern Pacific that were pickled in the same salt formation, and though in the track for forty years, have not shown deterioration.

The test to be made on the Hazen cut-off will be a severe one, owing to the soil of Nevada being of an alkali character. The ties, it is believed, have become so thoroughly impregnated with salt that they will act as a "ground" to the electric current in the block signal service. It is this condition, on the other hand, that makes them unfit to be used on the main line. It is thought that the preserving of ties and piling in Salt Lake may become an important industry, if tests now being made work out satisfactory.

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CONTENTS OF THIS ISSUE.

CONTRACTS FOR THE SUPPLY OF ELECTRICAL POWER.

On another page of The Canadian Engineer of this issue will be found an article by Mr. Kensit, of Calgary, Alta., on "Contracts for the Supply of Electric Power from the Manufacturer's Point of View." This subject is becoming of more and more importance with the increase in the number of central station plants for the sale of electric power and with the increased development of hydro-electric plants. With this increase and the signing of contracts for a term of years has come many attendant difficulties over the wording and intent of certain clauses in these contracts. There has been a great deal of discussion over one clause in particular, namely, that relating to the power factor of the load. This term, "power factor," as usually interpreted in contracts, is of very doubtful meaning, and Mr. Kensit in his article has given us a very complete and concise analysis of the clauses containing this term.

The whole subject of contracts for the supply of electric power is of great interest, so much so that we have made arrangements for the publication of a series of articles dealing with the technical terms of such contracts, and it is hoped that these articles may help to dissipate some of the misunderstanding and dissatisfaction occurring after the signing of such contracts.

A NEW DIRECT STEEL PROCESS.

One of the most interesting things to be seen at the Canadian National Exhibition, and later at the American Electrochemical Society meeting in Toronto, was the metallurgical demonstration of a direct steel process. This process, called the "Evans-Stansfield," is the result of the combined efforts of Mr. J. W. Evans, of Belleville, and Dr. Stansfield, Professor of Metallurgy, McGill University.

Mr. Evans has been working on this question with a view to finding a use for the titaniferous iron ores of Canada since 1904. Mr. Evans recognized that it was impracticable to smelt these ores in the blast furnace, and, therefore, devoted his efforts to devising an electric furnace that would meet the requirements of the case. In 1909, Dr. Stansfield became associated with him, adding to Mr. Evans' design some ideas of his own whereby the waste gases from the furnace are used to pre-heat and partly reduce the ores. A description of the Evans-Stansfield process, written by Dr. Stansfield, will be found under the section headed Metallurgical Comment in this issue of the Canadian Engineer. Dr. Stansfield there states that he has confidence that the process will prove a commercial success for the production of tool steel, and possibly on a larger scale for making steel castings and steel rails where the local conditions are favorable.

This process will undoubtedly mean much for the future of the steel industry of Canada. We have huge known deposits of titaniferous iron ores containing sometimes a small percentage of vanadium and sometimes nickel, and by means of this furnace, which Dr. Stansfield states is strictly controllable, the desired proportions of titanium in the alloy can always be obtained. Thus, the hitherto worthless ore bodies of Canada will now be turned into a valuable asset with the accompanying advantage of cheap direct steel, which may be used for high-speed tool steel work.

Mr. Evans and Dr. Stansfield deserve great credit for their perseverance in perfecting this process.

NEW HIGHWAYS IN BRITISH COLUMBIA.

A Canadian Highways Association has been formed in British Columbia, and their first meeting was held in New Westminster last week. Resolutions were passed urging both the Dominion and the Provincial Government to begin construction on a section of the Trans-Canada highway in British Columbia, and asking aid for the improvement of the road leading to Seattle from Vancouver, so that this section will be one of the finest highways on the Pacific coast. The important work of the meeting, however, was a resolution requesting the Provincial Government of British Columbia to collect and publish data as to the best kinds of road for different sections of the Province and the methods of construction. It also urges the Department of Public Works to launch an educational campaign on road-making, and the association promises to help in every way, with special lectures and by other means.

We are glad to note that the people of British Columbia are taking steps to improve the condition of roads throughout the province. It is a step which will almost immediately repay the amount invested by increased efficiency in the uses of the roads. Ontario and Quebec, although much older than British Columbia, have as yet done very little towards improving their highways. Poorly planned and laid-out roads are bound to show a great many losses to the communities through which they pass, but there are other economic features which must be considered, such as accidents to men, to vehicles, and to animals. The business of towns and railroads is affected by bad roads, and land values are also quickly affected.

At the annual meeting of the Ontario Municipal Association, held recently in Toronto, good roads was one of the subjects discussed, and the representatives from the cities and towns were among the most enthusiastic supporters of the movement. With the co-operation of the cities and rural municipalities there should be rapid advancement in the improvement of country roads.

We wish the Canadian Highways Association every success in their educational campaign.

A TOWN ENGINEER FOR BARRIE, ONT.

The town of Barrie is advertising for a town engineer, and will pay the munificent salary of $1,000 per annum. Barrie deserves congratulations on the generosity with which she treats her paid officials. One thousand dollars for a town engineer! Is it any question that trouble follows when such inadequate remuneration is paid. St. Catharines tried to do this sort of thing, but found out about two months ago that it was poor economy to save one dollar on salary and pay out tenfold on poor work. Many other towns have discovered the same thing. The western towns have profited by the mistakes made in the east, and they have attached reasonable salaries to the position of their municipal engineers. In the east, however, the municipalities do not even yet, after the stern lessons they have had, seem to appreciate the importance of the position and the necessity of procuring adequate men.

Kingston is now about to appoint a city engineer, and we find there a strong movement in the city council in favor of appointing a man with no technical qualifications whatever, simply because he is a local man, and can be obtained at a low salary. As we have said before in these columns, the city council of Kingston require an experienced engineer, and personal feeling should not prevent the appointment of the best man it is possible to obtain, even if the cost comes higher than for the local man.

Barrie, if they obtain their town engineer at the salary advertised, may get him cheaply from the salary point of view, but it will inevitably be a dear bargain before they are through, as St. Catharines and many other cities and towns have found it. A town with a population of over 7,000, as Barrie is, should be ready and glad to pay a salary sufficient to secure a first-class man. No private corporation, who are yearly spending the money some of our towns and municipalities are doing, would think of offering their engineers the miserable salaries these places do. And in return for the salaries paid these private corporations get good values for money expended, which is, in fact, one of the prime reasons for the engineer's existence. If the town council of Barrie would stop to think for a moment they would appreciate the mistake they are making in so lowering the dignity of the town. One thousand dollars a year, or about three dollars a day! They pay more in Barrie for their bricklayers and carpenters.

We can only voice a note of warning to both Kingston and Barrie in this matter, for this question of appointment of municipal engineers is one which deals eventually with the pockets of the citizens. If the citizens of these places appreciated the ultimate cost to them in the appointment of incompetents to these positions, they would take care that the right type of men, with proper training, were selected.

EDITORIAL COMMENT.

In a recent letter from the Public Works Department of the city of Montreal the secretary states that, according to law, tenders for sewers for Montreal have to be called for in a daily French and a daily English newspaper of Montreal, and that it is impossible for the Board of Commissioners to advertise outside of these. Is it any wonder that, under these circumstances, Montreal has to pay heavily for its sewers?

* * * *

The fact that nickel steel is in every way fitted for bridge construction will mean much for Canada. This steel is strong, tough, workable and reliable, and its use will effect a decided economy. In view of the enormous deposits which have been found in Canada there is no doubt that nickel will soon be far cheaper than at present, and will be greatly used in steel construction. There is a very rosy outlook for the nickel industry of Canada.

* * * *

We are pleased to note that Mr. Angus Smith, city engineer of Victoria, B.C., whom we mentioned in the editorial columns of The Engineer last week, has been reinstated as city engineer of Victoria. The council took issue with the temporary suspension by the mayor, and have ratified and confirmed all Mr. Smith's official acts. We are pleased to see that the council have taken the only true stand on this question and have vindicated Mr. Smith in the eyes of the public.

* * * *

In a recent issue of the official organ of the master plumbers of Ontario we note that since they have been incorporated as the Society of Domestic Sanitary and

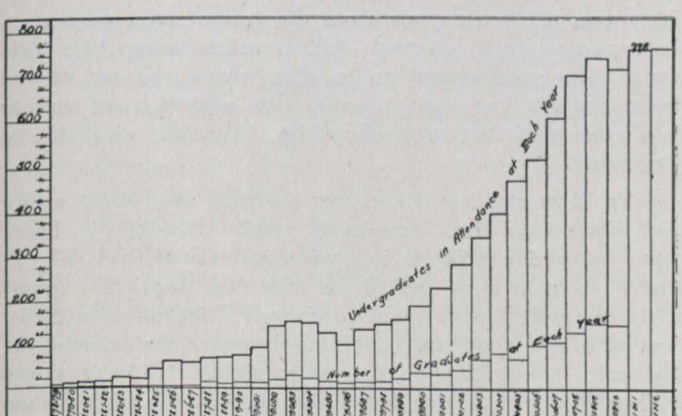
Heating Engineers of Ontario it is their intention to discard the name of plumber, which no longer describes their calling. An effort will be made to put the trade on a higher plane, and, as the means of raising the standard of work done, all members will be called upon to pass an examination. This will soon create a condition of affairs which will not be very pleasant for the engineers of Canada. The term "Sanitary Engineer" on the plumber's shop will give us rather a jar.

* * * *

To the critics of the principles of Scientific Shop Management we quote the following statement from the report of United States Secretary of War Stimson. This report was made concerning the methods of scientific management which have been utilized in the various arsenal shops of the United States War Department. Mr. Stimson states: The results thus far are highly gratifying and full of promise. There has been an undoubted increase in the efficiency of the workmen at the shop and a material reduction in the cost of manufacture. But at the same time, and to my mind even of greater importance, these results have been obtained without in anywise endangering the interests of the workingmen, either by decreasing their pay or requiring unpleasant exertion or "speeding up." On the contrary, any increase in the real efficiency must inure to the benefit of the workingmen.

ATTENDANCE IN THE FACULTY OF APPLIED SCIENCE AND ENGINEERING, UNIVERSITY OF TORONTO.

The accompanying curves showing the undergraduates in attendance at each year since 1878 in the Faculty of Applied Science and Engineering of the University of Toronto, and the number of graduates of each year in this faculty are of considerable interest. The returns of the registration show this year over 780 students



registered in Engineering. From a class numbering six in 1878 to the number of 780 in 1911 is certainly a great increase, and shows the measure of success this faculty has had in the teaching of Engineering.

