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NEW GRAIN ELEVATOR FOR THE HARBOR COMMISSIONERS OF MONTREAL.

The marine traffic of the port of Montreal is second only to that of the port of New York among all the ocean ports of North America. An important portion of the export traffic from Montreal is grain, which is, for the greater part, wheat from the Western provinces of Canada.

Prior to 1910 the export grain handling equipment in Montreal harbor consisted of a 1,000,000-bushel steel elevator, owned and operated by the harbor commissioners, adapted for unloading lake and canal vessels, but not designed for railway car traffic; a 1,000,000-bushel steel elevator owned and operated by the Montreal Warehousing Company (a corporation subsidiary to the Grand Trunk Railway), equipped for the unloading of both railroad cars and inland vessels; two obsolete wooden elevators, owned by the Canadian Pacific Railway, and since torn down; and a small fleet of floating transfer elevators of varying age and efficiency.

In the early part of 1910 the harbor commissioners of Montreal determined on the immediate construction of a new grain elevator of the highest class to provide (a) a rapid and efficient plant for the unloading of those railway cars for which the Grand Trunk elevator was not available; (b) extensive additional capacity for quick unloading of inland vessels, which were often being delayed for days in the harbor waiting to be unloaded; (c) sufficient additional storage capacity so that merchants could hold grain at the exporting point when it became advantageous to do so, and to eliminate the necessity for direct and almost direct transfer of inland cargoes to ocean vessels; (d) facilities for shipping grain from the new elevator, not only to the present vessel berths but to others under course of planning.

The harbor commissioners retained John S. Metcalf Company, Limited, as their constructing engineers for the new elevator. This company were the designers and builders of the Grand Trunk elevator in Montreal harbor, and of the great export grain conveyer system belonging to the commissioners, so that they were familiar with the developments of the port and the details of the problems to be solved.

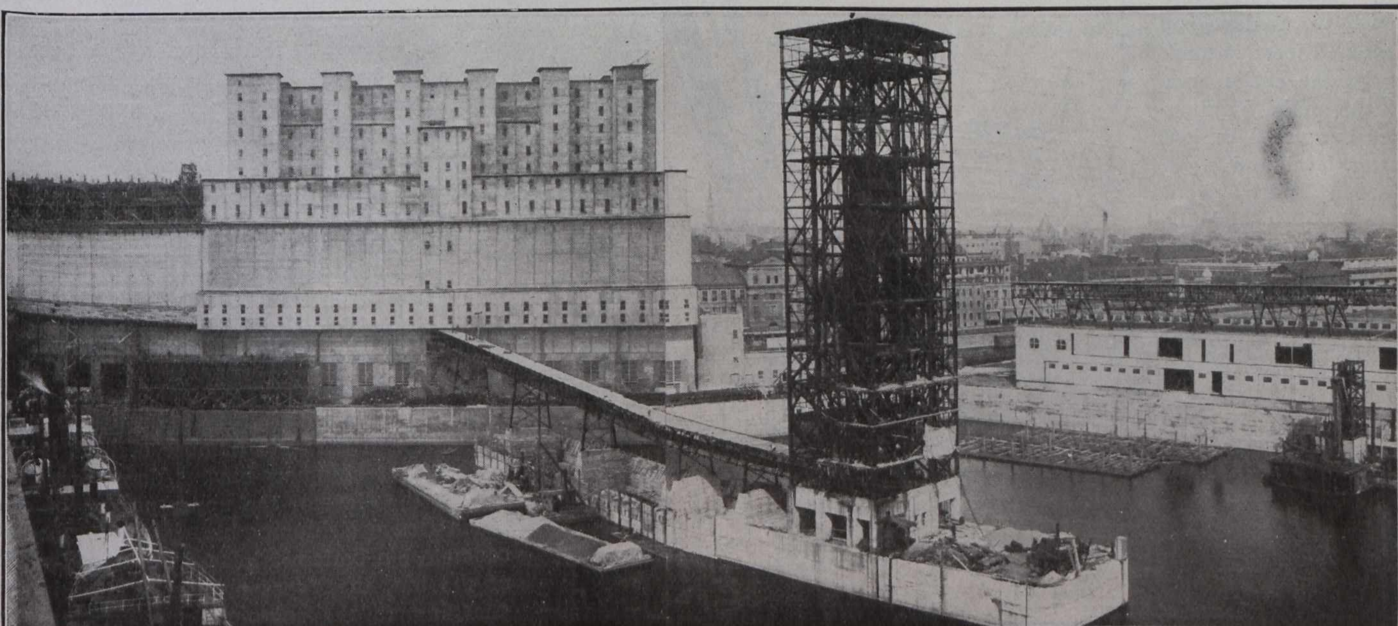


Fig. 1.—General View of Elevator from Outer End of Jacques Cartier Pier.

The instructions were to provide the best, in structure, equipment and efficiency. The commissioners were resolved that Montreal's export traffic in grain should not suffer through lack of thorough facilities.

In the summer of 1912 the elevator and a portion of the shipping conveyers were ready for the handling of car grain; and the marine unloading will be in operation October 1st.

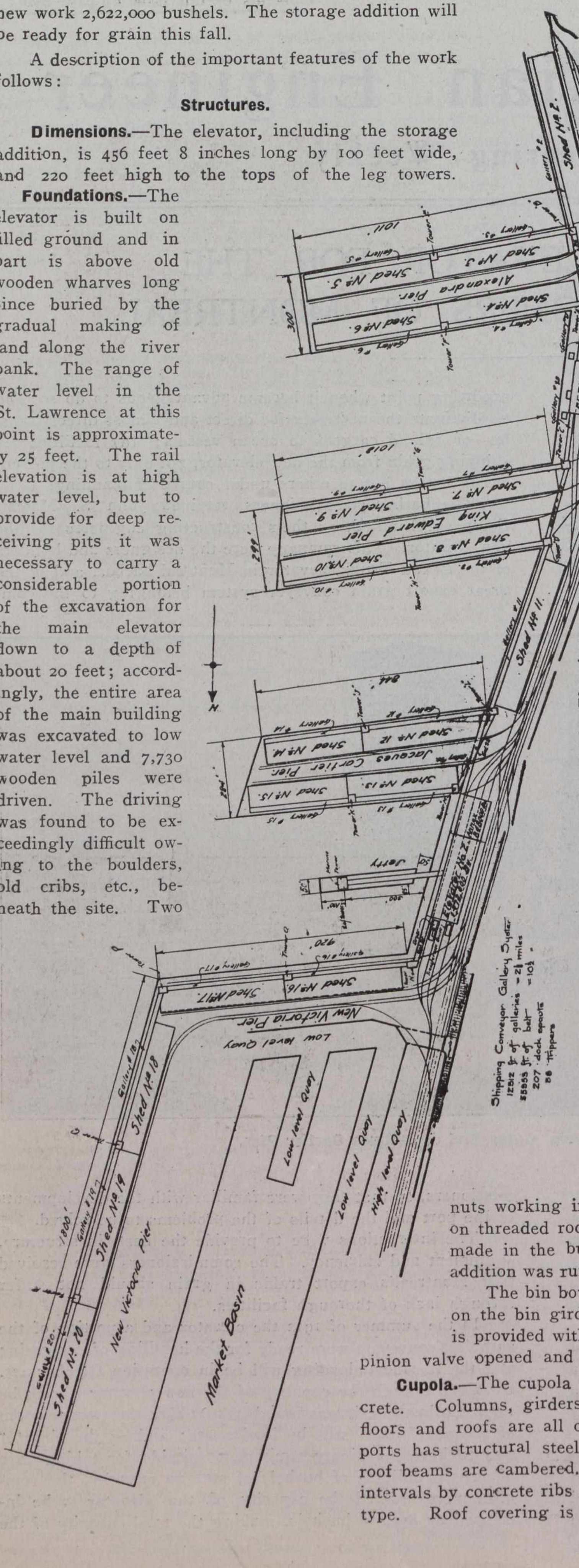
Even though the capacity of the new elevator was to be 1,772,000 bushels, it was found in 1911 that the storage room of the port would still be inadequate; and as the elevator was to have machinery equipment suitable for taking care of several millions of bushels of storage capacity, the commissioners ordered the capacity of the elevator to be increased by 850,000 bushels, making the total capacity of the new work 2,622,000 bushels. The storage addition will be ready for grain this fall.

A description of the important features of the work follows:

Structures.

Dimensions.—The elevator, including the storage addition, is 456 feet 8 inches long by 100 feet wide, and 220 feet high to the tops of the leg towers.

Foundations.—The elevator is built on filled ground and in part is above old wooden wharves long since buried by the gradual making of land along the river bank. The range of water level in the St. Lawrence at this point is approximately 25 feet. The rail elevation is at high water level, but to provide for deep receiving pits it was necessary to carry a considerable portion of the excavation for the main elevator down to a depth of about 20 feet; accordingly, the entire area of the main building was excavated to low water level and 7,730 wooden piles were driven. The driving was found to be exceedingly difficult owing to the boulders, old cribs, etc., beneath the site. Two large drivers with No. 1 Warrington steam hammers were employed. On top of the piles a reinforced concrete slab 3 feet 6 inches thick was laid, extending over the entire foundation area. An idea of the foundation problem may be gained when it is known that loads as high as 1,270 tons had to be carried on some of the columns.



General Plan of Elevators and Galleries, Grain Elevator No. 2, Montreal, Quebec.

(Built by the John S. Metcalf Co. Ltd., for the Harbor Commissioners of Montreal.)

Concrete piers and walls were built on top of the foundation slab and carried up to the track level. The track girders are of reinforced concrete, except over the receiving pits, where they are of steel. Boot tanks and track hoppers are of steel.

The foundations of the 850,000-bushel storage addition were differently treated. As there were to be no elevator legs, and consequently no boot tanks, in this portion of the elevator, the deep excavation necessary for the main elevator was not required. Consequently 1,535 reinforced concrete piles were used. These were of the Simplex moulded inserted type, with their tops about four feet below base of rail. Above them the foundation concrete was placed.

First Story.—Four railroad tracks extend through the entire elevator. The bin openings are 22 feet 6 inches above the tracks. The columns supporting the bins are of reinforced concrete, about 24 feet centres, in general, each way. Some of these columns are as large as 6½ feet by 5½ feet. They are surmounted by the heavy concrete girders supporting the bins. These main girders are 5 feet deep and 6½ feet wide. The first floor is of concrete except at hopper and grain openings, where steel gratings are employed. Curtain walls are of concrete, with a large area of fireproof windows. The track openings are closed by rolling steel doors.

Bins.—The bins are of reinforced concrete, are rectangular in form, and 86 feet deep. Bin walls are in general 8 inches thick. Bin capacities range from 6,800 bushels to 14,300 bushels; and the total number of bins is 278, exclusive of shipping bins. Along the water side of the elevator the upper portion of each bin is used as a shipping bin. An intermediate concrete bin bottom is placed about mid-height of the bin, the upper portion of the bin discharging to the shipping conveyers and the lower portion being used as an ordinary storage bin.

The bins were constructed by the use of moving forms. The forms were raised by nuts working in jack castings attached to the forms, the nuts travelling on threaded rods set vertically in the concrete walls. Rapid progress was made in the building of the walls; the height of 86 feet in the storage addition was run in less than 14 days, day and night work.

The bin bottoms are of reinforced concrete, in part supported directly on the bin girders and in part suspended from them. Each bin opening is provided with a cast iron and steel revolving turnhead, with rack and pinion valve opened and closed from the floor below.

Cupola.—The cupola construction is a remarkably fine example of reinforced concrete. Columns, girders, floor and roof beams, wind bracing, stairs, curtain walls, floors and roofs are all of concrete. In fact, only in the case of machinery supports has structural steel played any important part. The lower sides of floor and roof beams are cambered. Curtain walls are 2½ inches thick, supported at short intervals by concrete ribs connecting to the floor beams. Windows are of fireproof type. Roof covering is of tar, felt and gravel, except on the leg towers, where the concrete is waterproofed and covering omitted. The cupola is 107 feet high above the bin walls, and 220 feet above the base of the rail. This means that there are very few, if any, higher reinforced concrete buildings in existence.

Above the storage addition the cupola is but two stories high, as the only machinery above those bins is the conveyers and spouts for filling the bins.

Marine Tower.—A marine tower for unloading boats is placed on a jetty projecting into the neighboring slip. The tower is so placed in order that two vessels may be unloaded simultaneously, one lying along each side of the jetty. The tower is 340 feet from the elevator. It is built of structural steel, this material being adopted instead of concrete because it is expected that, in the event of the Georgian Bay Canal being built and 600-foot vessels being brought to Montreal for unloading it may be desired to extend the jetty farther and move the tower to such a distance from shore that 600-foot vessels may be unloaded without interference. As the shorter jetty is, however, better adapted to present congestion in the harbor, it has been adopted until such

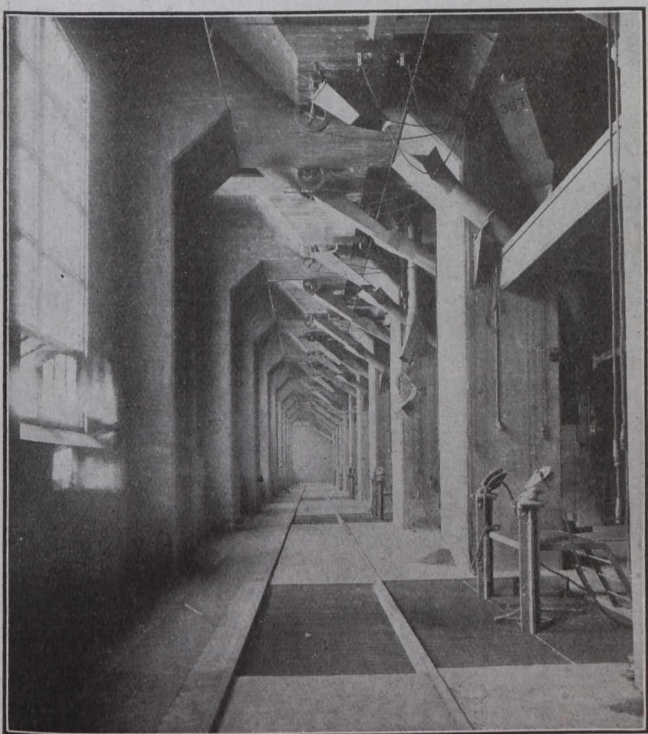


Fig. 2.—A View of the First Floor.

time as the increased size of lake boats coming to Montreal shall require its extension.

A steel gallery runs from the marine tower to the elevator, and contains the conveyer belts for taking grain received by boat to the elevator.

Shipping Conveyer Galleries.—Study of the accompanying diagram will show the extensive system of shipping galleries built and contemplated. Those already built in connection with elevator No. 1 were two miles in extent. Those to be added in connection with elevator No. 2 will bring the total to 2½ miles, using 10 miles of rubber belt. All galleries are of steel with concrete floors and roofs and corrugated steel side-covering.

Miscellaneous Structures.—A reinforced concrete building is provided for a grain dryer and its boiler plant, and a similar structure for the transformers and switchboard.

Equipment.

Receiving from Cars.—There are four receiving tracks, 24 track hoppers, and twelve receiving legs. Each leg is fed from two hoppers, one on either side, interlocking

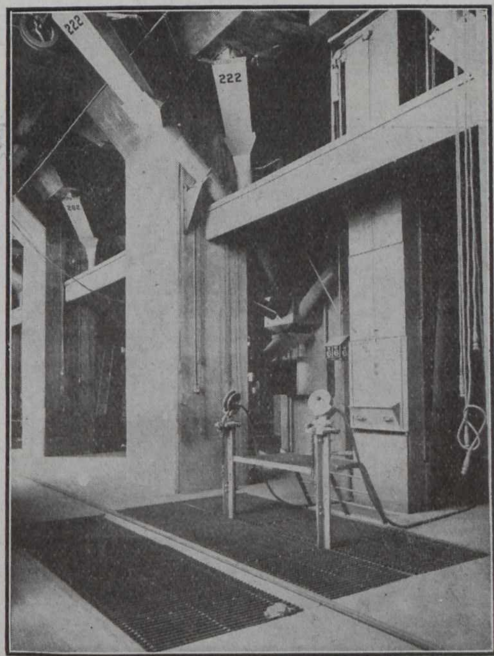


Fig. 3.—A Detail of the First Floor.

valves being used so that it is impossible for grain to reach the leg from more than one hopper at a time. Track hoppers are of large size, and a pair of power shovels is provided at each. Thus the unloading of a car on one side of the leg is independent of that on the opposite side, and

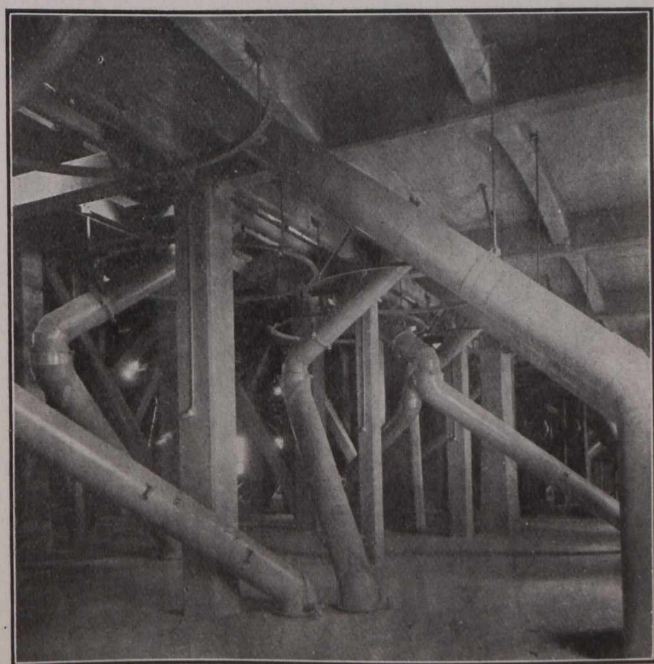


Fig. 4.—View of Distributing Spouts in Story Over Bin.

unloading from both cars may proceed simultaneously, as the legs are of sufficient capacity (12,000 bushels per hour each) to quickly elevate the contents of either hopper as soon as the elevation of the contents of the other has been completed. The elevator will receive 240 cars in ten hours with the ordinary complement of men, and with extra men can better this in emergencies.

Cars are handled by heavy carpullers using ¾-inch wire cable.

Each receiving elevator discharges to a 2,500-bushel garner over a 120,000-pound Fairbanks hopper scale, whence the carload is sent by spouts, or belt conveyers and spouts, to the desired bin.

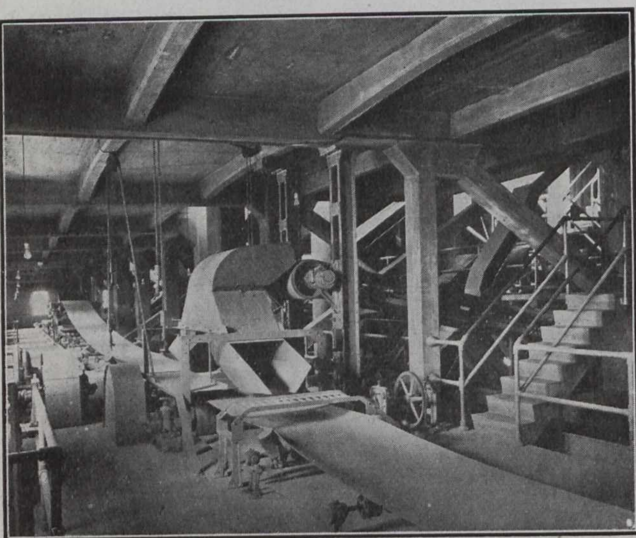


Fig. 5.—Belt Conveyers in Second Story Over Bin.

Receiving from Boats.—The marine tower is equipped with two marine legs, each of 20,000 bushels hourly capacity on the dip. One leg operates on each side of the tower, so that two boats may be unloaded simultaneously. The grain from the legs is weighed by two pairs of 6,000-pound Fairbanks continuous automatic weighing machines. Complete ship shovel and clean up shovel apparatus, operated by

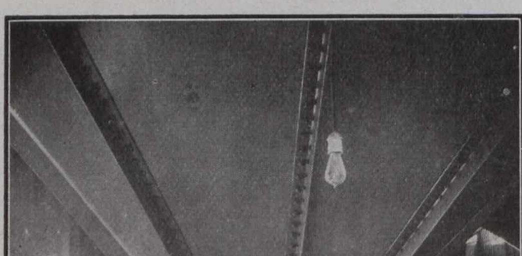


Fig. 6.—View of 2,000-Bushel Hopper Scale.

air, and the best of equipment for raising and lowering the legs, and adjusting them horizontally to the position of the boots is provided.

The marine legs are of steel, 115 feet long between centres of pulleys, and are the longest marine legs ever constructed.

The 40-inch belt conveyers carry the grain to the elevators, where two lofter legs elevate it to the cupola. There a system of 40-inch conveyers distributes it to the double-jointed spouts leading to the bins.

The maximum hourly capacity for receiving from boats will be 40,000 bushels.

Distributing.—Two reversible longitudinal conveyers in the cupola receive from the scale and distribute grain longitudinally of the elevator.

Cleaning.—While Montreal is not a cleaning point, two large steel cleaning machines are provided for emergency cleaning and separating.

Shipping to Cars.—Four carloading spouts are provided so that cars may be loaded if desired. This sometimes becomes necessary in order to get grain to a winter port farther east after the port of Montreal has closed.

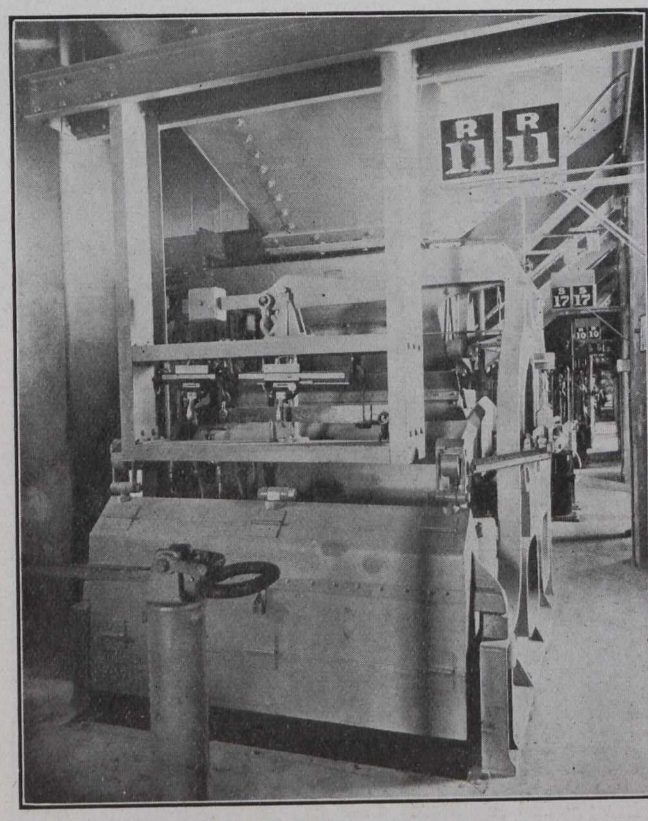


Fig. 7.—Automatic Weighing Machine, 5,000 lbs. per Draft.

Shipping to Ocean Vessels.—In connection with elevator No. 1 the shipping conveyers served 14 vessel berths on King Edward, Alexandra and Jacques Cartier piers and the neighboring shore wharves. Five berths are being added on the new Victoria pier.

The side shipping gallery of elevator No. 2 contains six shipping conveyers. Two will extend north to serve the Victoria pier, and four will run south to connect with the conveyers to the present 14 berths. It will be possible for either elevator to ship to any of the nineteen berths.

The shipping system of elevator No. 2 will be served by five shipping legs, each with a capacity of 16,000 bushels per hour. The total shipping capacity of elevator No. 2, starting with the shipping bins full, will be 90,000 bushels hourly for ten hours.

Grain for shipment by boat is weighed through five pairs of 5,000-pound Fairbanks automatic weighing machines, each provided with automatic registers, printing devices, and electrical counters in the weighman's office. As shipping to boats and receiving from boats are continuous operations, automatic scales are used for this work, but as it is necessary in receiving from cars to keep each car weight separate, hopper scales are employed for car receipts.

Drying.—A Hess drying plant with a capacity of 5,000 bushels per day is included in the equipment. This has a separate leg so that interference with the main receiving and shipping legs is avoided.

Power.—All power is supplied by electric motors of the induction type. In the elevator, marine tower and the new shipping galleries the motors number 80, and total 4,680 horse-power.

An ingenious and efficient system of electric signals controls the operation of elevator legs and shipping conveyers. When the extent of the shipping system is remembered, and the interconnection of the two elevators, it will be seen that the signal system, particularly for shipping, must be instantaneous and sure; its design was accomplished with credit.

The harbor commissioners' grain storage and shipping system will now consist of: Two grain elevators with two marine legs each, and a conveyer system by which grain can be delivered from either elevator to any of 19 steamer berths. Everything is of fire-proof construction and all machinery is electrically driven. There is a storage capacity of 3,620,000 bushels and contemplated extensions for 3,790,000 bushels more; total, 7,410,000. Grain may be received from cars at a rate of 33,000 bushels per hour and at the same time from boats at a rate of 55,000 bushels per hour.

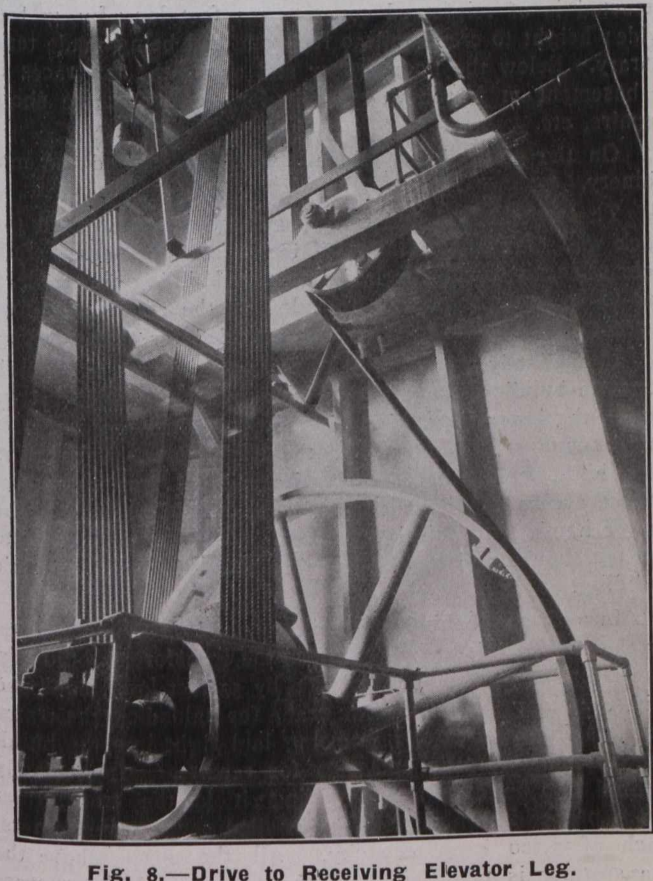


Fig. 8.—Drive to Receiving Elevator Leg.