The dropping off in the curves noted in the years 1895 and 1896 was due to the financial depression occurring at that time. Again, in 1909, may be noted a dropping off in the attendance due to the same cause. Following is a list of the total number of graduates to 1910 with other figures of interest in connection with the faculty:—

Total number of graduates, including 1910	1,153
" " " deceased	44
" " " in Canada	938
" " " United States	159
" " " other countries	12
Number having obtained degree of B.A.Sc.	480
" " " " C.E.	20
" " " " M.E. (Mining Eng.)	4
" " " " M.E. (Mech. Eng.)	4
" " " " E.E.	4

These curves also may be taken as an index of the growth in Canada to the present time. The above figures were obtained from Mr. A. T. Lang, the secretary of the Faculty.

GENERAL NOTES.

The rainfall was excessive over Ontario except near Lake Superior and in the Ottawa Valley. In other parts of the Dominion there was a deficiency which in the Maratime Provinces and to the westward of Manitoba was quite pronounced. Light snowfalls occurred in the Western Provinces during the last week and in Northern Ontario and in Quebec on the 31st.

The table shows for fifteen stations, included in the report of the Meteorological Office, Toronto, the total precipitation of these stations for October, 1911:—

	Depth in inches.	Departure from the average.
Calgary, Alta.	0.51	+0.02
Edmonton, Alta.	0.52	—0.24
Swift Current, Sask.	0.50	—0.21
Winnipeg, Man.	1.84	+0.32
Port Stanley, Ont.	4.18	+1.40
Toronto, Ont.	3.57	+0.87
Parry Sound, Ont.	5.37	+1.63
Ottawa, Ont.	2.21	+0.04
Kingston, Ont.	3.26	+0.56
Montreal, Que.	2.30	—0.71
Quebec, Que	2.82	—0.27
Chatham, N.B.	0.58	—3.11
Halifax, N.S.	2.02	—3.55
Victoria, B.C.	0.60	—1.66
Kamloops, B.C.	0.00	—0.53

CANADIAN PEAT BOGS.

The known peat bogs of Canada are estimated to cover an area of approximately 36,000 square miles, from which about 28,000,000,000 tons of air-dried peat could be produced. This is said to be equal in fuel value to some 14,000,000,000 tons of coal. To encourage the utilization of these resources, a peat bog of 300 acres, with an average depth of 8 ft., has been acquired by the Canadian Government, at Alfred, near Caledonia Springs, Prescott County, Ontario. About five miles of ditches have been dug, and a storage shed to hold 300 tons of air-dried peat, a blacksmith's shop, and an office have been built. It is estimated that the erection of a peat plant capable of producing 30 tons of air-dried peat daily should not cost very much, and since workable peat bogs are scattered throughout the farming regions of Ontario and Quebec, the most economical plan for utilizing this fuel would be the erection of a number of plants at convenient points, to be operated in the interests of the neighboring communities.

Metallurgical Comment

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

Correspondence and Discussion Invited

SOME EXAMPLES OF CASE HARDENING.

In view of certain facts that were recently brought to the writer's attention, it would seem that perhaps discussions on the rationale of "case hardening" have been kept to rather secluded circles. Be this as it may, it is certain that a resumé of what is actually accomplished by "case hardening" will not be amiss and by coupling with this discussion a description of some cases that have come under the writer's observation, it is possible that the recurrence of a certain type of "discovery," the nature of which will appear further on, may be prevented; or, on the other hand, if indeed the "discovery" be again perpetrated, perhaps it is possible to save time and money to many who might be tempted through ignorance to become interested in the "invention."

Digressing slightly for the time being, let us analyze certain procedures generally followed in drawing up steel specifications, and thereby establish a few facts that will make the discussion much more clear. It is a matter of common knowledge that when a steel is required for a given purpose, it is usual to specify limiting percentage of certain elements ordinarily existent in the metal. Now, all other things being equal, there is one element upon whose presence a great deal depends. This element is carbon. Speaking only of the ordinary steels (leaving out of consideration the alloy steels such as nickle, Chrome steel, etc.), it is possible to say that with a given percentage of carbon present, that the steel is suitable for certain purposes, will possess certain properties, may be subjected to certain heat treatment, etc. Now, merely considering our steel from the standpoint of the effect of heat treatment, it will be found that the degree of hardness that may be attained by heating and "quenching" a steel, is altogether dependent upon the amount of carbon in that steel. Ordinary steels containing .1 per cent. or so of carbon are capable of very little hardening, whereas steels of from .8 per cent. carbon up may be made extremely hard. This capability of being hardened increases with the carbon content. If, then, it is desired to make a tool that must be hardened, to take a cutting edge for instance, it would appear that steel must have a high carbon content; and this is the case, tool steels having in the neighborhood of 1 per cent. carbon.

Coming back to the main discussion, it will be necessary to consider the old Cementation Process of making steel. In this process, still existent to a certain extent, bars of wrought iron are packed in some fine carbonaceous material, such as charcoal, and then heated to and kept at a full red heat for a period covering from 7 to 11 days. During this time an action takes place whereby the wrought iron becomes gradually carburized by as it were, "soaking" up the carbon from the surrounding packing till, if so desired, the entire bar is highly carburized to the centre. In order to illustrate the action, one could imagine it as taking place very much in the same manner as blotting paper when placed edgewise will soak up a liquid, the greatest concentration being at the edge of the paper. This is exactly the case with the cemented steel bar. If layers of steel be taken off the bar, those at the surface will have the greatest carbon content, there being a gradual gradation to the centre of the bar. The point, as far as this discussion is concerned, is that the surface layers generally contain in the neighborhood of .9 per cent. to 1.5 per cent. carbon, i.e., the outer skin in any event is a high carbon steel which, as was pointed out, is capable of being hardened to a very high degree. It is in this last fact that there lies the principle of case hardening.

In short, the various case hardening processes are merely methods whereby low carbon steel is packed in some mixture from which carbon is taken up to form a high carbon steel skin on the object being treated. This, as we have seen, renders the treated metal capable of being hardened on the outside, i.e., a case of hardened steel is formed; hence, the term case hardening. The depth to which this case extends depends mainly on the length of time the steel is treated and, on the ingredients used in the mixture. Fig. 1 is a microphotograph showing how, in a case hardened object, the carbon content grades from the skin inward.

As intimated in the beginning, there are certain "discoveries" made from time to time, some of which have come

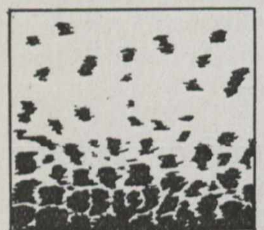


Fig. 1.

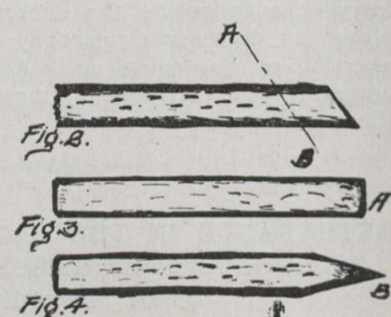


Fig. 2. Fig. 3. Fig. 4.

under the writer's observation, and all of which were nothing more or less than examples of case hardening. In all these cases it was claimed that by heating in certain ingredients, ordinary low carbon steel could be converted quickly into a good homogeneous tool steel. Indeed in some instances, the tools made from the treated steel seemed to bear out the results claimed; but, as will be seen, these tools owed their good properties to their shape and not to the "new process." All is not gold that glitters; and neither is all tool steel that seems from the outside to be capable of hardening.

To illustrate, let us consider the case of a wood-cutting tool, made from this "processed" steel. When this tool was tempered and sharpened it gave good results, not only at first, but as long as any of the new steel was left. Apparently the steel was as good as claimed. By taking a cross-section of the tool and examining it under the microscope, however, the explanation was self evident. Fig. 2 shows such a section. It was found that there was a high carbon steel skin on the tool as indicated by the darkened area in Fig. 2. If, now, the tool be quenched and tempered there will be a hard skin formed, a skin of almost tool steel composition. Now, since in sharpening a tool the grinding proceeds in more or less parallel planes, if the tool be ground back to AB, Fig. 2, for instance, we see that the **cutting edge is always in the high carbon steel region** and indeed, always will be. The tool was only a piece of case hardened steel—a fairly good tool; but, the steel practically worthless, as it was not homogeneous.

Another method of trying out these "new steels" was to work treated steel into a cold chisel. The reason why such a tool would stand up to its work was again shown by microscopic examination, although it must be said that in this case the tools did not last very long anyway, and there was very little necessity to proceed further. Let Fig. 3 represent a cross-section of a bar which we now know to have a high carbon steel skin. If the end A be forged out to form the cutting edge of the chisel, the high carbon steel at A will all be more or less brought together to a point as shown at B, Fig. 4. It is seen that there will be a considerable amount of high carbon steel in this region, and consequently, a very good cutting edge may be made, if the steel be tempered, but it will not last very long.

In almost every case the examination showed that any good properties were due to the fact that the shape of the object lent itself to preserving the high carbon steel in the neighborhood where it was most beneficial. It is of interest to know that a very good emergency lathe tool may be made by case hardening a piece of steel. In fact, in one case it was found that a tool could be made that stood up to its work while it lasted much better than ordinary special steels.

It is obvious that in order to demonstrate the uselessness of these steels, all that is necessary is to cut the skin off and the remaining steel will be useless for the above mentioned purposes. Care must be taken, however, to see that a sufficiently deep cut is taken, for in some cases it will be found that the carburization has gone in a considerable distance. Again, it may be found that the original steel bars are fairly high in carbon and are therefore capable of being hardened to some degree, so that even when the skin be cut off, it will be found that a chisel may be made that will cut gray castings. This is really a poor test of a tool steel unless conducted for considerable time. It does not take very hard steel to cut gray iron. The best test of all is, as intimated throughout this discussion, to subject the treated metal to microscopic examination. The skin will then always appear in an unmistakable manner.

THE CORROSION OF STEEL.*

A committee, of which Professor J. O. Arnold is chairman, and Dr. W. E. S. Turner is secretary, reported upon "The Influence of Carbon and other Elements on the Corrosion of Steels." Pure-iron carbon alloys had been prepared in Sheffield University from Swedish iron and charcoal, ranging from 0.1 to 0.96 per cent. of carbon; they were free from manganese sulphide, which favors electrolytic corrosion. Polished cylinders, 4½ in. long, ⅜ in. in diameter, of these alloys were separately kept in sea-water for thirteen weeks. In the rolled, normalized, and annealed specimens (in which, it was pointed out, the carbide existed either as the diffused, normal variety, or as the laminated variety of pearlite) the corrodibility increased to a maximum at saturation point, 0.89 per cent. of carbon, and then decreased upon the appearance of cementite. In the hardened or tempered specimens (in which the carbide had been converted into hardenite or the emulsified variety of pearlite) the corrodibility rose continuously without reaching any maximum. The deposit was light brown and easily removable on the top, and bluish black underneath; the latter adhesive deposit was found especially at the lower end of the bar.

In the tests of the solubility in acids, in which 1 per cent. sulphuric and hydrochloric acid gave substantially the same results, bars of ⅜ in., 1½ in. long, were separately immersed for forty-eight hours. The results differed from those of Heyn and Bauer, inasmuch as they showed a maximum corrodibility at 0.22 per cent. of carbon, which Heyn failed to observe, probably because he had no steel between 0.14 and 0.30 per cent. of carbon; Heyn put the maximum solubility at 0.4 or 0.5 per cent. These figures concerned normalized, annealed, and rolled specimens; in the tempered steels the solubility rose up to 0.3 per cent., and again up to 0.55 per cent. of carbon; the tempering temperature (500 or 400 deg. Cent.) had an influence. The report states that smooth curves were drawn through the experimental points, instead of joining the points by straight lines. Those curves look smooth enough. There is, for instance, a fine **S** curve, traced through five points, which do not mark the maxima and minima. If there were really not more than five determinations, the smoothness of those and other curves does not appear convincing. Solution pressures (potential differences) were also determined. The chief point, again brought out by these tests, is that **different irons behave differently in sea-water, acid, and in galvanic couples, so that no single method of testing can be regarded as a reliable criterion.**

* Read before the British Association for Advancement of Science.

AUTOGENOUS MELTING.*

In a paper on the "Autogenous Cutting and Welding of Metals," Mr. F. Carnavali described some investigations he had undertaken on the autogenous melting of various metals in general use.

The electrical process, he said, required costly installations which were cumbersome and inconvenient, while, on the other hand, owing to the difficulties involved in controlling the high temperatures attained, the results were uncertain. In addition, the high temperatures were restricted to very narrow zones of the metal. The oxygen process was subject to many serious drawbacks owing to the variation in the volumes of the mixed gases, the presence of water vapor, and of other gases likely to prove injurious to the metals, while the low temperature attained, which rarely exceeded 1,600 deg. C., prevented rapid working. The oxy-hydrogen process did not permit of easy control of the melting flame, while the variable amounts of free oxygen present occasioned injurious oxidation of the metal. On the other hand, such free hydrogen as might from time to time be present was occluded by the molten metal, leading to the formation of blowholes. The dissociation of the water vapor formed in the flame also lowered the temperature considerably. The thermit process was suitable only in a limited number of cases.

The oxy-acetylene process, on the contrary, when properly worked, possessed numerous marked advantages over the other processes mentioned. In the first place, the operating flame could be easily controlled, and the temperature attained at various zones could therefore be readily regulated. In the second place, the work could be readily accomplished owing to the high temperatures (nearly 3,500 deg. C.) which could be reached by the combustible gases, and by the dissociation of an endothermic gas like acetylene. Other advantages arose from the employment of pure gases which had no injurious effect on the metal, from the fact that the products of combustion (hydrogen and carbon monoxide) did not dissociate, and from the great economy of the method as compared with others, as this permitted of high temperatures being attained with a minimum cost, while the

* Abstracted from a paper read before the Iron and Steel Institute, Eng.

appliances were easy to handle and trustworthy in operation.

The most important conditions for securing good results in oxy-acetylene melting were the use of the purest acetylene obtainable; the use of a blow-pipe so designed as to ensure careful adjustment in the proportions of the mixed gases, and to secure their exit at a velocity capable of maintaining the metal sufficiently fluid without the melting flame being too rigid; the provision of an absolutely neutral zone in the melting flame; the use of a pure conducting material of well-defined composition, similar to that of the metal to be melted, in the form of small rods, of such a size as to be rapidly melted without hindering the simultaneous heating of the adjacent parts, care being taken that the edges should be free from impurities, and that, whenever possible, they should be arranged at an angle to each other, so as to allow the neutral zone of the flame to penetrate well into the inside, and so completely melt the two surfaces before the extraneous metal was introduced; the use of deoxidizing and fluxing powders for the purpose of eliminating the oxides present, together with the incidental impurities; and rapidity in melting, in order to avoid excessive heating, which would not only alter and deteriorate the original structure of the metal, but would even favor the occlusion of gas—particularly hydrogen—and so occasion the formation of blowholes in the melted zone. In addition, care should be taken to see that no sudden cooling should take place owing to any sudden projection of the flame, while, on the other hand, the conditions must, of course, be modified with regard to the conductivity and specific dilatation of material as well as to the thickness, size, and shape of the pieces operated upon.

STEEL DIRECT FROM THE ORE IN THE ELECTRIC FURNACE.

(Evans-Stansfield Process.)

By A. Stansfield.

In this process iron ore mixed with charcoal and any necessary flux is heated in a closed chamber until the ore is reduced to the metallic state. The heated product is then transferred to an electric furnace, where it is melted to separate the slag from the steel. The steel is then tapped or poured into a ladle and from that into the moulds.

The process has been devised for treating titaniferous magnetite ore from the Orton Mine, Hastings County, Ontario. Shipments of the ore have shown the following analysis:—

Magnetic Oxide	75.40% (Iron 54%)
Titanium Oxide	12.65
Nickel	0.12
Vanadium	trace
Silica	1.5
Lime	5.75
Alumina	3.95
Sulphur	trace
Phosphorus	0.015

The detailed treatment which has been adopted for this ore has been as follows:—

(1) The ore is crushed to pass through a 20 mesh sieve.

(2) The crushed ore is passed over a magnetic concentrator to remove gangue and part of the titanium. This operation is not usually needed when treating ore from the Orton mine.

(3) The dressed ore is mixed with lime, charcoal, pitch and tar and the whole is briquetted.

(4) The briquettes are then placed in a closed chamber and heated to a bright red heat until the iron oxide has been reduced to the metallic state. In most of the tests made in the laboratory this operation has been carried out in crucibles, but on a larger scale it will be performed in towers, as described later.

(5) The red hot charge is now transferred to an electric furnace, in which it is melted by means of an electric arc. After the ore has melted the fusion is continued for a few minutes until the slag is tranquil and the steel sufficiently heated. The furnace is tapped, or poured in the case of a tilting furnace, to transfer the metal to a ladle from which it is poured into moulds.

The reduction of the ore to the metallic state will be effected on the large scale in towers of special construction, as indicated in Fig. 1. These towers contain vertical pipes, into which the briquettes are introduced. Gases from the

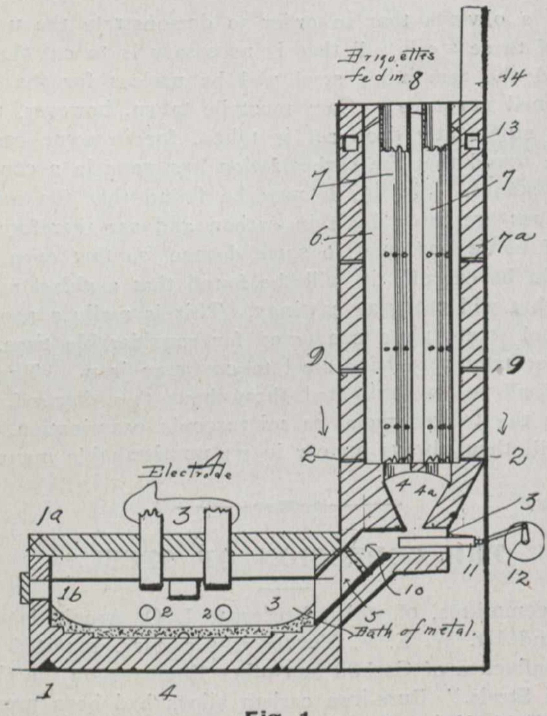


Fig. 1.

electric furnace and from the briquettes themselves are burned round these pipes and serve to heat them. The ore in the presence of carbon becomes reduced to metal, and finally is charged by the mechanism shown into the electric furnace. Fig. 2 is a photograph of an electric furnace with a tower for the reduction of the ore.

In regard to the use of the tower, it should be noted that the briquettes are being heated continuously in the tower, but that they are only fed into the electric furnace during a part of the operation. In order to make steel, it is essential that the charging process should be discontinued for a time, in order to get the steel and slag into the right condition for tapping. This is provided for in this apparatus and that without interfering with the continuous heating of the briquettes.

The following points may be noted with regard to this process:—

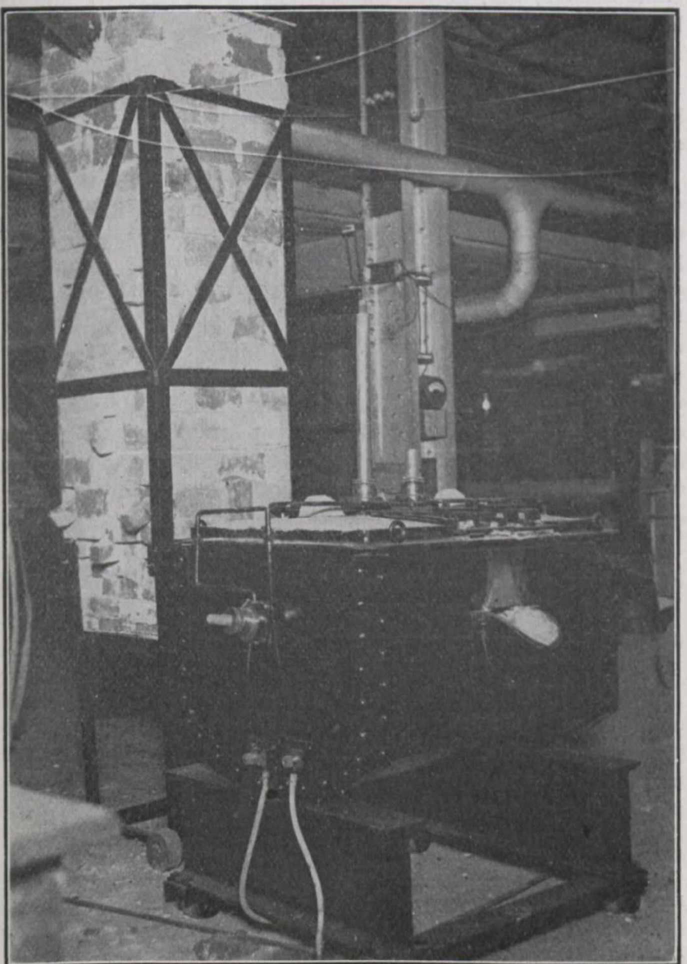
(1) It is found that by treating the Orton ore by this process a sound steel can be obtained which, when of suitable composition, is of considerable hardness and has valuable properties for use as a cutting tool. When used for tool making, this steel compares favorably with the usual

varieties of carbon steel, and even approaches the special quick cutting steels.