Grain can be shipped by conveyer system to ocean steamers at their regular berths at a rate of 150,000 bushels per hour, equal to 4,500 tons per hour. It is possible to deliver grain to five steamers at the same time at a rate of 30,000 bushels per hour each, or it is possible to deliver to 10 steamers 15,000 bushels per hour each at the same time.

The present conveyer system comprises two miles of conveyer galleries and over eight miles of rubber belting, In addition to this there is under construction another half mile of gallery with two miles of rubber belting.

The constructing engineers for the Montreal harbor commissioners were the John S. Metcalf Company, Limited, Montreal, under Mr. F. W. Cowie, chief engineer. This company were also the designers of the conveyer system in connection with elevator No. 1.

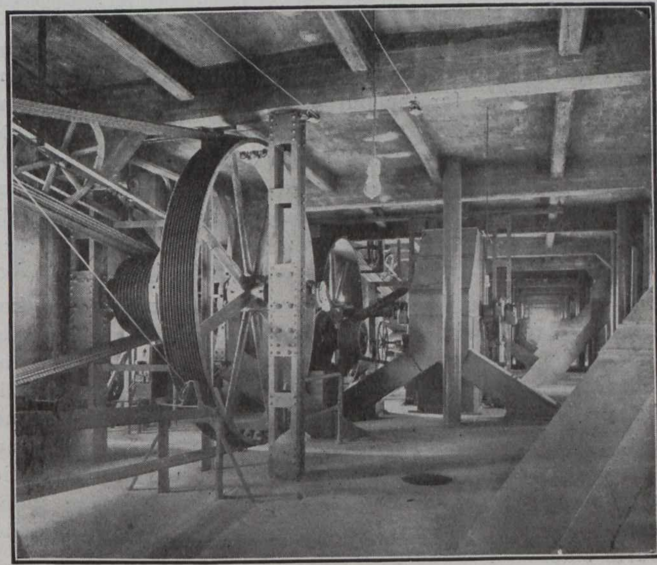


Fig. 9.—View of Top Floor Showing Elevator Heads and Drive.

It is easy to say that this building or that building is the best ever built, and that this elevator or that elevator can handle more grain than any other; the harbor commissioners responsible for the new work, Messrs. Stephens, Ballantyne and Geoffrion, with Mr. David Seath, secretary, are content to let the elevator and accessories speak for themselves.

PHYSICAL PROPERTIES OF CONCRETE.

The National Bureau of Standards of the United States in its general investigation of structural materials is engaged, among other things, in the determination of the physical properties of concrete. At the suggestion of engineers and others, the Bureau of Standards is investigating the cause of cracking in concrete structures, where the necessity for expansion and contraction joints is questioned. For this purpose, reference marks were placed on some of the typical old and new concrete work in Wayne County, Michigan, also at Greenwich, Connecticut. Measurements will be taken from time to time during the summer and winter to determine the expansion or contraction in the concrete caused by temperature variations and the changes of volume which take place during the hardening of the concrete. Similar reference marks are being placed on the lock walls of the Panama Canal and various other structures, from which valuable information will be obtained.

Steel on the Tofield-Calgary branch of the Grand Trunk Pacific has been laid as far south from the main line as Irricana, and that the grade is now ready for entry into the latter place. A bridge at the Bow River, about four miles out of Calgary, is likely to delay track laying a little. This bridge is of steel construction and is to be erected by the Canadian Bridge Company.

POWER PLANT OF MOUNT HOOD COMPANY.

The power plant of the Mount Hood Railway and Power Company (now owned by the Portland Railway, Light and Power Co.) is one of a number of similar plants that have been built within the last few years to supply light and power to Portland and other near-by towns and cities in Western Oregon and to Vancouver and other towns in Washington. The following description of the plant, now nearing completion, is given by W. P. Brereton, chief engineer of construction:

A dam approximately 100 feet high in the middle and about 400 feet long is in course of construction across the Big Sandy River for the purpose of diverting water. The water thus diverted is carried for a distance of about 9,700 feet with about 18-foot fall through 800 feet of timber flume having a capacity of 700 second feet, 4,200 feet canal of trapezoidal section, and then through a tunnel approximately 4,700 feet long, about 11 feet by 11 feet cross section, driven through the hill, and discharges into the Little Sandy River.

About 200 feet below this point of discharge a diverting dam has been built about 14 feet high and about 115 feet long. The water thus diverted is carried for a distance of about three miles along the hillside with a 34-foot fall, through a timber flume, having a capacity of 800 second feet, discharging into a reservoir. This reservoir has an area of 180 acres with a total capacity of 138 million cubic feet, and is formed by constructing an earthen dyke about 40 feet high on three sides and using the hillside for the fourth side.

Located inside this reservoir is the intake for the three penstocks, and for this purpose the ground has been excavated down to the lowest point of the reservoir, and the intake and gatehouse for the three penstocks built up of concrete from this elevation to a height of about five feet above high water, or about 40 feet high. The forebay is about 300 feet wide, excavated down to the lowest elevation of the reservoir. A spillway is provided in this dyke for taking care of 800 second feet with a 2-foot 6-inch depth of water on the crest.

Suitable racks and stop logs are provided at the entrance of each of the three penstocks and the penstocks themselves are controlled by 10-foot butterfly valves operated by hand or electric motor controlled from the power house.

Two penstocks, each 9 feet in diameter, are being carried through tunnels from this intake for about 400 feet, where they emerge into the open, and at that point a suitable standpipe, 5 feet in diameter, and tank is provided for each penstock. These 9-foot penstocks continue down to the power house. A third 9-foot penstock is being laid from the intake for about 160 feet for future extension.

The general design of the pipe line is as follows: The pipes are carried at or near ground level, tunneling in places having to be resorted to owing to the nature of the ground, for a distance of 700 feet when each 9-foot pipe branches into two 78-inch pipes, thus forming four 78-inch pipes, two of which are connected to Platt turbines of 6,400 horse-power each, a third to a 6,400 horse-power, Wellman-Seaver-Morgan machine and the fourth for the 6,400 horse-power Wellman-Seaver-Morgan turbine under option.

Total length of pipe line 9-foot diameter approximately 1,190 feet; total length of pipe line 78 inches diameter approximately 260 feet; total fall from pipe intake to power house, 280 feet.

Two 78-inch pipes terminate in 54-inch hydraulic valves and two 78-inch pipes in 60-inch hydraulic valves.

The dimensions of the 54-inch, hydraulically operated, straightway, wedge gate valves follow. These valves were built at the Bridgeport, Conn., works of the Crane Company.

Height, open, 23 feet 1⅞ inches, centre of valve.
Height, closed, 18 feet 5⅞ inches, to top of loop.
Face to face, 40 inches.
Diameter of cylinder, 40 inches.
Width over all, 37 inches by 73¾, bonnet flange.
Diameter of spindle, 4¾ inches.
Weight, 37,634 pounds.
Diameter of flanges on the run, 66 inches.
Thickness of flanges on the run, 3 inches.
Drilling, 48⅝-inch bolts on 62½-inch between centres.
Size of by-pass valve, 8 inches.
Working pressure, 140 pounds.
Test, 250 pounds for one hour.
Height over all from bottom of flange, closed, 21 feet 2¾ inches.

Each valve is located at the end of a steel penstock supplying water to turbines in the power plant near Bull Run River, Bull Run post office, about 27 miles from Portland, Oregon. The body, bonnet, disc, cylinder and piston are made of Ferrosteel, and the piston is equipped with bronze rings. The guide ribs in the bonnet and body are bronze lined, and the discs are furnished with bronze rollers. The stems are steel, encased in bronze tubing.

Twenty-four-inch branch pipes are taken from one 78-inch pipe on each pipe line for the purpose of supplying the exciters, these branches being governed by 24-inch gate valves. The 78-inch pipe lines are safeguarded both by automatic relief valves on the turbines and also by bursting plates on the pipes themselves.

The power house is being built on the south bank of the Bull Run River, the turbine tail races discharging directly into the river. The building at present being constructed is of reinforced concrete 191 feet long by 47 feet wide; height to crane rail 30 feet, one end being made temporary. Below the floor proper and above the tail races is a basement 11 feet high suitable for small machine shop, repairs, etc.

On the power house floor proper is located the machinery.

The switchboard and control gallery are located on the back wall of this building 11½ feet above the floor. Sufficient length of rails is laid into this building to enable a car to be brought in and unloaded by the crane, a 35-ton, three motor electric crane being provided for this purpose.

Immediately at the back of the power house is a small concrete building about 57 feet long by 33 feet wide in two floors, the lower floor, which is 12 feet high, being used for low tension switch room, and the upper floor, which is 12 feet high, being used for switches and bus structure. Direct access can be had from the control gallery in the power house with this latter room. The railroad track to the warehouse and depot are laid across the roof of this building.

Immediately behind this building, and on the same level as the roof of this switch room, is the transformer building, consisting of a room 18 feet wide by 53 feet long, equipped with a 40-ton, 3-motor electric crane for unloading the transformers from the cars, rails being laid right into the building for this purpose and also for repairs. Immediately behind this building and adjoining it is the transformer room proper in which will be installed seven transformers, each of 3,300 k.v.a. capacity. All the space above the transformer is taken up with the necessary bus structure for the outgoing high tension lines. All the necessary waste water and drainage is carried by pipes into the tail races.

In the water power plant are two 42-inch Type B Francis turbines manufactured by the Platt Iron Works, each of 6,400 horse-power complete with Lombard type N. S. oil pressure governors, pumps and tanks. These turbines are connected to steel penstocks through 60-inch hydraulic valves and work under a static head of 320 feet. Directly coupled to the shafts of these turbines are two Westinghouse alternating current revolving field generators, each 3,750 k.v.a. 3-phase, 60-cycle, 6,600-volt, 514 r.p.m.

One 6,400 horse-power horizontal, Francis type, single discharge turbine, manufactured by the Wellman-Seaver-Morgan Company, complete with N.S. 10 Lombard hydraulic governors, pumps and tanks, etc. This turbine is connected to a steel penstock through a 54-inch hydraulic valve and works under static head of 320 feet.

Direct coupled to the shaft of this turbine is a Westinghouse alternating current, revolving field generator 3,750 k.v.a., 3-phase, 60-cycle, 6,600-volt, 514 r.p.m. The fourth unit under option will be similar in all respects to the 6,400 horse-power Wellman-Seaver-Morgan, Westinghouse set.

Two 24-inch exciter wheels, manufactured by the Platt Iron Works, developing 300 horse-power each, when operating at a speed of 690 r.p.m. under 320-foot head, direct coupled to two 150 kw. Westinghouse direct current generators, 250 volts, 600 amperes, 6 poles, compound wound.

The engineers on this contract are Smith, Kerry and Chase, of Toronto, Canada. The chief engineer is W. P. Brereton; assistant engineer, J. S. Bodkin; chief draftsman, J. R. Carroll.

HISTORY OF AN OLD IRON BRIDGE.

In a recent bulletin of the American Railway Engineering Association Mr. George K. Lowell, general manager of the Detroit, Toledo and Ironton Railway, gives a brief history of the Iron Railroad, together with the original construction of the Iron Bridge, spanning Storms Creek, on the line of the Iron Railroad, two and one-half miles north of Ironton, O.

Construction of the Iron Railroad was originally commenced in the year 1849, and the line was completed to the Vesuvius Mines, about six miles north of Irontown, during the year 1850. The track was laid with strap rail laid on wooden stringers, and the stringers laid on cross-ties spaced six feet apart. John Campbell, John Peters and others, of the Ohio Coal and Iron Company, were the original founders of the Iron Railroad.