(2) The steel can be run into cast iron moulds for obtaining bars of the size of lathe tools. These bars merely need sharpening and tempering and are then ready for use in the lathe.

(3) It is probable that the peculiarly good properties of this steel are due in part to the presence of titanium in the ore from which it is obtained. In the case of ores containing a large proportion of titanium, it would, however, be desirable to remove a portion of this, as a large percentage of titanium would increase the cost of making the steel without having any decided advantage.

(4) In regard to the cost of making steel by this process, theoretical calculations and practical observation on the small scale indicate that the amount of electrical power needed for making tool steel will not be very different from the amount required to make pig iron in existing electric furnaces. The cost of the steel will, however, be greater than that of pig iron produced in that way, on account of the expense of crushing, briquetting, etc., but the cost will certainly be low enough to admit of the profitable production of steel for tools.



The Evans-Stansfield Furnace.

It is more difficult to predict the cost of working on a larger scale for the production of steel castings and even steel rails, but there seems to be a fair probability that this may be done at a profit.

In regard to this it should be noted that in the smelting of iron ore the greater part of the heat is required for the reduction of the oxide to metal, only a small proportion being needed for melting the metal and slag. In this process the reduction of the ore is largely effected by heat delivered from the combustion of waste gases from the briquettes, and in this way the amount of work left for the electric furnace is very much reduced.

The crushing of the ore in this process enables it to be dressed by magnetic concentration and also makes possible a more intimate mixture of the ore and the charcoal which is to reduce it. The effect of this is that the reduction to metal is effected more rapidly than if the ore and charcoal were uncrushed, as in the ordinary electric smelting of ores. This will enable the reducing towers to be made of more moderate dimensions and will increase the speed of smelting for a given size of plant. It is in effect using a mechanical preparation to lessen the cost of a furnace operation. It is possible, however, that when operating on a larger scale the fine crushing and briquetting may be found unnecessary.

The ore used in this process has been practically free from the elements sulphur and phosphorus and, therefore, there has been no need of any refining process in the electric furnace. When smelting for high carbon steel any phosphorus present in the ore will tend to pass into the steel, and, therefore, it will be necessary to use an ore which is free from phosphorus. Sulphur in the ore, on the other hand, will be eliminated to a certain extent, but not as perfectly as when smelting for pig iron. It is, therefore, desirable when smelting for a high grade steel that the ore should be reasonably free from sulphur.* Charcoal is employed rather than coke as a fuel on account of its freedom from sulphur, but it would be possible to employ a cheap charcoal made from such materials as sawdust and other waste from saw mills, as the briquetting of the charge renders the presence of dust unobjectionable.

The process has been operated up to the present on an experimental scale producing no more than 100 lbs. of steel on any one occasion. The work has been done in part by Mr. Evans in his laboratory at Belleville, and independent experiments have been made in the Metallurgical Laboratories at McGill University Recently the furnace belonging to these laboratories, which is shown in Fig. 2, was sent to Toronto and the process was exhibited in operation at the Toronto Exhibition. The writer has confidence that the process as outlined, with such modifications as will suggest themselves when operating on a larger scale, will prove a commercial success for the production of tool steel, and possibly, on a larger scale, for making steel castings, and even steel rails, in localities where the ore, electric power, and other supplies can be obtained on favorable terms.

*Both sulphur and phosphorus can, of course, be removed very completely in the electric furnace, but that involves a longer operation and increases the cost.

NAUTICAL INVENTION.

Two Italian electrical engineers living in France have devised an apparatus for fixing the direction of wireless sounds so that vessels approaching a coast at night or in a fog, especially so that they are not able to take bearings by lighthouses and configurations of the land, may calculate where they are from musical notes sounded from two shore stations.

The receiving instrument can be manipulated so that the direction of the maximum of sound defines within a quarter of a compass point the location of the sounder.

CONTRACTS FOR THE SUPPLY OF ELECTRIC POWER FROM THE MANUFACTURER'S POINT OF VIEW.

By H. E. M. Kensit, M.I.E.E.

It is becoming daily more common for the manufacturer to cease operating his own power plant and to take a supply from an electric power company, under contract for a term of years.

The technical terms of such contracts are usually more fully thought out by the power company than by the manufacturer. The power company have a thorough grasp of the technical conditions and of the results to be expected from past experience in similar matters, which the manufacturer has not. The contract contains technical clauses, as distinct from legal clauses, which neither the manufacturer nor his legal adviser, however competent, can fully grasp in all their bearings. Any "snags" hidden in these technical clauses usually only come to light after the contract is signed, sealed and delivered and the accounts rendered.

Most contracts for any considerable amount of electric power now contain a clause that the "power factor" of the load must be kept within certain defined limits or an extra charge will be made, and there is probably no other one clause which, when enforced, has led to more misunderstanding and dissatisfaction.

The following are samples of these clauses:—

(1). "When the power factor of the greatest amount of power taken for said twenty minutes falls below 90%, the corporation shall pay for 90% of the said power divided by the power factor." (Hydro-Electric Commission of Ontario).

Here the reference to "twenty minutes" means that the charge will not be based on a peak load lasting less than 20 consecutive minutes at any one time.

To interpret the extra charge due to the power factor, suppose that a 100 h.p. is taken and that the power factor turns out to be only 80%.

Then 90% of 100 h.p. = 90 h.p. A power factor of 80% = 0.80. 90 h.p. divided by 0.80 = 112.5, so that the customer will have to pay for 112.5 h.p., or 12½% more.

(2). "The city................. agrees to pay for the energy on the basis of at least an average 90% power factor, and should the energy be found to be delivered at less than an average 90% power factor, the basis of payment shall be adjusted by increasing the payment calculated as above, so as to make it correspond to a delivery of power on a basis of 90% power factor."

If we take the phrase "make it correspond" to mean proportionately, then if the apparent power was 100 h.p. and the power factor proved to be 80%, the power to be paid for would be: $100 \text{ h.p.} \times \frac{90}{80} = 112.5 \text{ h.p.}$, as in the previous instance.

(3). "The intent of this contract is that the Cement Co. shall arrange its equipment so that the power factor shall be about 90% and that the measurement shall be so made that the Cement Co. shall pay for the true and not the apparent energy."

This is not very clearly expressed, but the intention is the same as in the previous instances.

To arrive at a clear understanding of this matter we should consider three points:—

(1). What is the "power factor" of a supply of electric power, and why does it affect the cost of power?

(2). What power factor can usually be obtained under ordinary conditions, and what will any variation amount to in dollars and cents?

(3). If the power factor is not as good as it should be, what can be done to improve it?

To really grasp the full meaning of the "power factor" of an electric supply necessitates acquaintance with the principles of alternating current, but it can be made fairly clear without this. Alternating current reverses its direction of flow so many times a second (standard practice is 25 or 60 complete cycles per second) that the result as regards power supply is equivalent to a steady flow in one direction. The main object of these reversals is to give facility for transformation from one voltage or pressure to another, thereby enabling the use of static or stationary transformers for altering the pressure, instead of moving machinery, and generally increasing the facility of transmission and distribution.

The current flows at a certain pressure or voltage, and so long as the waves or rushes of current and pressure are simultaneous, that is, "in phase," the power factor is said to be a 100%, or, as there is no effect due to it, we may consider that there is no power factor.

A supply to incandescent electric lamps only, gives a load factor so nearly 100% that the effect is not worth consideration.

The connecting of motors to a circuit, however, immediately introduces a power factor. The motors have an inherent property called self-induction, which amounts to a back pressure or voltage causing a part of the current to be out of phase with the pressure. The power delivered then consists in effect of two currents, one of which is in phase with the pressure and is doing useful work, and the other, which is known as "idle" current, doing no work except heating the conductors through which it passes. The "true electrical energy" is the product of the current and pressure which are in phase; the "apparent energy" is the sum of the two currents multiplied by the pressure and is what would be obtained from the readings of the ammeters and voltmeter.

The difference between this "true" and "apparent" energy constitutes the power factor, and the power factor of any circuit $= \frac{\text{true energy}}{\text{apparent energy}}$.

This "idle" current has to be reckoned with, however, on account of its heating effect, and if it exists and to the proportion to which it does exist, the power company has to increase the size of its generators, transformers and transmission lines in order to carry it, and thereby increase its capital expenditure proportionately.

The wattmeter, or instrument used to measure the power, records only the true energy, and the power company would not, therefore, be paid for the "idle" current, though it costs them money to produce it.

Since the idle current, or, say, the power factor, is caused by the customer's load, and since it is to a great extent within his control and not at all within control of the power company, it is but just that the customer should be required to keep it within reasonable limits.

A physical analogy, though not exact, may make the meaning of "power factor" clearer.

Suppose a manufacturer, without stating the conditions of delivery, contracted for the supply of a certain quantity of water per day. The supply through a given pipe in a certain time would depend upon the pressure. If, now, the delivery pipe entered at the **bottom** of a high tank which was kept full, then the head of water in the tank would cause a back pressure on the supply, which would mean increased work to the pump and, therefore, increased expense to the contractor, for which he would be justified in expecting increased payment. This back pressure corresponds with the power factor of an electric circuit, and the increased expense to the contractor corresponds to the increased expense to the power company.

Now as to the second of our three points, i.e., what power factor can usually be obtained under ordinary conditions, and what will any variation amount to in dollars and cents?

The following table shows the efficiencies and power factors that may be expected from polyphase motors of first-class design and make; if not first-class, or if single phase, both efficiencies and power factors may be considerably lower:—

Constant Speed Polyphase Induction Motors.

Size	Efficiency % Half Load	¾	Full	Power Factor % Starting	Half Load	¾	Full	Starting Current in terms of Full Load Current
5 h.p.	79	82	82	60	76	84	88	2¼ to 2¾
10 "	81	83	83	60	80	87	90	"
20 "	83	84	84	60	81	88	91	"
50 "	85	86	86	60	81	88	91	"
75 "	86	87	87	65	83	89	92	"
100 "	88	89	89	65	85	91	92	"
Average	84	85	85		81	88	91	

In designing alternating current transmission systems the generally accepted allowances made for the power factor of the load are as follows:

Lighting load only	95%
Mixed load, chiefly lighting	90%
Mixed load, chiefly motors	85%
Motor load, ordinary	80%
Motor load, if very intermittent and irregular	75%

These naturally allow for the worst conditions ordinarily met with, but even worse conditions do sometimes exist where the load is irregular and the motors over large for the work or of poor design, average power factors as low as 70%, or even 65% being sometimes met with in mining work, steel rolling mills and similar intermittent loads.