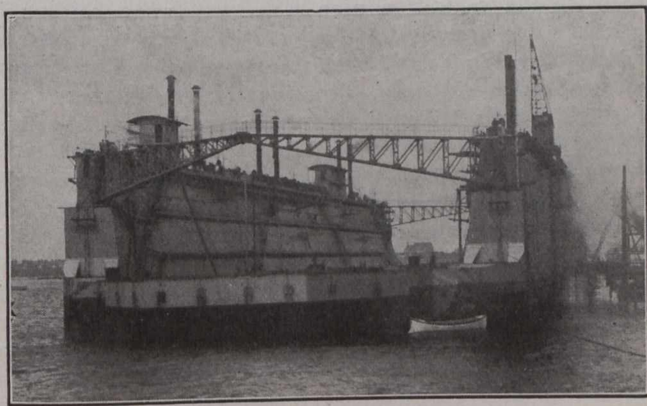
In the construction of the Iron Railroad it became necessary to span Storms Creek, two and one-half miles north of Ironton. In the original construction of the Iron Railroad, Storms Creek was spanned with a wooden trestle bridge, 97 ft. in length, but during the year 1857 the structure was considered insufficient to carry the increased loading of the road's equipment, and it was decided to construct an iron bridge of larger capacity, and more safe for the operation of the railroad. Thomas W. H. Moseley, a civil and constructing engineer, of Kentucky, was called upon to prepare a plan for the construction of a wrought-iron bridge to be placed on the site of the wooden structure spanning Storms Creek. The plans were prepared for what is known as Bowstring Construction Iron Bridge, patented February 8th, 1857, and constructed by Moseley & Company, of Cincinnati, O., in the year 1859, the bridge being constructed for the loading of 2,000 lbs. per linear foot, live load.

In the year 1905, the Detroit, Toledo and Ironton Railway, successors to the Iron Railroad, increased the weight of its locomotives and cars, and it was necessary to strengthen this bridge by placing timber trestle bents under the floor or track system. With this addition, the bridge, as originally constructed, is still in use, and over it passes as heavy tonnage as on any road in this section of the country.

THE MONTREAL FLOATING DOCK "DUKE OF CONNAUGHT."

There has recently been delivered at Montreal the floating dock "Duke of Connaught," which has been built by Messrs. Vickers (Limited), of Barrow-in-Furness, England. In *The Canadian Engineer* of August 15, 1912, we gave some details of the launching of the dock. We are now able to present a more complete description. This dock, one of the largest yet constructed, is capable of accommodating the largest existing vessel of the British navy. It is of the double-sided, self-docking type, and consists of a pontoon, or lifting portion of the dock, and two parallel side walls, built on to and forming part of the same, and the whole length is divided into three complete and separate sections, which, when bolted together, form the complete dock. These sections are so arranged that when the dock is separated into its three parts, any two of them can dock the remaining third between them. For this purpose each section is fitted with its own independent pumping machinery, so that it can also act as an independent unit. The general dimensions of the dock are as follows:

Length over platforms, 600 ft.
Length over pontoons, 550 ft. 6 in.
Width overall, 135 ft.
Depth of pontoon at centre, 17 ft.
Length of side walls, 470 ft. 6 in.
Height of side walls above pontoon dock, 42 ft.
Width of side wall at base, 17 ft. 6 in.
Width of side wall at top, 12 ft. 6 in.
Clear width between roller fenders, 100 ft.
Draught of vessel, 27 ft. 6 in.
Lifting capacity, 25,000 tons.



View of Dock.

The construction of the dock is such as to make it suitable for lifting a modern British battleship, the pontoon dock being specially stiffened to allow it to support a large portion of the weight of the vessel on side or bilge, as well as central keels. The pontoon consists of a rectangular structure plated in all round with the exception of the portion of the deck which comes directly under the walls, and stiffened internally by longitudinal and transverse girders. The two end sections have their outer extremities built in the form of a point or bow terminating in a working platform carried on plate and braced girders. The bottom plating, except under the walls, is arranged to run transversely, and is connected to the plating of the sides and points by chine angles; the top or deck plating, similarly arranged, is connected to the face of the side wall by chine angles. The pontoon is divided into four compartments by three longitudinal intercostal water-tight plate-bulkheads. Transversely the pontoon is divided into 54 bays, 20 in the central section and 17 in each end section, by transverse girders, consisting of plate-bulkheads. In the compartments under the walls the plate-girders are replaced by special lattice-girders. In addition to the bulkheads, the deck and bottom platings are stiffened by means of a series of longitudinal frames which run fore and aft over the length of the pontoon, intercostal between the transverse girders. In addition to the transverse lattice-girder under the wall, intermediate transverse ordinary frames are fitted, 2 ft. 6 in. apart, and are prolonged upwards, forming the ordinary frames of the walls. The central bulkhead between the transverse girders is stiffened by vertical "breathing" plates, which are well stiffened and connected to a longitudinal curtain plate. Outside this framing of breathing plates and longitudinal curtain plate, the pontoon deck and bottom are stiffened by longitudinal framings consisting of angles, connected to the transverse bulkhead stiffeners by gussets and diagonals. These framings extend to the line of the face of the wall. In the centre section several of these frames are provided with plates riveted to them, to take the load from the side keel-blocks. The intermediate longitudinal bulkheads are formed of vertical plates, intercostal between the transverse girders, to which they are attached, as they are also to the top and bottom plating. To facilitate the complete withdrawal of all water in the pontoon, shallow troughs are fitted, which form a gutter. The walls of the dock are placed horizontally and have a batter on the face or inside wall. The top deck of the walls is plated longitudinally, and is connected to the side plating by double-chine angles. An engine-deck, on which is placed all the machinery of the dock, is fitted about 16 ft. below the top deck, and is arranged water-tight. Each wall is divided, in addition to the joint chambers, into ten water-tight divisions by plate-bulkheads, coming in line with the bulkheads in the pontoon, of which they are a continuation. At each end of the wall a docking land is formed, on which the central portion can rest when being self-docked. The framing of the walls is of two types, braced and ordinary. In line with the transverse girders of the pontoons, of which they form a continuation, the frames consist of single angles stiffened by vertical web-plates, the front and back plates being cross-connected by a series of diagonals and gussets. The ordinary frames of the walls consist of single angles back and front, cross-connected by a series of horizontal struts. Special stiffening is fitted in way of machinery. About one foot below the top deck a running deck is provided for enabling ropes to be easily handled and run from one end of the dock to the other outside the stanchions. Timber-heads and such fittings required in berthing vessels are fitted on this deck. At a distance of about 15 feet and 29 feet respectively below the running deck, two further stages, known respectively as painting and shoring stages, are provided. Each end of the central section and each square end of the terminal sections are provided with a joint chamber, by means of which the sections can be joined together or parted. For the purpose of dealing with commercial vessels, which ordinarily will not have the weight or dimensions of the dreadnoughts, the dock has been designed so that it can work when required in two independent units of unequal size, and to facilitate the rapid connection of the two portions, cast-steel rocking joints, in the form of knuckles, are fitted at the level of the keel-blocks. The pumping installation of the dock is driven by steam generated in boilers carried on the dock itself. Each section of the dock has its own complete pumping installation, and each installation consists of two boilers and two engines and pumps installed in specially constructed chambers on one of the walls. The pumps, which are of the centrifugal type, 17 inches in diameter, are seated on a main drain at the bottom of the dock, which is continued over practically the whole length of each section. From the main-drain compartment pipes are led to each separate water-tight division of the dock. Each compartment is governed by its own separate valve, and the main inlet pipe and pump discharge pipe are governed by separate screw-down valves, and in addition have each a non-return flap-valve on the outside. The compartment valves of each section of the dock are all operated from a valve-house placed on the top deck of each section, by means of the Westinghouse electro-pneumatic system, which is based on the principle of operating presses by compressed air and controlling the same from a distance by means of valves operated by an electro-magnet. Each valve house is in telephonic communication with its respective engine-room and also with the others when the dock is working as a single unit. Each section of the dock is also provided with a direct-acting steam-pump, arranged to draw from the sea, and capable of providing a full stream of water for fire service or washing down vessels. These pumps are also connected to the main drain, so that they may be used as a drainage service for completely emptying the compartments. Two similar steam-pumps are also fitted on the opposite wall of the dock.

Steam heating is provided to prevent water in the compartments from freezing, and also for the mechanism that could be affected by frost. Each water-tight compartment is provided with the Gardner and Ferguson indicating system, to show, in the valve house, the level of the water inside it.

Similar gear is also provided for indicating the draft of water over the keel-blocks. The dock is provided with eight steam capstans, four on each wall. The spindles of the capstans are carried down vertically to the level of the pontoon deck, where, in a small chamber in the wall at this level, cable-lifters are fitted, so that the mooring cables may be hauled in or paid out when the dock is being moved about. Donkey boilers are provided on the wall remote from that in which the main boilers are fitted, to provide steam for the capstans and fire-pumps fitted on that wall. On the top deck of this wall a three-ton electric travelling gantry crane is fitted and arranged to traverse the whole length of the wall. At both ends of the combined dock a pair of flying gangways or swinging bridges are fitted, affording access from one wall to the other.

The dock will be lighted throughout the machinery compartments by means of electric lamps. The outside lighting consists of bracket standards, each supporting a cluster of lamps. Box terminals are also fitted on the walls, from which lamp clusters can be taken by flexible leads for lighting any particular portion of the ship on the dock. Electric current will be supplied through cables from the shore.

The dock is provided with the usual bollards and timber heads. Roller fenders are also fitted to protect the walls of the dock from an entering steamer. Eight mechanical side shores, four on each wall, are provided. These can be screwed in or out by a standard fitted in the top deck. Keel-blocks, side or docking keel-blocks, and bilge blocks are provided; the latter are arranged to pull in or out to suit the shape of the ship when she has taken the keel-blocks. The keel-blocks are strongly made and closely spaced, to enable them to take the weight of the heaviest and most modern ironclads. Ladders are fitted leading from the upper deck of the dock to the pontoon deck, and also into the various compartments of the dock. Suitable hand-rails are fitted all round the top deck. Ventilation by means of cowl and downcast pipes is arranged to each boiler and engine room, and also to the interior of the walls. A valve-house large enough to contain the valve-control table and the recording instruments is fitted on the top deck of each of the three sections; each valve-house contains the apparatus necessary for controlling the valves of its own particular section.

IRRIGATION LESSONS FROM THE OLD WORLD.*

By Sir William Wilcocks.

Living among Arabs for the last thirty years, I hesitated at first to say anything at this meeting, as they greatly respect silence in the East. "O man, God gave thee two feet, two hands, two ears, two eyes and one tongue, know thy destiny." However, I have remembered that I was born sixty years ago in a tent on an irrigation canal in Northern India, and have spent my life in those arid lands where, in ex-President Roosevelt's words, it is water and not land which measures production; and that therefore I might say something to-night on the subject of eastern irrigation.

The spirit of irrigation in the East is the spirit of the homestead. The intense cultivation, the need of many heads and many hands to weed, to care after live stock, to gather in the varied harvests, to manipulate delicately and to trim carefully, justify one in slightly changing the words of the Psalmist and saying that "irrigation and marriage meet together, children and prosperity kiss each other." Children in towns are a source of expense, on irrigation farms they are a source of wealth. In Egypt children four and five years old take out huge buffaloes to pasture and control them by a string tied to the horns and passed round one of the ears. Boys of eight and nine lead out sheep and guide them so that they clean the land of weeds and confirm the truth of that old English saying that "the feet of sheep are shod with gold." Girls and women cut and bring in clover, pick cotton, clear rice fields of weeds, prepare the fuel and look after the house. All are busy from morning to evening, and the larger the number of hands, the cleaner the crop and the more plentiful the yield. In the old world east a man is not considered fit to sit down among respectable people if he has passed a certain age and is unmarried. And although I did not know it then, I know it now, that it was this spirit of irrigation which prompted me in my younger and more romantic days to write down on the first page of my note book those delightful lines of Burns:

> "To make a happy fireside clime
> For weans and wife,
> Is the true pathos and sublime
> Of human life."

I know that in the younger West, book learning is considered the royal road to wisdom, even though it is only one child in ten who really benefits while nine are being brought up on indigestible mental food. In the old East, the brilliant children are allowed to learn books, while the others are brought up in intimate knowledge of their parents' professions. On farms where all the laborers are members of the house, there are none of the strikes, and none of the unrest in which the West lives and moves and has its being to-day. I was not surprised, therefore, to find that the home-loving Mormons had the only cozy, comfortable and settled villages I saw in Alberta. Raymond, Macgrath and Cardstone had a settled, sitting-down look about them which reminded me of villages in Egypt and India. I know that Mormonism has few friends in this country, but in all matters we should, I think, remember Shakespeare's sage words:

> "There is some soul of goodness in things evil
> Would men observingly distil it out."

* Paper read at the Sixth Annual Convention of the Western Canada Irrigation Association, Kelowna, B.C., August 13th to 16th, 1912.

We can even learn something from the Mormons, who are the nearest people here to the irrigators of the old eastern world. Their farmsteads are clustered together and they thus secure in the country some of those privileges which make town life so attractive. A man walks a little farther to work, and the ploughman homeward plods his weary way along a longer track, but then life is more sociable once he gets home. I wonder how many people in towns would drop in of afternoons and see each other if everyone had to walk across a square mile of country or half a square mile to see his or her neighbor. The solitary, homeless-looking houses which lay scattered over the bare veldt looked more like rogue elephants living their unsociable lives than anything I have seen in my life. Where I was straining my eyes for bunches of children, I saw only bunches of horses or bunches of pigs. And yet, you pay ten shillings a day for labor. Bunches of sturdy boys and girls are worth their weight in gold. While you people here are asking for colonists from home, the East produces its own colonists, better suited to the country and infinitely cheaper than imported labor.

A small, well-worked farm with irrigation pays much better than a large farm which cannot be kept in good tilth; and here comes the difficulty in this country with its severe winters. A farmer, however small he may be, could not exist in a farm house which cost less than, say £200 to build. Now, £200 spread over 160 acres is £1. 4. per acre, and spread over 40 acres is £5 per acre. It is the cost of the farmsteads which is the serious side of small farms in England and it is still more serious here. Agitators in England abuse both the English landlords and the so-called stupid agriculturists who stand by them, but the agriculturists know that it is not the price of the land, but the cost of the farm buildings which stand in the way of small holdings. Big holdings in irrigated land will be eaten up by their own weeds, and the only way to manage is with small holdings and comparatively expensive farm buildings. In Alberta the Canadian Pacific Railway charges very moderately for its irrigation water, but the price of the land is high for small holdings, and the rate of interest for borrowed money is excessive. Government land banks with very moderate rates of interest as they have them in paternal (falsely called retragrade) countries like Russia, are one of the needs of irrigated Canada. Such money would only be lent to bona fide settlers making themselves at home on their lands, and not to the "caterpillars of the commonwealth," who only buy either to half develop and then sell at a profit and clear out after skimming the cream off the lands by exhaustive crops, or to sit and wait for the unearned increment.

Rotation of crops and, whenever possible, the keeping of live stock, is the life of irrigated lands in the East. Cereal crops are always followed by leguminous crops. The leguminous crops are the mortal enemies of the weeds of the cereal crops and vice versâ. Good leguminous crops provide all the nitrogen required, while small quantities of superphosphate insure heavy yields of corn and tend to hurry up the ripening of the crop. Irrigated land in Egypt has been heavily cropped every year, and over large areas twice every year, and is as rich to-day as it was 7,000 years ago. Rotation of crops has secured this, backed up always with as many cows, sheep and poultry as the land can carry. The average holding of a well-to-do family in Egypt is two acres. When there is no work on the farm some members of the family are always working at earthwork or porterage somewhere. An entire family of men, women, children and a few donkeys will take a quarter of a mile of earthwork digging somewhere and finish it at some fixed rate and time. Seeing such folk one understands why Abraham's wealth was described as consisting of "man servants and he asses, female servants and she asses."

Every canal bank in India is a minature forest, and if the government forest department out here were to cover the banks of the canals in the bare and naked prairies with poplars, willows and suitable trees, the country would begin to look quite homelike. Wherever trees are growing in shingle they seem to flourish, and it has struck me that if holes some four feet deep were made with jumpers and filled with shingle and loose top soil and trees planted in them and watered once or twice they would soon have their roots comfortably housed out of the way of the frost. Lord Kelvin has proved at Glasgow that small meshed wire netting round a farmstead makes a better wind-break than any masonry wall, however high, and delicate plants can live behind it. I have promised my friends here to go to Glasgow as soon as I return to Liverpool and send them out full details of the netting Lord Kelvin has used. It might help many a farmer to secure a decent belt of trees round his farmstead.

All the regulating works on the rivers are much bolder here than in the East. When the welfare of millions of people is concerned we cannot afford to run any avoidable risks. Time alone can tell whether the boldness of the engineers here is justified or not. No one here has seen the tragedies the East has witnessed. In the Euphrates Valley I have walked down a canal 250 miles long, 400 feet wide, and 15 feet deep, which irrigated probably 1½ millions of acres of land, and where it is conjectured that over two millions of people must have died of hunger in a year or two when the head works holding up 30 feet of water on the Tigris River were swept away. By the time Canada is as densely peopled as that, the engineers will play for safety as we do in the East. None of our works on irrigation canals in the East are temporary. All the works are as solid and permanent as money can make them. We all say that the original works can be cheaply built in the dry; once the canal has begun to carry water and establish water duties, works are costly indeed and attended with risks.

The question of water rights has been settled in the East from the remotest antiquity. Water has attached to it duties as well as rights, and the state is the sole proprietor of every drop of water which flows in any stream, and of the channel in which the water flows, and it never concedes its rights to anyone. When Victor Emmanuel amalgamated all the Italian states, his government was face to face with hundreds of varieties of water rights by individuals and corporations. An ordinary man would have hesitated, but Count Cavour was no ordinary man. He was one of those strong men a country about to become great produces, just as coming events cast their shadows before. With a stroke of the pen the water was made the property of the state after the wise Eastern way, and commissions appointed to examine into and fix the compensation due to all holders of rights and patents. Modern Italy owes much of its prosperity to Count Cavour's action. If the government of British Columbia were to declare itself owner of all water rights and appoint a commission such as Count Cavour did to fix the compensation righteously due to concessionaires, you would settle this vexed question straight away and have time to devote your energies to new projects without any misgivings. I say it in no spirit of men-pleasing, but as a simple matter of fact, that your government in Canada enjoys such a reputation for honest dealing, and deservingly enjoys it, that you would in this country truly and righteously judge every case on its merits and no one would suffer any wrong. If Cavour inspired his generation with such a love of fair play that all the claims of Italy, and some of them were many hundreds of years old, were equitably settled; you men of northern blood would not be one whit behindhand.

In the East to-day all the land needed for future canals and drains is taken up and the works begun before irrigation water is allowed to enter the canals. If the drainage system of a country is suited to a rainfall of 16 inches and you make the rainfall equal to 40 inches by artificial irrigation you must make provision for this extra water in the drainage lines. When a man buys a plot of land here he signs an agreement to allow his neighbors a right-of-way for their irrigation water. He should also sign an agreement to allow his neighbors a right-of-way for their drainage water. It is only in this way that you will be able to exorcize the demon of alkali efflorescence which is ever ready to enter the plot of land out of which the demon of drought has been driven by artificial irrigation.

In the East the irrigation farmer levels his land with a care and skill which testify to his long experience of the value of an even grade for securing the maximum of yield from the minimum of water. The economy of water to be gained by good surface tilth the East is learning from you western farmers.

Mr. President, ladies and gentlemen, I thank you for listening to what I have had to say on this subject of irrigation, the oldest and youngest science of the world. Here, in this new country, in this 20th century, A.D., the words of this most ancient poem are as true to-day as they were over fifty centuries ago in far distant Babylonia:

> "O thou river, who didst bring forth all things
> When the great Gods dug thee out
> They set prosperity on thy banks."

WATER POWERS OF BRITISH COLUMBIA.

The water-power resources of British Columbia are being investigated by the Commission of Conservation, and the resulting information is to be published, as soon as it can be made available, in a report to be entitled, "The Water-Powers of Western Canada," which the Commission have in course of preparation.

The securing of even preliminary field information in a territory like British Columbia requires much more time than in a country less mountainous. Good progress, however, is being made. The British Columbia Government's Department of Lands, under the Hon. W. R. Ross, has made a substantial contribution to assist the Commission in its water-power research.

This practical assistance from the Department of Lands has enabled parties to be detailed for investigation on the mainland coast. These parties have been in the field since the beginning of August, and are being directed by the Commission's engineer, Arthur V. White, who is in charge of the work.

The Commisison has three field parties investigating the watershed of the Fraser River above Lillooet, extending to Tête Jaune Cache and westward beyond the Fraser Lake district.

To-day, if one views a map of British Columbia and asks what are the power possibilities of the interior of the province, no person can inform him. After the Commission has completed its present reconnaisance survey, it will be possible, first, to form some reliable conception of the water-powers of British Columbia south of the line of the Grand Trunk Pacific; then later on, the country north of the new transcontinental line will be canvassed for information respecting its water-powers. It is pioneer work, and, so to speak, blazes the trail for the capitalist and the engineer. To describe and draw attention to these blazed trails is part of the work the Commission aims to accomplish through its publications.

THE HARDINGE CONICAL MILL FOR FINE GRINDING.

By H. W. Hardinge.*

Crushing is not confined to the efforts of the metallurgist alone, but it has an equally wide range, or even wider range, as it finds its way into commercial industries, so numerous and varied that though we may have given years to the subject, in the same manner as have all metallurgical investigators, our learning is but slight.

Crushing or dividing may possibly be subject to two or three general mechanical principles. Dynamic action due to impact, when the energy forces rend along the lines of

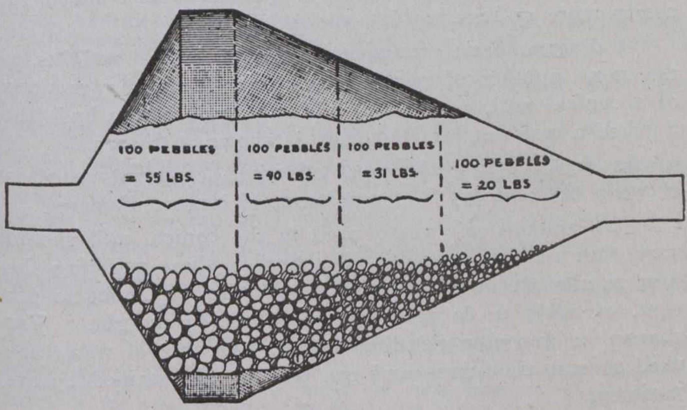


Fig. 1.

least cohesive resistance, or by pressure strains rending through slower separation of the crystals, deforming the mass; or by abrasion and separation from the surface inward. The first can be defined as a blow from a hammer, the second by compression in the jaws of a crusher, but the third is more difficult to define, because of its limited employment owing to its waste of energy, but might be likened to the wearing away of the faces of millstones. Nature in the manufacture of soil from the rocks has employed all three, but evidences would tend to show that in finest division she has been prodigal of her energy, for such fine division has been mainly produced through abrasion, except in the case of the chemical separation in the formation of the many clays. It is with this fine division that we, as metallurgists, are at present interested and how best economically it may be produced. For years the "California" stamp has been the most widely used device for the crushing of ores, and held its position in the first rank because fine grinding, as understood at present, was not a necessity, but with the advance from mechanical separation of the gold and silver content of ores, to that of chemical separation, the necessity for finer and finer grinding in order to liberate the mineral has progressed much faster than the mechanical means to do this fine grinding, so that to-day the stamp is slowly giving way to other applications of crushing energy. We very well remember when in 1895 and 1896 we were shown the first adaptation of the pebble or tube mill, and when told what it would do in the way of fine grinding, there was no hesitancy on our part in declaring that the claims were absurd, but shortly after the small mill was started, we were converted, and became the strongest of advocates of the pebble mill for still further reducing what at that time was considered fine grinding, mainly by stamps and rolls.

In this tube mill was a principal of step reduction not obtained by any mechanical device before that time. The stamp had reached its possible limit because it, with every blow, receded farther and farther from efficiency, owing to increasing disparity of size and weight, between reducer and particle. It has taken a long time to bring us to a recognition of the fact that to economize our energy, the units of force must correspond to the units of matter being acted upon. The well known rule of physics particularly applies here, i.e.: "Crushing strength of a body is in proportion to the area of its section."

We have many times been asked to explain the action within the conical mill, and the cause for its sizing action. Many articles have been written on the theory of the pebble and ball mill, which in turn have produced suggestions and practices resulting in changes of length, diameter, feed, discharge, speed of rotation, charge of pebbles, size of pebbles, etc.

Improvements have been left to the discretion of the machinery designer, who, as a rule, has but little knowledge of the specific technical requirements of the metallurgist, or of where the economic limit begins or ends. We could cite many instances where a lesser expenditure of energy would have improved metallurgical results, and it should be the aim of the metallurgist to fit his machinery to his ore, and not endeavor to adapt his ore to any specific machine. Realizing these conditions, we thought we saw in the conical form of mill a device which could be made more or less adjustable to many classes of ores—from granulation for concentration to sliming for cyanidation, for in the zone of largest diameter, we have all the features necessary for the greatest application of energy, e.g., the largest pebbles or balls, the greatest superincumbent weights, the greatest height of fall and impact due to greatest peripheral speed, and in this zone is found the largest particles of material to be reduced, thus admitting of a much coarser feed than would otherwise be possible if the crushing forces were not segregated. After a first division or reduction, these par-

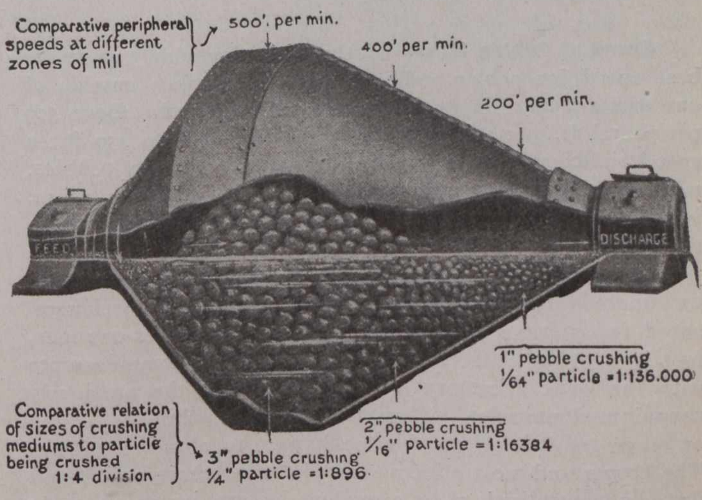


Fig. 2.

ticles, through the action of the displacement, dependent upon their relative mass, travel up the cone, through constantly decreasing zones of size and weight of crushing bodies as well as decreasing energy due to reduction of peripheral rotation speed proportionate to the division of the particles in passing through successive zones, as illustrated in Fig. 1.