A consideration of the above figures will show that where the amount charged for power is to vary in proportion to the "power factor," this power factor becomes a very important matter.

While an individual motor working at full load may have a power factor of 90% or a little more, a number of motors on more or less intermittent and irregular work do not usually give a resultant load factor of more than 80%, and may only give 70%, or even less.

Right here is where the manufacturer or power user not infrequently gets let in for what he does not fully expect or realize. Usually he has no clear idea of what his power factor is likely to be, and thinks he is getting a 10% margin anyway. The power company, on the other hand, know perfectly well that the power factor of a load consisting entirely or mainly of motors will not reach 90%, and that there will consequently be an extra payment required on the score of low power factor.

It is usual, as shown in the sample clauses given above, to name 90% as the normal power factor, but it would appear fairer in the case of contracts for motor loads to name a higher price and a power factor that there is some probability of being able to obtain in practice.

As to the difference in annual cost that may be caused by a power factor lower than the 90% specified in the agreement, suppose the case of a steel rolling mill using 500 h.p., paying $25 per h.p. year for power, and having an average power factor of 75%.

500 h.p. @ $25 = $12,500. $\$12{,}500 \times \frac{90}{75} = \$15{,}000.$

or an extra cost per annum of $2,500, i.e., 20%.

Now, as before explained, it is perfectly legitimate and proper that the power company should be paid extra for a load involving a power factor which is lower than that covered by their ordinary rates, but it ought to be clearly understood in such cases what the power factor and consequent extra charge to the customer is likely to be.

As to the third of the three points to be discussed, i.e., if the power factor is not as good as it should be, what can be done to improve it.

Low average power factor in connection with an ordinary polyphase motor load, assuming the motors to be of good make and design, is mainly due to frequent stopping and starting, and to working the motors at less than full load. It is greatly aggravated by using motors too large for their work, so that even when the tool is fully loaded the motor is under loaded.

If the motors are large for the work and the work is intermittent or variable, the average load factor may easily be that due to an average of half load. Referring to the table of power factors, it will be seen that the average power factor of motors from 5 to 100 h.p. is 91% at full load and 81% at half load, a difference of 11%. In practice, when some of the motors are being constantly stopped and started, or varying between small load and full load, the difference may be considerably greater.

Much may therefore be done to improve the power factor by having the motors properly proportioned to their work and, as far as possible, avoiding starting several motors at the same time or allowing them to run light. As good modern polyphase motors have an overload capacity of at least 50% for half an hour, and much greater momentary overload capacities, there is seldom any necessity to put in motors rated above the output of the tool, and in many cases of intermittent load the motors may safely be of less rated h.p. than that of the tool.

If the works give a low load factor that has to be paid for, it is therefore well worth while to take careful measurements of the power required by each tool and to re-arrange the motors and drives accordingly.

If these measures are not sufficient to secure a power factor reasonably close to the 90% specified, this result can always be secured, where there are a number of ordinary induction motors installed, by substituting for one of these a separately excited synchronous motor of slightly larger capacity than required for driving its load and adjusting the excitation until the desired power factor is secured. This will affect the power factor of the entire load or works. It is not usually desirable or economical to endeavor to bring the power factor of a motor load above 90%. This is a matter in which the advice of a competent electrical engineer would have to be taken as to the choice of a motor to suit the conditions in the particular factor under consideration, but it is not an expensive matter, and the saving in the first year would, in many cases, more than repay the entire cost.

In conclusion it may be asked why should all this complication come in at all. The reply is that it is an inherent and unavoidable factor in the alternating current system of power supply, that this system represents the latest and best practice in power distribution, and that there is no definite prospect at the present time of its being superseded, so that power factors must be accepted and reckoned with. They are at least as great a nuisance to the power companies as to the power users, and power companies would usually sooner have a good power factor than the additional payments which they have to charge when the power factor is low.

THE HALLIGAN DAM.

The Halligan dam, a structure which has attracted much attention in Colorado, is the subject of a paper by Mr. G. N. Houston which will be presented before the American Society of Civil Engineers on Dec. 20. The full paper will be found under the title of "The Halligan Dam" in the Society's "Proceedings," volume 37, page 1143, from which the following notes are taken:

The dam is 16 miles from the nearest railroad siding. It forms a reservoir of 6,408 acre-feet, owned by the North Poudre Irrigation Company, of Ft. Collins.

Before Mr. Houston was retained as consulting engineer, plans had been prepared for an arched cyclopean masonry dam, with a gravity section, to store water to a depth of 55.5 ft. above the outlet tube, and a contract had been let for its construction at cost plus 20 per cent. Work was commenced, but, after building to a point slightly above the lower outlet tube, the available funds were exhausted and the work was temporarily abandoned. The foundations remained in this condition for about eighteen months, and then the work was to obtain as much storage capacity as possible for a limited sum of money.

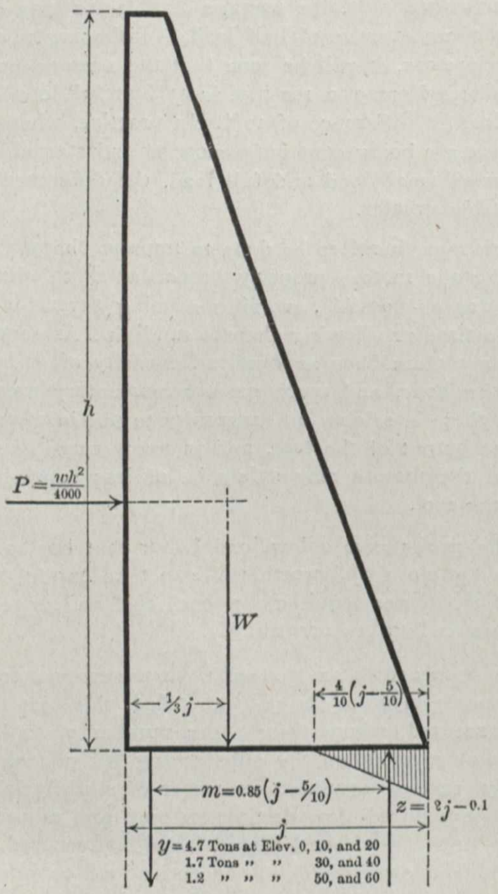


Fig. 1.

New plans and specifications were prepared for a cyclopean masonry dam, reinforced with steel rods, to be built on the foundations already constructed. This dam is of lighter cross-section than the original gravity type designed, and 14.3 ft. higher. This additional height increased the storage capacity by at least 2500 acre-feet, which, at the usual price of $40 per acre-foot, is worth $100,000. The dam was built for $7,000 less than if it had been constructed according to the original plan. In other words, the company saved $107,000 by the use of this design instead of the usual gravity section.

There are about 3,500 cu. yd. of masonry in the old work, and 12,134 cu. yd. in the new structure, making a total of about 15,634 cu. yd. in the whole dam. The cost of the old work was more than $100,000, that of the new work was about $80,000. Work was begun under Mr. Houston's supervision in July, 1909, and completed on May 1, 1910.

Construction.—The foundations, as left by the first contractor, were very uneven, and, before beginning the new structure, it was necessary to use about 1,400 cu. yd. of masonry to bring them up to zero elevation.

For 35 ft. above this point the dam contains irregular masses of rock, varying from 1 cu. ft. to 2 cu. yd., bedded in a 1:3:5 concrete, mixed wet. Smaller rocks were used to fill in between the large masses, 6 in. being the minimum distance between the stones. The quantity of cement used in the concrete for this part of the work was about 1.20 bbl. per cubic yard. The rock content averaged 27 per cent. of the total mass.

After the construction had reached approximately El. 35, the character of the large rock became so poor that it was decided to build the remainder of the dam entirely of 1:3:6 concrete. The projecting lip of the spillway, however, was built of a mixture of about 1:2½:4. The crushed rock varied from a small percentage of pieces having a greatest dimension of 6 in. to pieces ½ in. in diameter. All material finer than ½ in. was excluded on account of the large percentage of mica which it contained. The sand used was very coarse although it varied somewhat.

Concrete was laid during the day through all but the severest winter weather. The water was heated, and varied in temperature from 130 to 160 deg. Fahr. An attempt was made to heat the sand, but was abandoned as not necessary. The temperature of the concrete as deposited in the dam varied from 35 to 60 deg. Fahr. Before bedding the large rocks they were cleaned with a jet of steam. During the night the new work was covered with tarpaulins, under which lighted lanterns were placed. Concrete was not mixed when the temperature was lower than 20 deg. Fahr.

The bulk of the reinforcement was of high-carbon steel. A small quantity of twisted steel was also used in the upper part of the dam. Where the elevation of the old foundation was —3, or lower, the reinforcement was bent and built into the work. Where the foundations were higher than this holes 1 in. larger in diameter than the bars were drilledfrom 3 to 5 ft. deep and the bars were set in neat cement grout.

Spillway.—Mr. Houston originally contemplated a spillway wholly within the cross-section of the dam, but his attention was called to the fact that a discharge over it having a depth of from 2 to 3 ft. would probably leave the face of the dam. As there was a possibility of discharges of much greater depth, it was necessary to widen the crest of the spillway in some way, hence the projecting lip. The surface of the spillway is a compound curve, formed by the arcs of three circles, and following as nearly as possible the curve of discharge of a sharp-edged weir, as determined by Bazin's experiments. The capacity of the spillway is about 14,000 sec.-ft., and that of the two outlet tubes is about 1,400 sec.-ft.

Stresses.—The following analysis of the stresses in the dam is based on the following assumptions.

First: That the high-water level is 9.7 ft. above the spillway, that is, to the top of the dam.

Second: That the dam resists the water pressure partly as a cantilever beam and partly as an arch.

Third: That the center of gravity of the compressive forces is at a point distant from the down-stream face 0.15 of the effective thickness of the dam.

Fourth: That the dam section is a complete triangle, thus making the perpendicular line through the center of gravity of the section cut the base at a point one-third the thickness of the dam from the rear face.

Fifth: That the safe load (tension) on the reinforcement is 12,000 lb. per square inch.

Sixth: That the neutral axis of dam, considered as a beam, is at a point 0.4 the effective thickness from the downstream face.