In addition to the automatic adjustments of work to mechanical energy, the device is subject to a still further regulation by changing the axis from the horizontal to

* Abstract of paper presented at Toronto meeting of the Canadian Mining Institute.

different inclinations from the horizontal, which will cause the finer particles to travel toward the outlet much more rapidly, and consequently be subject to lesser action of the grinding bodies than when in the horizontal position, which latter position is assumed for the finer grinding. The working machine is provided with means for making these different adjustments.

For very fine grinding, it is found advisable to elongate the cylindrical portion.

Even the conical mill, subject as it is to varying adjustments, produces vastly different capacity results when working on different ores, as will be seen by comparing the following performance of 8-ft. Hardinge mills operating under similar conditions of power, pebble charge, r.p.m., etc., in three of the largest concentrating plants in the United States, under the supervision of experts of the highest metallurgical order, and though of widely different capacities, as shown, each plant manager reports the results as highly satisfactory.

Mesh	On 40	On 60	On 80	On 100	On 200	Through 200	Tons per 24 hours.
	Per cent.						
Calumet & Hecla Mining Co.	2.0	2.1	6.5	6.0	43.0	40.8	45.0
Federal Mining & Smelting Co.	4.0	7.5	7.0	10.5	18.0	53.0	98.4
Miami Copper Co.	16.0	15.5	8.9	7.7	13.8	38.1	180.0

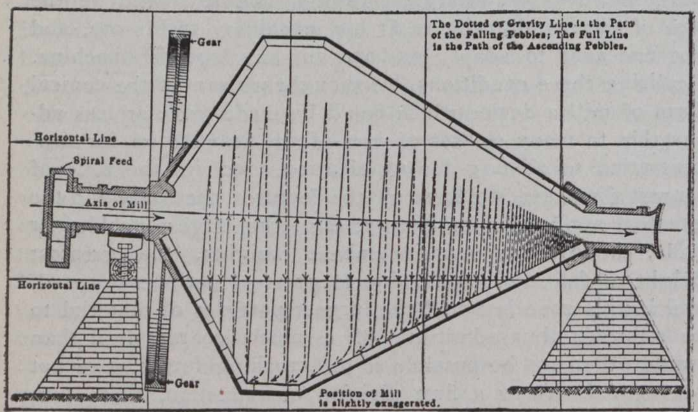


Fig. 3.

Speed of Pebble Mills.—Authorities vary widely as to the best speed for pebble mills, but in no instance outside of our own practice do we know of their being run above 500 peripheral ft. per minute, but range from 400 to 450 ft., a speed sufficient only for a free movement of the pebbles, while in the conical mill we find the most effective r.p.m. is one which will give 560 ft. at the largest diameter where the greatest work is being done by the largest pebbles on the largest particles, producing a cascading effect, relative to hundreds of small stamps. This maximum of peripheral speed and energy force gradually reduces, in stages or zones, foot by foot until its effective action is fairly commensurate with the work necessary to further divide the previously comminuted particles. Thus in the one machine is a step or stage reduction from kinetic impact to abrasive rolling. The proper and most effective speed is one where centrifugal force is neutralized, then overcome by gravity at about 60 deg. from the horizontal. This "proper speed" is again dependent upon the "mesh" of the material fed, for where same is minus 30, impactive action may not be necessary.

In the case of the conical mill the material undergoing division automatically travels forward at each reduction as though actuated by an Archimedes screw, up and out the cone, while in the older style of cylindrical mill, of equal dimensions throughout its length, the travel is dependent upon displacement by the feed and the passage through the same varying sizes of pebbles from end to end.

Perhaps the main causes for this sizing and step reduction action can be explained by the following diagram (Fig. 3) in which it is shown that when the mill is operated on an inclination from the horizontal the charge is lifted at right angles to the axis, but in falling drops under the action of gravity, vertically and at an angle to the line of lift. The larger particles undergoing disintegration, according to respective mass content, will fall faster than the finer particles which must then, due to displacement, find a position nearer the outlet end of the mill. The material as well as the grinding bodies, through the acceleration due to their mass in falling, reach the lining of mill and continue a course down the cone or inclined surface, toward the larger diameter, forming more or less of a triangular line of travel. The finer particles, according to their size and, therefore, friction surface presented, are retarded in their travel down the cone by surface friction and tend to arrange themselves in zones or classified areas. It is to this zigzag action within the mill that the discharge of material as crushed becomes more or less positive and automatic.

A diagrammatic representation of the actual weights of the same number of pebbles, shovelled from four sections of a conical mill, as reported by an engineer who had just finished a test run for efficiency, is shown in Fig. 3.

In dry grinding the most effective peripheral speed is between 625 and 675 ft. per minute, of largest diameter.

The amount of water used in the conical mill should vary with results desired. For fine or slime grinding the best results are obtained with a relation of about 40 per cent. of water to 60 per cent. of solids, by weight. For coarser or granular grinding greater amounts of water are used to suit conditions and can only be ascertained by experiment.

The following results taken from screen tests covering a period of several days, operating with different amounts of water and inclinations of mill, upon the same (composite) mesh and weight of feed, will give a fair idea of possible results which may be obtained in the one mill:

Mesh	% on 8	% on 20	% on 40	% on 60	% on 80	% on 100	% through 100
Heads	16.7	51.I	13.9	6.8	4.4	3.0	7.0
Tails of 1st test	......	4.8	9.8	22.8	22.3	0.9	39.0
Tails of 2d test	......	......	I.3	8.0	27.5	2.5	60.0
Tails of 3d test	......	......	......	I.4	10.0	2.0	87.0

Lining.—The pebble mills are lined with silex blocks throughout or a combination of silex and ribbed steel or iron plates, the plates being fitted with a lifting bar of special design, which not only assists in lifting the mass of pebbles higher, affording greater impact in the central portion of the mill, but also prevents a slipping of the charge.

The conical ball mill is lined, as are the other types of ball mill, with steel plates, and various sizes of steel balls are employed to break up the ore or other material undergoing disintegration. Herein comes again the principle of the stage reduction, in that the balls in weight are approximately relative to the size of particle undergoing division, and automatically take positions in the mill relative to size and diameter of cone. To operate a ball mill of this type to best advantage, the preliminary feed should be reduced by rock crusher so that the largest pieces will not exceed 1½ to 2 ft., or a relative weight to the crushing body of approximately 50:1.

Survey is being made for an electric line from Port Haney, on the main line of the Canadian Pacific Railway 26 miles east of Vancouver, and also on the Fraser River, to Lillooet Lake. It is presumed that this is being carried on by the British Columbia Electric which has water rights on the river and lake, and which it will develop. This company is rapidly extending its interests on the lower mainland and at Victoria.

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THE MONTREAL HARBOR.

The Montreal harbor, as the gateway to Canada, is our most important port. The marine traffic of the port of Montreal comes second only to that of the port of New York among all the ocean ports of North America. The Harbor Commissioners have had in view the necessity for providing adequate facilities for taking care of the traffic flowing through the port. The government has been generous in the past in providing funds for the improvement of the St. Lawrence River channel and for placing the harbor in shape to compete with the ports in the United States. A great portion of the export traffic from Montreal is grain, and it is, therefore, necessary to provide plant for the unloading of the railway cars, capacity for the quick unloading of inland vessels, storage capacity for grain to eliminate the necessity for direct and almost direct transfer of inland cargoes to ocean vessels, and facilities for shipping grain from the elevators. In this issue of *The Canadian Engineer* will be found a description of the new grain elevator at Montreal, which has just been finished, having a total capacity of 2,622,000 bushels. The elevator represents the most modern design and development in this type of construction, and reflects a good deal of credit upon the Harbor Commissioners and the constructing engineers. It will, no doubt, have a thorough trial of its efficiency this coming season, and should do much towards relieving the congestion of last season.

OPERATING RESULTS OF A DOUBLE-DECK STREET CAR.

We noted in the issue of August 29th the introduction of the double-deck street car into the transportation question of some of the larger American cities. Operating results on the Pittsburg double-deck car have been published, and, while these are only preliminary, as the car has been in service only for a month, they throw some interesting light on the ability of this type of car to handle traffic under city conditions without confusion in boarding and alighting, and without the slowing down of schedule speeds. The car is an open trailer, built single-ended for trial use, and the separate entrance and exit doorways are equipped with plain, swinging half-doors. These doors, however, have been re-designed, for a quick-acting door materially cuts down the delay in loading and unloading. The results so far indicate that for handling heavy traffic, where people are loaded at one point and are unloaded within a restricted area, having comparatively few stopping points, the car is undoubtedly a success. This applies especially to the case in which very large crowds have to be moved to or away from ball parks or racetracks, or where large factory forces are leaving their work, so that the entire load is presented at practically the same time.

THE DESIGN OF IRRIGATION WORKS.

In his address to the sixth annual convention of the Western Canada Irrigation Association, Sir William Willcocks laid emphasis, among other things, on the boldness of the design of engineering structures in Western Canada. Sir William Willcocks, in addition to being a noted irrigationist, is the designer of the

Asouan Dam. He states that all the regulating works on the western streams are not so conservatively designed here as in the East. He adds that where the welfare of millions of people is concerned the engineer in the East cannot afford to run any risk; time alone will show whether the boldness of the engineers in Canada is justified or not. His statements are exceedingly interesting and deserve careful attention. It is true that irrigation conditions in Western Canada are very different from the far East. At the same time Sir William sounds a note of warning which should not be disregarded. It is perfectly right and proper to design economically, but where it is a question of safety or economy, safety, of course, must rule. He states truly when he says that the original works can be cheaply built in the dry; once the canal has begun to carry water and establish water duties, works are costly, indeed, and attended with risk.

THE AMERICAN ROAD CONGRESS.

The American Road Congress in Atlantic City this week will bring together everybody interested in the improvement of highways, from national and State officials down to the taxpayer. In fact, this last-named attendant will be particularly welcomed, for his vote decides the question of improvement, and one object of the Congress is to give him information which will enable him to reach a wise decision. The importance of good engineering and good contracting on road improvements will assume large proportions in his mind when the taxpayer learns how essential these factors are to the economical use of the money he furnishes. He does not appreciate this yet, and he is in danger of being misled by enthusiasts whose knowledge is not much greater than his own. At the Congress will gather the experts who have made a scientific study of road-building, the administrative officers in charge of the work, the users of roads who realize the necessity of intelligent improvement and adequate maintenance, and the men who produce the materials and machinery used in road-building. The original plans were developed jointly by the four national organizations representing those who foot the bills, the builders, the users, and the material and machinery manufacturers. Later, the road-builders' organization decided to withdraw. It is unfortunate that all of the organizations in the road congress coalition formed last year could not hold together, and so concentrate their efforts for the good of a cause which is more important than the individuality or advantage of any organization. However, the gap left by the withdrawal of the road-builders' association was taken by a number of its leading members and other prominent specialists, so that no change in the Congress programme originally announced has been necessary. A feature of the Congress which is likely to be particularly instructive is the exhibition in which the United States government, numerous States and the manufacturers of machinery and materials will cooperate. The details of this display have been worked out so completely, and the exhibits are so varied that it seems certain the result will excel anything previously accomplished, even at the Brussels Exposition two years ago. Relatively few people, even among civil engineers, have a true appreciation of the extent of the road-building industry, and this exhibition will, therefore, emphasize the importance of the proceedings of the Congress by demonstrating the magnitude of the interests engaged in highway improvements.

THE LAUNCH OF H.M.S. "AUDACIOUS."

One of the most interesting naval events of the year has just taken place at Birkenhead, England, where the new battleship of the super-dreadnought type, H.M.S. "Audacious" was successfully launched by the Countess of Lytton from the yards of the shipbuilding firm of Messrs. Cammell, Laird & Company. It is one of the most powerful ships under construction, and naturally attracted many people from all over the British Isles to witness the ceremony, and it was necessary for a special train to leave London in order to convey some of the 1,100 guests of the company.

Canada was represented by Colonel Sam. Hughes, Minister of Militia and Defence, who the night before had just returned from the French Manoeuvres, and who, the following week, was to be the guest of the King at the military manoeuvres, which this year were carried out near Cambridge.

As is the case at the launch of all units of the Royal navy, a religious service took place, after which Lady Lytton severed the silken cord with an ornamental axe of free rennaissance character, that had been specially designed, and the great vessel glided slowly into its native element.

The event was witnessed by many thousands of spectators, who crowded every vantage point, and thronged the special patforms that had been erected.

The chairman, Mr. W. Hichens, in his speech, made some interesting comparisons. He said:

"The present ship is not the first of that name in the annals of the British navy. So far as I know there have been two others. The first was a wooden frigate of 1,624 tons and 168 feet in length, built during the reign of George III. The second was built in 1869. She was an iron cased vessel of 3,774 tons and 280 feet in length. The present 'Audacious' would hold two comfortably, being 550 feet long and having a displacement of 23,000 tons."

The representative of the Admiralty, Captain H. B. Pellay, M.V.O., R.N., made another interesting comparison when he pointed out that a projectile from one of the 13.5 guns of the "Audacious" was heavier than the whole broadside of H.M.S. "Victory," of 1805.

H.M.S. "Audacious" is of the same type as H.M.S. "King George V.," and the group, when completed of the four vessels, will be the "King George V.," the "Centurion," the "Ajax," and the "Audacious."

The type is an improvement on the battleships of the "Orion" class, although similar in design generally. Whereas the "Orion" and her sisters have a displacement of 22,500 tons, the class to which the "Audacious" belongs displaces slightly over 23,000 tons, and has a length of 555 feet, as compared with 545 feet, with a beam of 89 feet, which is slightly in excess of the 88½ feet of the other class.

The Propelling machinery, as in the case of the Dreadnoughts, consists of Parson's turbines with Yarrow type boilers. There are to be ten 13.5 inch guns mounted in five turrets on the centre line of the ship, while the guns for repelling torpedo attack are twenty of 4-inch calibre, that is four more than in the "Orion" class.

It is a notable feature in connection with this vessel that the armour plate is of exceptional thickness and this is already at the dock waiting to be placed in position, now that the launch has been successfully carried out.

Two interesting facts came to light in connection with the firm of Messrs. Cammell, Laird & Company in that they were the owners of the "Sirius," which was the first steamship to cross to New York, and in 1834-5 they built two iron steamers for the Honorable East India Company for the exploration of the River Euphrates.

TESTING NEW CAST-IRON WATER PIPE LINES FOR LEAKAGE.

The methods for testing new cast iron water pipe lines for leakage and the amount of leakage to be expected on good work, was discussed by E. G. Bradbury, of Columbus, Ohio, in a paper read before the Ohio Engineering Society, and published in the proceedings of the Society for 1912. A brief abstract of the paper follows:

A discussion of the methods of testing new lines of cast iron pipe for leakage, and an estimate of the amount of leakage to be expected in well laid lines, was given in a paper by E. G. Bradbury, of Columbus, Ohio, before the Ohio Engineering Society. The paper which is published in full in the Proceedings of the Society for 1912 is here briefly abstracted.

From experience with a number of pipe systems, the writer has become convinced that under ordinary conditions of pipe laying it is improbable that the leakage in a new system will be greatly less than 3,000 gals. per mile daily unless the same is carefully tested and all defects remedied. By testing in the open trench, under a pressure of at least 50 per cent. in excess of the maximum static pressure expected in the pipe, recalking all dripping joints and replacing defective pipe, it is possible to reduce leakage to an extremely low amount.

Reliance cannot be placed on the behavior of the pressure gauge in judging of the tightness of pipe. The gauge may, under certain conditions, drop rapidly when there is no leakage, owing to failure of the gates to close with absolute tightness, or perhaps to air contraction or absorption. It may stand up fairly well to pressure when there is considerable loss, if a large amount of air has become entrapped, and has reached its minimum volume.

Water is reduced by 1/21740 of its volume per atmosphere. Assuming the case of a 6-in. pipe of 1,000 ft. long as representing the average section under test, the volume of water contained is 1,470 gals., if the pipe is completely filled. If this water is under pressure, 1470/21740 or .065 gals. must be lost in order that the pressure may drop 15 lbs. Experiments by the writer indicate that 16,000 drops from metallic surfaces are approximately equal to 1 gal., and on this basis 70 drops would necessarily escape from the pipe referred to for each loss of 1 lb. pressure. With first-class calking, when the men know the work is to be tested in open trench, the average loss from 1,000 ft. of pipe before testing is about 200 drops per minute equivalent to about 90 gals. per mile per day. By going over the joints leakage may be reduced to a point where there is no visible dropping or escape of water, and pressure can then be maintained for a considerable length of time, if the pipe is free from air.

If there is air contained in the pipe, it is often impossible to maintain pressure. This may be due to any or all of the following causes: Air will undoubtedly escape through minute crevices that cannot be penetrated by water. In the compression of air heat is generated, expanding the air, and in the cooling process following, the air necessarily contracts and a loss of pressure results. To what extent this takes place in the comparatively slow process of increasing the pressure in a pipe test, or in other words whether all of the heat is radiated during the process of compression, is not known, but in view of the fact that air compressed to 150 lbs., and not cooled, is increased over 500 deg. F., and has a volume practically double that of the same air under the same pressure after cooling, it is possible that some slight action of this nature may occur. Further, as the pressure is thus reduced, the natural tendency is for the air to lose more of its heat, inducing further contraction. It is also probable that there may be an absorption of the elements of the air by the water. The amount of gas absorbed by water at a given temperature, is a function of the volume, regardless of pressure, and the weight of gas absorbed is therefore proportional to the pressure. Variation of temperature also effects absorption. A very complex action must necessarily result from these conditions, but the general tendency of the several factors is in the direction of reduction in volume of the pipe, with consequent loss of pressure. It is never possible to maintain pressure in a test made immediately after filling the pipe as well as a few hours later. This is undoubtedly partly, and in some cases wholly, due to the absorption of water by the yarn in the joints, but if air is present it often contributes to the trouble.

In reports descriptive of tests of this nature, appear frequent references to the difficulty of obtaining anything like uniform results with the pressure gauge, and the loss of presure often observed where no leakage is apparent is the occasion of considerable surprise. The writer is convinced that if all air is excluded from the pipes and all joints kept visible during the test this phenomenon will disappear. Owing, however, to the difficulty of getting rid of the air this is not always feasible in practice. Excellent results may be obtained, regardless of the behavior of the gauge, if all parts of the pipe are inspected under pressure and all visible leaks stopped. This method also eliminates possible trouble from minute gate leakage.

During the summer of 1911 the attention of the writer was particularly called to the subject of this paper by his connection, as designing and supervising engineer, with the water distributing system of the village of Grandview Heights, Ohio, a suburb of the city of Columbus. An arrangement was made by this village to purchase filtered water from the Columbus water works at a net price of $1.20 per 1,000 cu. ft. The necessity for the tightest possible work was obvious and specifications were drawn requiring that all pipe be tested in the open trench, under a pressure of 150 lbs., to the satisfaction of the engineer. The system comprises 5,719 ft. of 12-in. pipe, 7,701 ft. of 8-in., 16,508 ft. of 6-in. 75 valves, 36 hydrants and 2 air valves. Every section of pipe was tested and gone over until no evidence of leakage was visible with all pipe exposed. The record of tests shows that in many cases gauge pressure could not be held, though every pipe and joint was in plain sight and no leakage could be located.

After completion a number of observations of the water entering the system were made by means of a 1-in. meter. Two service pipes were connected with the system during these tests. The amount passing the meter varied, the minimum being 10 and the average 25 cu. ft. per day. It is perhaps not unreasonable to assume that the minimum metered quantity for one day expresses the leakage from the system, but the average figure was taken. The working pressure on the system varies from 45 to 90 lbs., averaging about 65.

On the completion of the system a 6-in. meter was installed at the Columbus water works pumping station for the measurement of all water sold to the village. This meter was new and was carefully tested by the city department and stated to register accurately down to the smallest stream provided by their testing apparatus, namely 1/32 in. It is, however, probable that there would be some under-registration in case of very small flow. During the first month's operation but two services were connected, and the quantity of water registered by the meter was 600 cu. ft., equal to a little less than 27 gals. per mile per day, including whatever may have been used by the two consumers. Soon after this 80 taps were made. After an interval of about two months the city meter and all individual meters were read. The amount of water passing the 6-in. meter for the period of 58 days was 46,600 cu. ft. and the sum of the readings of the house meters was 39,300 cu. ft. During this period an extension of 550 ft. was made and water was used to settle the trench to the amount of 1,200 cu. ft., leaving a quantity unaccounted for of 100 cu. ft. or 2.3 gals. per day per mile. The amount of water supplied to the village was equal to 17.5 gals. per consumer per day, figuring on the average number connected for the entire period. The population is suburban, and the use purely domestic. The writer believes that few complete systems have been installed with as low a leakage as this.

The value to this municipality of a tight system is, of course, much greater than to cities pumping their own water, the net cost of water being slightly over $0.16 per 1,000 gals.; for each 1,000 gals. per day per mile lost, the actual cost is about $320 per year, which, capitalized at 4 per cent., amounts to an investment of $8,000, or, in other words, if the system had a leakage of 1,000 gals. per day per mile (which is considerably below the probable average in similar systems) the village could afford to spend $8,000 if, by so doing, the leakage could be reduced to the present amount.

The value of tight water pipes to a city pumping its own supply is less readily computed. Fixed charges, attendance, etc., are not materially affected by moderate leakage, except as additional capacity is required at an earlier date. The fuel bill, and, in case of treated water, some items of the cost of purification, are chargeable in proper proportion to such leakage as may exist. It may safely be stated that the cost of careful inspection and testing is always more than justified by the saving that can be accomplished.

Regarding the amount of leakage permissible in new work, general practice would appear to justify anywhere from 60 to 250 gals. per day per mile per inch of diameter. Loweth proposes 60 to 80 gals. per inch-mile. Gregory, in the improvements to the Columbus water supply, specifies the limits of allowable leakage, under about 110 lbs. pressure, given in Table I.

Table I.

Size, ins.	Leakage allowable, gals. per hour per lin. ft.	Equivalent in gals. per 24 hours per mile.	Gals. per 24 hours per inch mile.
20	0.08	10,138	507
24	0.10	12,672	528
36	0.15	19,008	528

These requirements would seem to lean far toward liberality. The writer is of opinion that except under particularly unfavorable conditions, it is possible to reduce the loss to a very low figure—so low indeed as to be almost negligible. Open trench testing, as above described, and rigid insistence on the closing of all visible leaks will accomplish this result, and by no other means can it be done. It is better to specify this test than to state figures of permissible leakage, as results far better than one would feel justified in specifying are possible, and it is impossible to demand better work than required by the specifications.

NICKEL IN CANADA.

Canada to-day produces about 90 per cent. of the world's supply of nickel. Practically all of the remainder comes from New Caledonia, an island in the south-western Pacific controlled by France.

In 1910 the value of nickel ore and matte exported from Canada to the United States was approximately $3,450,000. As the only refineries in America are in the United States, nearly six-sevenths of the Canadian nickel was refined to the south of the border. The refining process raised the value of this Canadian ore to nearly $12,000,000. The major portion of this refined nickel is used in the manufature of nickel steel.

RAILROAD RATES

"The only just method of determining the reasonableness of transportation charges is to measure them by the service performed." That was a recent statement of Mr. W. W. Finney, president of the Southern Railway Company. "This is all right as far as it goes," replied a newspaper editorial, "but will not Mr. Finney tell us how to apply this yardstick?" Subsequently, the railroad president did so, and in response to a request, he has forwarded his views on the matter

At the outset, he says, it should be borne in mind that the railways of the United States—although public highways, and, as such, properly subject to such governmental regulation as will insure to all citizens equality of rights on them, under similar circumstances and conditions, and as will prevent unreasonable or extortionate charges—have, nevertheless, been built with private capital and are the private property of their owners.

It is a fundamental economic truth that the investment of funds in any class of property is dependent on the safety of the principal and the rate of profit that may be expected as compared with the rate that can be earned on investments in other kinds of business. In other words, the flow of capital into any particular business will be retarded unless it may be expected to earn a reasonable profit as compared with the earnings of capital in other enterprises.

The question of what is a reasonable charge for a specific service is complicated by the fact that neither as a matter of transportation policy or of public policy can charges on all classes of traffic be uniform. Commodities of great weight or bulk in proportion to their value must be carried at rates substantially lower than those which may properly be charged for the carriage of commodities which are of high value in proportion to their weight or bulk.

As a result of the necessity for different rates on different classes of commodities, each individual rate or each rate applying to a class of commodities must be considered on its merits in its relation to the particular service performed. The cost of performing the service, as nearly as it can be ascertained, must certainly be taken into consideration. No rate should be made so low as not to pay something more than what Mr. Acworth, the eminent English economist, has aptly termed "the actual out-of-pocket cost" of moving that particular traffic. If it pays this cost and contributes, even in a small measure, toward the general expenses and fixed charges of the carrier, it is a profitable rate, provided the carrier has a considerable volume of traffic moving at higher rates. The low-class traffic moved at these low rates is not a burden on the higher-class traffic, for, by just so much as it contributes to general expenses and fixed charges, it reduces the amount which the higher-class traffic must contribute. In practical rate-making the question of the cost of the service has a controlling bearing only as determining the level below which a rate can not properly be made.

The value of the service is another important factor in rate making and in determining the reasonableness of a rate that may be challenged. Transportation enables those engaged in any given industry to carry on their business in those localities best suited for it and to market elsewhere the surplus not needed for consumption at the point of production. By moving commodities from places where the supply exceeds the local demand to places where they are scarce and are wanted, additional value is given to the whole volume of production—including the proportion consumed locally, as well as to that carried to other markets. As affecting the consumer of, let us say, cotton goods—by way of illustration

—the carriage of the raw cotton to the mill and the transportation of the finished goods to his market, is a process of production. This transportation gives added value to the raw cotton produced on the farm and to the goods procured in the cotton mill, and the carrier is, therefore, entitled to fair recognition for its service in the process of producing the finished cloth and placing it in the hands of consumers, just the same as is the farmer and the cotton mill owner.

The increased value given to a commodity by transporttion is the measure of the value of the service to the owner of the commodity. It is not, however, the absolute measure of a reasonable rate, for, if the transportation charges were so high as to absorb all of this increased value, the owner would have no incentive to ship and the traffic would not move. This may be illustrated by referring to the rail movement of a very low-grade commodity, such as ordinary sand —a commodity which is found in abundance in most localities and the value of which, generally speaking, can be very little increased by transportation. It is manifest that it would be impossible to make a practical rate on sand for any such distance as from Philadelphia to Chicago, for the reason that the out-of-pocket cost of performing the service would be far in excess of the value of the service to the shipper.