Seventh: That the thrust in the arch is uniformly distributed over the thickness of the dam.

The general method used is to assume the safe load on the reinforcement, find what part of the water pressure can be safely carried by the dam considered as a beam, and then assume that the arch carries the remainder of the pressure.

In the following equations the various functions are represented by the following letters:

P = Total overturning pressure on the dam, in tons;
P″ = That part of P assumed to be sustained by the beam action, in tons;
P′ = That part of P assumed to be sustained by the arch action, in tons;
w = Weight of 1 cu. ft. of water, in pounds;
r = Radius of curvature of dam, in feet, = 324;
j = Thickness of the dam at any point, in feet;
h = Height of the dam at any point, in feet;
W = Weight of masonry in the dam above any point, in tons;
T = Thrust in arch due to P′, in tons per square foot;
y = Assumed stress in steel, in tons;
c = Maximum compression in the outer face of the dam due to beam action alone, in tons per square foot;

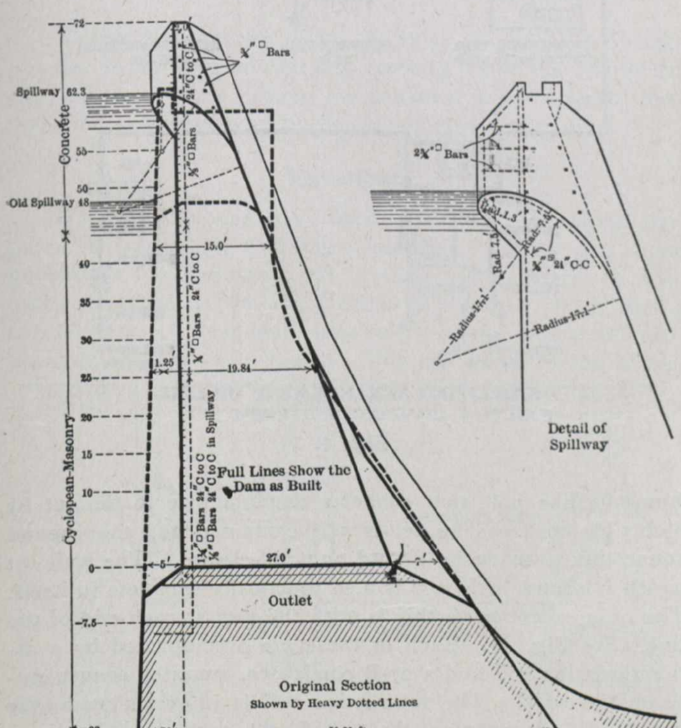


Fig. 2.

z = Total compressive stress in dam due to beam action alone, in tons;
q = That part of the pressure at any point sustained by arch action alone, in tons.

A diagram of the stresses acting on the dam is given in an accompanying cut.

Expressing moments around the center of gravity of compression forces, we get,

$$\frac{1}{3}P''h - W\left(m + 0.5 - \frac{1}{3}j\right) - y\,m = 0$$

Solve for P″.

Then

$$P' = P - P''$$
$$q = 2P'/h$$
$$T = qr/j$$

To determine c, take moments around y:

$$\frac{1}{3}P''h + W\left(\frac{1}{3}j - 0.5\right) - c\,(0.2j - 0.1)\,m = 0$$

Solve for c.

The stresses obtained by this method are shown in Table 1.

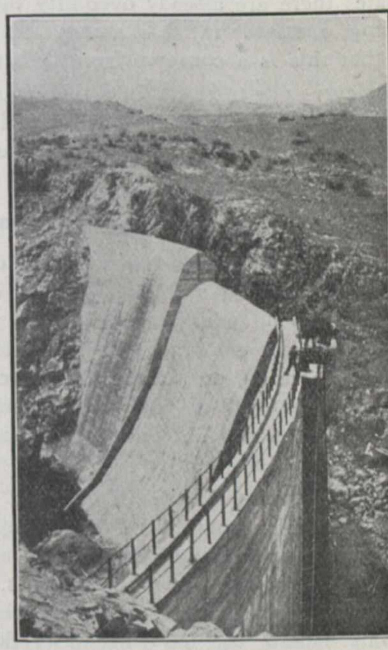


Fig. 3.

Table 1.—Summary of Stresses.

Elevation.	Tension in steel in tons per square inch.	T.	c.
62.3 Spillway	0.0	0.0	....
60	0.0	0.0	....
50 Calculated	4.5	0.0	5.8
40 Assumed	6.0	4.4	8.0
30 ″	6.0	7.2	9.7
20 ″	6.0	7.5	12.3
10 ″	6.0	9.3	13.5
{ 0 ″	6.0	10.5	15.7 }
{ 0 ″	10.0	9.1	10.3 }

The factor of safety is about 6.

A PECULIAR SHORT CIRCUIT.

A letter box placed on the junction of two principal streets in Victoria, B.C., came in contact with the wires belonging to the lighting circuit recently. Several people who used it were severely shocked. The condition of the box was finally intimated to police headquarters, and an officer was sent to the corner to warn passersby until the trouble was attended to.

RAILWAY TELEPHONY.

Howard W. Fairlie.

Composite and Simplex Systems.

The extensive adoption of the telephone for the purpose of train dispatching is an event of comparatively recent occurrence. The apparatus designed for this purpose is the result of painstaking study and long experience in other branches of telephony. The arrangement of telephone train dispatching systems is the outgrowth of continued effort of telephone engineers to overcome defects as they have appeared in practice.

As a result of this specialization, we now have apparatus that has become standardized with the railroad world. We are told by the telephone manufacturers that in Canada and the United States there are already over fifty thousand miles of railroad being operated in this manner. Investigation goes to show that this is a conservative estimate.

With nearly every one of these lines this change has been made within the last three years. The experience of the railroad has surely fulfilled the prophesied popularity of the telephone in this new field.

Use of Composite and Simplex Systems.

It is not the purpose in this paper to touch on any of these more highly developed systems. On the contrary, the end in view is to present in as plain a way as possible, two simple methods of using one line for both telegraph and telephone purposes at the same time. There are many roads whose present circumstances do not seem to warrant the immediate installation of a straight telephone train dispatching system.

It is to these railways that the Composite and Simplex systems appeal with the strongest force. They are by no means new inventions; neither are they complicated any more than an ordinary telegraph or telephone line is. For railroad engineers who are interested in the possibilities of the telephone in this sphere, the following brief description is addressed. Every device that means a saving of time is a boon to the railway official, and the telephone is, in the matter of communication, the greatest of these.

Advantages of Telephone.

When we come to discuss regular dispatching systems, the advantages may be taken up in greater detail, but any railway engineer can appreciate the saving in time by being able to communicate anywhere within the system without the intermediary of a third person with really a different language spelt out laboriously word by word. Questions and answers are freely exchanged and with the consequent saving of time and temper.

Increased Telegraph Efficiency.

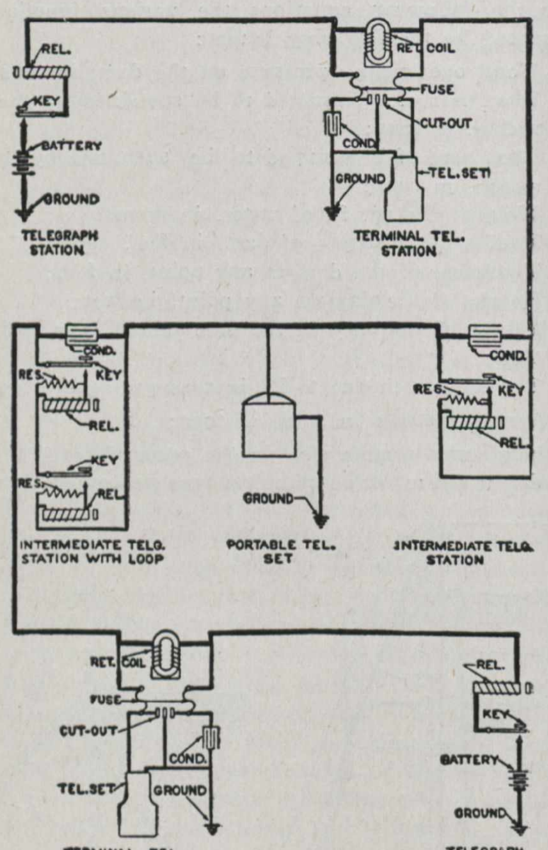
Wherever there is a telegraph line employing the usual single wire, that same line may be converted into a combination telephone and telegraph line without the least change in line construction. The only change necessary is the installation of the telephone instrument with its small accessory details, such as protectors, etc. Of course, it will be a grounded telephone line that is obtained, but where it was possible before to send but one message at a time, and that in the Morse code, the operators may now send two without the least interference, and one of these will be a direct conversation. This is known as a Composite telephone and telegraph system, and its application is almost altogether for railway service.

Composite Circuit Details.

In Fig. 1 is a general diagram of a composite line. Examination shows it to be an arrangement without the least complexity. Terminal telegraph stations are just as in a straight Morse circuit. A simple intermediate telegraph station simply has its relay bridged by a condenser and resistance. Where a line is looped through an office, each relay is bridged with a resistance as before and a condenser in parallel with the two instruments.

Composite Telephone Instruments.

All that remains is the connections of the telephone sets. Whether these are wall type office instruments or portable sets, their arrangement is identical. They are simply bridged



SIMPLIFIED ARRANGEMENT OF LINE RAILWAY COMPOSITE SYSTEM.

Fig. 1.

from the line pole that connects the line wire to the set by a flexible cord. The set is self contained and the ground connection is made by a cord and rail-clamp. The wall set which is shown in Fig. 2 is also practically complete in itself. The only exception to this is with the sets at each end of the line. (See Fig. 1). Each of these are accompanied by a 48-A retardation coil and a 27-B condenser, mounted conveniently on the wall. The retardation coil is in series with the line, and is to prevent the telephonic currents passing to earth over the ends of the line. This it does on account of the high frequency of these currents, while the telegraph currents are not impeded, because they are of much lower frequency than those from the telephones. The action of the condenser along with the coil is such that the telegraphic currents produce no disturbances in the telephone instruments.

A typical installation that will illustrate most of the connections is shown in Figure 3. This is a station with both a composite telephone and a Morse instrument.

Some Auxiliary Apparatus.

A 27-B condenser with a capacity of 1 microfarad and built to stand a potential of 1,000 volts is bridged across each telegraph instrument on the composite system. This condenser acts as a path for telephone talking and signalling currents, instead of having to pass through the impedance of the relays and be interrupted whenever a telegraph message is being sent.

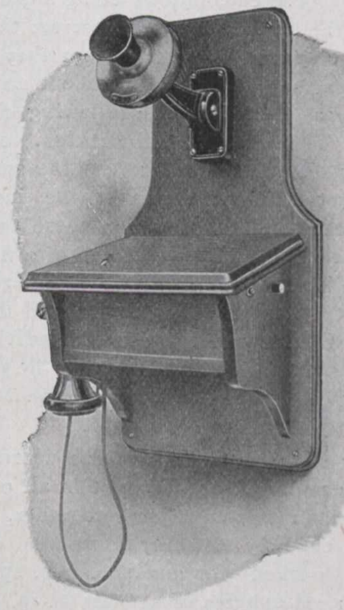
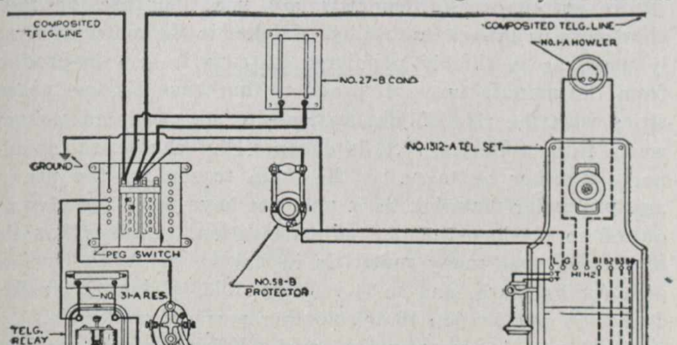


Fig. 2.—Telephone Set Closed.

The 31-A resistance across the relay is of high resistance but low inductance and so any currents from the telephones that happen to pass around the condensers go through these resistance and prevent any disturbance in the relay.

Signalling.

Different methods have been used for signalling purposes in connection with the telephones. Bells and hand generators are not used, but in their place, there is with every set what is commonly called a howler. It is just a special type of telephone receiver with an adjustable diaphragm, and shown in Fig. 4. The call given by the howler



INTERMEDIATE TELEGRAPH AND TELEPHONE STATION RAILWAY COMPOSITE SYSTEM.

Fig. 3.

is a whistle or shriek, whose tone can be adjusted to any pitch by the adjustment of the diaphragm. In each composite set an interrupter on the induction coil is used to furnish a high frequency signalling current from a small battery of dry cells. A push button on the side of the 1312-A wall set allows the person calling to ring any code with the greatest ease.

This covers in a very general way the main features of the system.

Special Conditions.

Since every telegraph line has its own peculiar conditions, the manufacturers of composite apparatus should always be consulted as to the best arrangement possible for each case. Of course, conditions such as length of line, kind of wire, etc., are all fundamental points in the question. Many roads using composite systems are experiencing the

Fig. 4.—Howler.

greatest satisfaction on lines 100 miles in length. On lines using duplex or quadruplex circuits, or where machine sending is used, the composite system is not ordinarily recommended.

Simplex System.

The Simplex is the circuit that was contrasted with the Composite in the first of this article. Its operation is more commonly understood than is the composite, and effects the same result, viz., simultaneous telegraphy and telephony. However, it uses two wires as on the ordinary metallic telephone circuit. Hence, the telephone line may be transposed in this arrangement for the prevention of disturbances due to neighboring telephone, telegraph or high tension lines. A diagram of connections is shown in Fig. 5, and illustrates the "Repeating Coil Simplex" which is the type commonly in use.

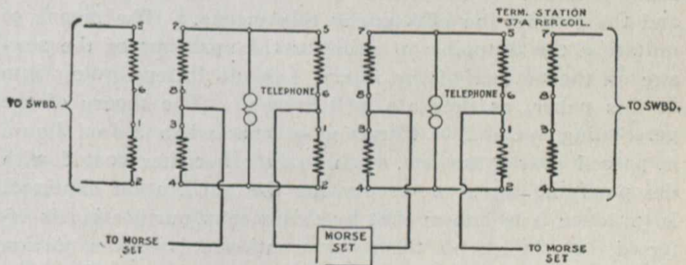


Fig. 5.—Simplex Circuits.

In its operation, the telegraph currents traverse the two wires and two winding of each coil as parallel branches of the one circuit. The telephone currents are repeated through the different repeating coils just as the currents of a lighting transformer are. Upon the efficiency of this repeating coil for voice currents depends the transmission of the conversation.

The telephones used with this circuit are the ordinary bridging instruments, and ringing is done as in the ordinary magneto instrument. This circuit may be connected directly to a telephone switchboard. With Composite systems the use of the howler prevents this arrangement.

General Application.

Summarizing, Composite circuits are used on lines designed primarily for telegraph work and afterwards adapted to the telephone. Simplex circuits are the converse where telephone lines are adapted to purposes of telegraphy. This is not a rigid classification, as the use of either system depends on the conditions found in each particular case, but it will aid in a general understanding of the use of each.

Advantage to Railways.

Railway engineers and officials interested in improving their means of communication throughout the different divisions will do well to consult with the departments of the different manufacturers who specialize in this work.

In a future issue some of the problems of straight train dispatching systems will be discussed.

Although this is intended as a mere outline of the most simple application of simultaneous telegraphy and telephony, still it must not be forgotten that the principle is capable of many extensions.

On the lately completed New York and Denver circuit, as a case in point, three telephone messages and eight telegraph messages are being sent simultaneously over two pairs of wires. Over long lines the increase of capacity obtained in this way is appreciated not only by those directly concerned, but by any layman who will consider the question.

Railroad men, in particular, who have never investigated this method of communication, can solve many of their problems in this department by an application of either Composite or Simplex circuits.

NOTES ON THE THEORY AND PRACTICE OF PERCOLATING FILTERS.*

By John E. Farmer, F.C.S., Chemist, Croydon Corporation Sewage Works.

Before anything new can be put into practical form the mind must have been at work, and worked out certain details, also the expected results. How and when the idea entered the mind of the first one to put into practice the percolating method of sewage purification I cannot say, as I have not seen any definite record of the event. It was probably brought about by the action of rain falling on porous soil, and the purification effected by this means. The means of imitating the dropping of rain for the spraying of the sewage on the surface of the filters, I do not intend going into in this paper, as they are well known. The theory of the percolating method of filtration is, that when a foul liquid is passed over a surface, such surface becomes coated with the purifying agent necessary for the purification expected. In practice it is known that by this means purification is effected, but the simple theory as mentioned is only a portion of that required to explain the whole working of a filter. By allowing the foul liquid to flow over a surface, you obtain certain results ; it is quite natural the mind would work on the questions of the cause and also on probable improvements.

One factor that comes to one's mind on considering the theory is that of surface area. It would be expected that if the area was increased, greater purification would be effected; this is proved by the greater purification given by a clinker filter than with one of gravel, the grade and quantities being equal.

On comparing the surface area of a material of different sizes, it is seen that with the same mass the surface area can be increased considerably. Taking a 1-ft. cube measure, which would hold one sphere of 1 ft. diameter, containing 904.78 cube inches, it would have a surface area of 452.39 square inches, but the same measure would hold 1,728 spheres of 1 in. diameter, the total area being 5428.6 square inches and the mass 904.78 cube inches, the same mass as the sphere of 1 ft. diameter, but with twelve times the surface area. Another factor that must be taken into consideration is the size of the space left between one particle and another forming the body of the filter. If the size is too small the friction is too great for the proper passage, in the downward direction, of the solid matter, also for the movement of the air. Taking the same measure and spheres as above, the size of the spaces, with 1 ft. diameter sphere, would be 205.8 cube inches each, and with 1 in. diameter, 0.48 cube inch. These calculations being made from mathematical figures, the results are more correct than any which can possibly be obtained in practice, but they are useful in giving an impetus to the mind to work out an ideal filter.

In the theory as mentioned the following conclusions are arrived at:—(1) The smaller the particles comprising the filter the greater the surface area; (2) the smaller the particles comprising the filter the smaller the individual space between the particles. In my opinion these two conclusions have a great bearing on the construction of a filter, when the work expected to be done is taken into consideration, namely, the oxidation of the matter in suspension and the purification of the liquid. If the space between the individual particles is of such a fineness that the resistance to the passage of the solid matter is greater than the accumulation rate choking is the result, also ponding of the surface.

The capacity of the interstices can be decreased, not only by using smaller material, assuming it is all one grade, but by mixing a small grade and a large together. This is apparent when the capacity of the interstices of any given grade of spheres is taken—for instance, 1 in. spheres—a cube foot would take 1,728 spheres of at least ⅜ in. diameter, and reduce the total capacity of the interstices from 823.22 to 775.5 cube inches, but increase the surface area from 5428.6 to 6191.8 square inches. The remaining interstices would still take a sphere of about 1/16 in. diameter, and still further increase the surface area, but with a lessened interstitial capacity. It is obvious that to increase the surface area by so mixing the grades, the resistance to the passage of the solid matter and air is increased.

A general conclusion from the foregoing is that the following are factors that must be taken into consideration before determining the grade of material to use:—(1) Quality of the sewage liquid required to be treated; (2) quantity required to be treated on any given area, and (3) the degree of purification required.

In practice many materials are used because of their cheapness or proved suitability. Clinker is the material mostly used, as in thickly populated districts it is a by-product from the manufacture of products that have become necessities with the rise of civilization—in some places gravel, waste from potteries, &c., is cheaper, but cheapness should not altogether be taken as the main reason for the use of any particular material, as it may not have the properties required to produce the desired purification. Clinker has the advantage over many materials in having a large surface area for its mass, and so is very suitable, giving a greater degree of purification than smoother surfaced materials. A material may be composed of such different-sized particles that when not graded the interstices may conform to that which is required of the filter, but care must be used, as the obtaining of a solid mass, as in the mixing of materials for concrete, is to be avoided, that which is to be kept in mind being maximum surface area with a maximum interstitial volume. To obtain these maximums, clinker is generally used, and the filter built up in grades, the larger size at the bottom, decreasing in size to the top.

By having the small sized materials at the top, the surface area per cube unit is greater than the lower depth,

*Paper read before the Association of Managers of Sewage Disposal Works at Croydon, September 30th, 1911.

thereby arresting the solids on the surface layer of the filter, where it can obtain a greater amount of oxygen than lower down the filter. The advantage of having the larger materials at the bottom of the filter is the increased drainage effected, as the resistance through friction is much less than it is with the top layer of smaller material. Experience has proved that good drainage of the lower portion of a percolating filter is absolutely necessary, and to obtain the best results a smooth surfaced material such as gravel is found to be the most efficacious.

There are many things connected with sewage purification that require elucidation before it can be said to be on a strictly scientific basis, but with the combination of the labors of all those working on the subject, also patient investigation by those working every day on the purification of sewage, this subject may in the future be on as much a scientific basis as many of the industries are to-day. One who sees a filter every day notices that there are many changes taking place during a year, for instance. At times the surface is covered with a dirty greyish colored growth; after a time this gives place to a greenish colored growth. At another period there is no growth perceivable; sometimes the various growths are in varying sized patches; also the amount of humus matter being discharged increases suddenly; the degree of purification at times is unaccountably affected.

To find out the cause and effect of these changes will no doubt help forward not only the solving of the problem of sewage purification, but help to place it on a scientific basis, so any sewage works manager that has the courage to tackle the investigation of any one of the changes that goes on in a percolating filter will have his patience well tried, and, if successful, will be rewarded with the pleasure of having attained something towards building up the science of sewage purification.

Where, as in most cases is the case, the expenditure in the construction of the filters is limited, it is much better to spend money on that portion necessary for the purification, such as the distribution, filtering mediæ, and drainage, than on having artistic walls, as no matter how pleasant to the eye a set of filters may look to outward appearance, if they do not do the work expected of them the manager does not derive much benefit from the artistic appearance.

Sewage purification, as regards the liquid portion, has got to such a pitch that, provided the money is forthcoming, any degree of purification can be attained, but the question to my mind is can the same purification be obtained with less expenditure, or can a greater quantity be purified with the same purification and the same expenditure.

BOLT SOCKET FOR CONCRETE CONSTRUCTION.

A simple and effective type of bolt socket to be inserted in concrete was recently patented and is now manufactured by David Craig, Boston, Mass., says Engineering News. It is made by forming a round wire into a helical coil just fitting into the thread of a lag screw or bolt, leaving the ends of the wire extending tangentially from the circle of the helix. This formed wire is then placed on a so-called "master bolt" and placed through the form in which concrete is to be poured. When the concrete has set the "master bolt" is removed, leaving the wire to form the female screw in the concrete, into which the bolt may be screwed at any time. It will be noted that the ends of the wire protrude into the concrete, forming an effective reinforcement of the concrete, as well as holding the screw bore firmly in place. These sockets are made in various sizes and lengths, the latter being short, so that if a long bolt is required the socket may be in two or more pieces, each piece with its protruding ends acting to hold the socket in place.

The main use of such a socket is to provide means for attaching hangers of whatever sort to the members of reinforced concrete structures, but the Craig socket has been most successfully used by the Boston elevated railway with separately molded concrete work to tie together two adjoining pieces. It should be noted that with this socket, as in all other metallic sockets, insulation should be provided to prevent the transmission of any electric current to the reinforcement.

PERSONAL.

Mr. T. H. McCauley has been appointed consulting engineer for the street railway system of the city of Lethbridge, Alta. Mr. A. Reid has been placed in charge of the organization work.

Mr. Joseph E. Chalifour has been appointed chief geographer for the Dominion Government. He takes the place of the late R. E. Young. Mr. Chalifour has for three years been assistant geographer to the Dominion.

Mr. Provost Hubbard, Chief of the Division of Roads and Pavements of the Institute of Industrial Research, has been appointed lecturer in Engineering Chemistry at Columbia University. He will conduct the courses in Bituminous Materials given in connection with the graduate courses in Highway Engineering.

Mr. Harry C. Oswald has been appointed assistant secretary of the Canadian Pacific Railway Company. He has been connected with the company for the past twenty-six years, during which he has capably filled various positions in several departments. The recognition of his services is welcomed by his many friends, who feel that in his new position he will acquit himself as ably as he has in the others he has filled.

Messrs. W. E. H. Carter and Alexander H. Smith have formed a partnership as consulting mining engineers, to be known as Carter & Smith. Their head office will be Canadian Mining Journal, Toronto.

Mr. Carter is a graduate of the School of Practical Science of the class of '98, and has had a general experience along the line of mining engineering. For some years he was Inspector of Mines for the Province of Ontario, but during the last few years has been in consulting practice only.

Mr. Smith is also a graduate of the School of Practical Science. He has had considerable experience in gold mining in Mexico, being for some years manager of certain of the mines operating there.

UNIVERSITY APPOINTMENTS.

The following non-resident lecturers in Highway Engineering for 1911-1912 have been appointed at Columbia University: John A. Bensel, M. Am. Soc. C.E., New York State Engineer, Albany, N.Y.; Walter W. Crosby, M. Am. Soc. C.E., Chief Engineer, Maryland State Roads Commission, Baltimore, Md.; A. W. Dow, Chemical and Consulting Paving Engineer, New York City; Walter H. Fulweiler, Assoc. M. Am. Soc. C.E., Chief Chemist, United Gas Improvement Co., Philadelphia, Pa.; John M. Goodell, Assoc. Am. Soc. C.E., Editor-in-Chief, Engineering Record, New York City; Nelson P. Lewis, M. Am. Soc. C.E., Chief Engineer, Board of Estimate and Apportionment, New York City; Logan W. Page, M. Am. Soc. C.E., Director, United States Office of Public Roads, Washington, D.C.; Harold

Parker, M. Am. Soc. C.E., Chairman, Massachusetts Highway Commission, Boston, Mass.; Charles P. Price, Assoc. Am. Soc. C.E., Manager, American Tar Company, Malden, Mass.; H. B. Pullar, Chief Chemist, American Asphaltum and Rubber Company, Chicago, Ill.; John R. Rablin, M. Am. Soc. C.E., Chief Engineer, Massachusetts Metropolitan Park Commission, Boston, Mass.; Clifford Richardson, M. Am. Soc. C.E., Consulting Engineer, New York City; Philip P. Sharples, Chief Chemist, Barrett Manufacturing Company, Boston, Mass.; Francis P. Smith, M. Am. Soc. C.E., Chemical and Consulting Paving Engineer, New York City; Albert Sommer, Assoc. Am. Soc. C.E., Consulting Chemist, New York City; George W. Tillson, M. Am. Soc. C.E., Consulting Engineer, Borough of Brooklyn, New York City.

COMING MEETINGS.

THE ENGINEERS' CLUB OF TORONTO.—Nov. 23rd, 96 King Street West, Toronto. Paper by Mr. Joseph B. Tyrell, M.A. "Exploration in the Far North," illustrated with lantern slides. R. B. Wolsey, Secretary.

THE CANADIAN SOCIETY OF CIVIL ENGINEERS.—Nov. 30th. Meeting of the Toronto Branch at the Engineers' Club of Toronto, 96 King Street West, Toronto. Paper on "The Niagara River Boulevard." E. A. James, Secretary.

THE AMERICAN ROAD BUILDERS' ASSOCIATION (150 Nassau Street, New York). Nov. 14-17. Annual Convention, Rochester, N.Y.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—Nov. 15. Sixth Annual Convention, Toronto. F. Dagger, Secretary, 21 Richmond Street West, Toronto.

AMERICAN ASSOCIATION FOR HIGHWAY IMPROVEMENT.—Nov. 20-24. First Annual Convention, Richmond, Va. Logan Waller Page, President, United States Office of Public Roads, Washington, D.C.

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

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—President, T. A. Starkey, M.B., D.P.H., Montreal. Secretary, F. C. Douglas, M.D., D.P.H., 51 Park Avenue, Montreal.

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Tuesday, Nov. 21st, 1911, address by Alexander Allaire, M.E., on "Modern Methods in Foundation Work." No. 5 Beaver Hall Square, Montreal. J. E. Ganier, Secretary.

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Tuesday Dec. 19th, 1911, lecture by Dr. T. A. Starkey, of McGill University, Professor of Hygiene, on "Ventilation of Public Buildings." No. 5 Beaver Hall Square Montreal. J. E. Ganier, Secretary.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—Dec. 13-15. Montreal. F. C. Douglas, M.D., D.P.H., Secretary, 51 Park Avenue, Montreal. (The date of the meeting has been changed from Nov. 21-23 to Dec. 13-15.)

THE CANADIAN FORESTRY ASSOCIATION.—February 6, 7 and 8, 1912. Annual Meeting, Ottawa. James Lawler, Secretary.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, C. H. Rust; Secretary, Professor C. H. McLeod.

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

TORONTO BRANCH—
96 King Street West, Toronto. Chairman, H. E. T. Haultain, Acting Secretary; E. A. James, 57 Adelaide Street East, Toronto. Meets last Thursday of the month at Engineers' Club.

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

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

OTTAWA BRANCH—
Chairman, S. J. Chapleau, Ottawa; Secretary, H. Victor Brayley, N. T. Ry., Cory Bldg.

MUNICIPAL ASSOCIATIONS.

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

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

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

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

UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. E. McMahon, Warden, King's Co., Kentville, N.S.; Secretary, A. Roberts, Bridgewater, N.S.

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

CANADIAN TECHNICAL SOCIETIES.

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

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

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

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

BUILDERS, CANADIAN NATIONAL ASSOCIATION.—President, E. T. Nesbitt; Secretary Treasurer, J. H. Lauer, Montreal, Que.

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

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

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

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

CANADIAN FORESTRY ASSOCIATION.—President, Thomas Southworth, Toronto; Secretary, James Lawler, Canadian Building, Ottawa.

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

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

CANADIAN MINING INSTITUTE.—Windsor Hotel, Montreal. President, Dr. Frank D. Adams, McGill University, 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., Castle Building, Ottawa, Ont.

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

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

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

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

DOMINION LAND SURVEYORS.—President, Thos. Fawcett, Niagara Falls; Secretary-Treasurer, A. W. Ashton, Ottawa.

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

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, W. B. McPherson; Corresponding Secretary, A. McQueen.

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

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

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

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

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

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

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

NOVA SCOTIA SOCIETY OF ENGINEERS, HALIFAX.—President, S. Fenn; Secretary, J. Lorne Allan, 15 Victoria Road, Halifax, N.S.

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, W. H. Pugsley, Richmond Hill, Ont.; Secretary, J. E. Farewell, Whitby.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, J. Whitson; Secretary, Killaly Gamble, 703 Temple Building, Toronto.

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

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

ROYAL ASTRONOMICAL SOCIETY.—President, Prof. Alfred T. de Lury, Toronto; Secretary, J. R. Collins, Toronto.

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

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

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

WESTERN CANADA RAILWAY CLUB.—President, Grant Hall; Secretary, W. H. Rosevear, 199 Chestnut Street, Winnipeg, Man. Second Monday, except June, July and August at Winnipeg.