As transportation has contributed all of the increased value which is given a commodity by its carriage to market, which, as we have seen, is a factor in effective production, the carrier is entitled to a reasonable share of that increase. The value of the service is, therefore, a most important factor in determining what is a reasonable charge for a specific transaction. Out of the intimate relation of the cost of the service and the value of the service to the reasonableness of a transportation charge grows the fact that, in an era of generally advancing prices, when both the cost of the service and the value of the service are increasing, the level of the reasonable charge for the service thus affected also advances.

In determining the proportion of the value of the service which the carrier may reasonably and justly charge for its part in creating that value, intelligent consideration must be given to comparison with rates charged by the carrier for other similar services, to comparison with the rates of competing carriers, to comparison with the rates at which carriers in other localities move the same commodity under similar circumstances and conditions, to comparison with the rates on similar commodities which might be substituted in use for the one in question, to the intrinsic value of the commodity, to the risk of breakage or other injury in transit, to the insurance risk, to the effect of the rate on the volume of traffic, and to the general condition of the business to which the special traffic is related. When the reasonableness of a rate is called into question, consideration and great weight must be given to expert testimony.

Of all these guides for determining the reasonableness of a specific rate, the effect on traffic is perhaps the most important, for an increasing volume of traffic is prima facie and almost conclusive, evidence that the rate is not unreasonably high, though it may be unreasonably low.

It will be seen that, in the final analysis, the reasonableness of a transportation charge is largely a matter of expert judgment. So is the reasonableness of any price or charge that may be called into question. If one of you employs a lawyer, without any agreement as to what his fee shall be, and, after the service has been performed, you decline to pay his bill on the ground that it is too high, he sues you for the amount of his bill. The question raised is what would constitute a reasonable charge for the service performed, and, on this, testimony will be introduced to show, primarily and principally, the value of the service to you. Testimony will also be presented as to the usual fees which this lawyer and other lawyers receive for similar services, as to the amount of time consumed, and the skill which he displayed in rendering the service. Based on this testimony the jury will form a judgment as to what is a reasonable charge for the specific service performed.

The same method is followed in condemnation proceedings when a railway company seeks to acquire land for railway purposes and fails to reach an agreement with the owner as to the price to be paid. The question here presented is as to the fair and reasonable present value of the land to its owner and as to the fair and reasonable amount to be allowed him for the damage, if any, that may result to his remaining property by the construction of a railway through it. Evidence will be considered as to the value of that particular strip of land, as to the profitableness of the uses to which it has been put by its owner or of the uses to which it might be put. Evidence will also be considered as to the prices at which other tracts of land in the same locality have been sold, and on all these points expert testimony will be considered. The amount which the owner paid for the land, if bought sufficiently near the time of condemnation to be pertinent, may be introduced in evidence and will be considered, but it is not controlling on the jury, which, from all the evidence introduced, must determine what is the just and reasonable compensation to its owner at the particular time when it is taken.

RAILROAD EARNINGS.

The following are the railroad earnings for the week ended September 7th:—

	1911.	1912.	Increase or decrease.
C.P.R.	$2,230,000	$2,649,000	+ $419,000
G.T.R.	1,033,652	1,082,457	+ 48,805
C.N.R.	336,500	376,400	+ 39,900
T. & N.O.R.	39,787	29,610	— 10,177
Halifax Electric	8,553	5,627	— 2,925

The Canadian Northern Railway earnings and expenses for August with comparisons were as follows:—

	August. 1912.	August. 1911.	Increase.
Gross earnings	$1,745,800	$1,420,600	$325,200
Expenses	1,375,000	1,105,900	269,100
Net earnings	370,800	314,700	56,100
Mileage in operation	4,297	3,711	586

For the months of July and August net earnings of the road increased $189,100 over the same two months of 1911.

From July 1st to date gross earnings were $4,720,400, an increase of $753,500.

The net earnings of the Toronto and Northero Ontario Railway from the beginning of the financial year, November 1st, to the end of June, as reported to the provincial treasurer, have been $350,022, as against $314,814 for the same period last year. The gross receipts have been $1,178,839 against $1,024,382 for the same months of last year. The net earnings include or royalties of $98,436 this year, compared with $18,391 from the same source last year.

The increase in mileage for the period of nine months has been 264.24. The mileage increase last year in the same period was 174.28. The ore royalties for June this year were $26,427, while a year ago in the same month the ore royalties were nothing.

INSURING SOUNDNESS IN STEEL RAILS.*

By Robert W. Hunt.

While steel rails have been of great scientific and engineering interest from the day of their first experimental use, and much literature has been written upon them, there has never been a time, at least in America, when matters relating to their manufacture and service have received as much public and even governmental attention as during the past two years. I have been actively identified with the manufacture of steel rails from the rolling of the first commercial order for them in America up to and including the present time. As a steel maker I became thoroughly familiar with the theoretical and practical details of the business; and later, as a consulting engineer and inspector of all steel products, and especially of steel rails, I have endeavored to keep in touch with and cognizant of everything relating to the art.

All steel rails are made from steel ingots. Steel ingots are formed by pouring or casting liquid steel into cast iron ingot molds. The larger the cross section and the greater the length of the ingots, the greater the difficulty in obtaining sound castings, i.e., sound and homogeneous ingots. Without sound and homogeneous ingots it is impossible to produce sound and homogeneous rails; and, unfortunately, the most important unsoundness will be first in the centre of the ingot, and last in the centre of the rails produced from it, where it is frequently impossible to detect without destroying the rails. The large tonnage in each heat of rail steel (whether made in Bessemer converters or in open-hearth furnaces) under present mill practice, necessitates the casting of ingots of large cross-section and long enough to make several rails.

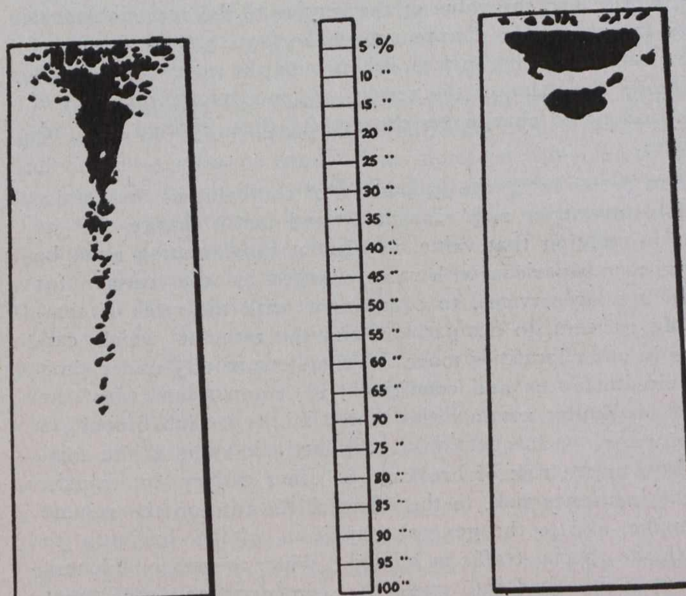
It is a long-known fact that the greater the mass of steel in a casting, the greater the tendency of the metalloids (carbon, phosphorus, sulphur and silicon, and particularly the hardening metalloids, phosphorus and carbon) to segregate at the part of the casting where the metal remains longest liquid, which, under normal conditions, is at the centre and toward the top of the mass. Again, it has long been known that the necessary cooling of the metal from the outside inward causes a contraction which results in the formation of a cavity or "pipe," which defect is increased by hasty and uncontrolled casting of the molten steel into ingot molds. Over twenty years ago Robert Forsyth, then chief engineer and manager of the Union Steel Company, Chicago, Ill., demonstrated that if rail-steel ingots were laid on their sides before the interior steel had set, the pipe would not be formed in the middle of the top end of the ingot, but upon the upper side and liable to extend toward the bottom end; and that, therefore, ingots should be left standing in a vertical position until the interior metal had solidified. (Journal of the Franklin Institute, Vol. 127, May, 1889).

Much time, labor and money have been expended in seeking to overcome the piping and segregation in ingots without greatly increasing the cost of production through expense of operation, lessening product, etc. Technically several of the schemes have given good results, but they require increased cost of manipulation, and, most serious of all, more time. Unfortunately for success in casting sound ingots, modern practice has been in the direction of larger heats of steel, and it is easy to appreciate that with a casting ladle containing up to 100 tons of liquid steel, much if any control of the stream flowing through its nozzle is an impossibility. Therefore, the soundness of the resulting ingots is a matter entirely independent of the personal skill of the workmen. However, while the efforts to produce sound ingots have not been generally commercially successful, I am loath to believe that the difficulties will never be overcome. Such has not been the spirit under which the great successes of the past were accomplished, and I do not think it now exists. If a positive necessity for sound ingots be commercially established, a commercial way to produce them will be found.

As the general existing conditions produce ingots with the most undesirable steel in their upper part, it has been and is the practice in manufacturing steel locomotive tires, ordnance forgings, armor plate, large steel shaftings and other what are termed high-grade products, to reject arbitrarily at least the upper one-third of the ingot. It is true that even so great a discard will not always prove an absolute safeguard, but if the ingots are carefully made it will do so. Against bad or ignorant workmanship it is hard to find any absolute protection.

In rail purchases it has been found impractical to secure so great a discard. Personally, I believe the future will bring it, unless the insistence upon it shall lead to improved methods in casting ingots; until that time comes, I think that, through the railmakers developing other uses for the discarded steel, the decided increase of cost will be avoided.

Experience has proved that rails made by the basic open-hearth process are more liable to have interior pipes and segregated spots than Bessemer rails; no doubt principally because the ingots are larger and the size of the heats prevents slow casting. Of course the smaller contained percentage of phosphorus lessens the danger from its segregation, but the greater carbon content made possible by the law phosphorus increases the segregation of that element.

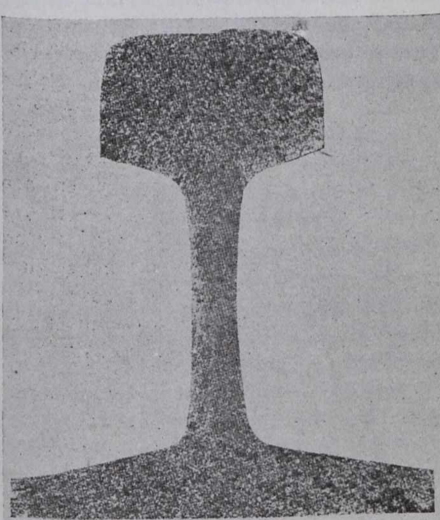


Figs. 1 and 2.—Cross-Section of Ingots from the Same Heat Showing Different Depths of Piping.

Intelligent and careful investigation by a committee of the American Society of Civil Engineers, of which I had the honor of being secretary, resulted, August 3, 1893, in the recommendation of a series of rail sections which, while not adopted by all American railways, were used by so great a number that they became accepted as standard sections. In 1902 another committee was appointed by the same society, of which also I was secretary. That committee, while deciding not to recommend any changes in rail sections, did present certain specifications governing the manufacture of rails. Later developments resulted in that committee asking to be discharged in favor of one more directly representing

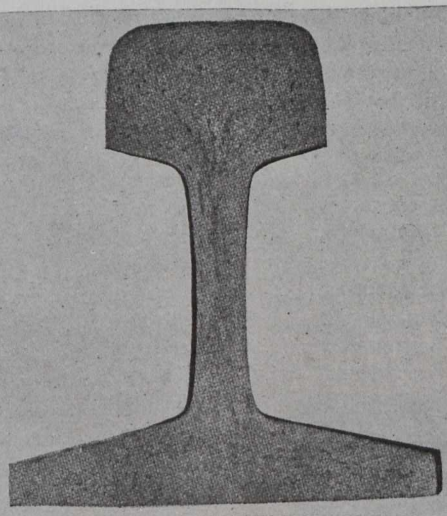
* Presented at the Sixth Congress of the International Association for Testing Materials, New York, September, 1912.

the railway organizations of the country; and this committee (American Railway Association committee) recommended, under date of March 23, 1908, a series of rail sections which have, to a certain extent, displaced the so-called American Society sections; and, in my judgment, wisely so. The same committee has recommended rail specifications; several



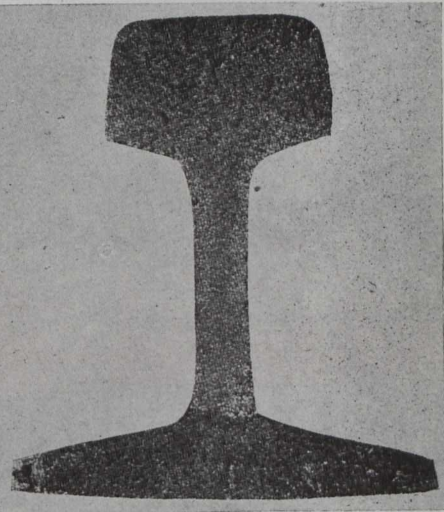
Analyses.
Corner of head: .674 Carbon, .023 Phosphorus
Centre of web: .895 Carbon, .047 Phosphorus

Fig. 3.—Photograph of Fracture Showing Evidence of Segregation Along Centre of Web.



Analyses.
Corner of head: .674 Carbon, .023 Phosphorus
Centre of web: .895 Carbon, .047 Phosphorus

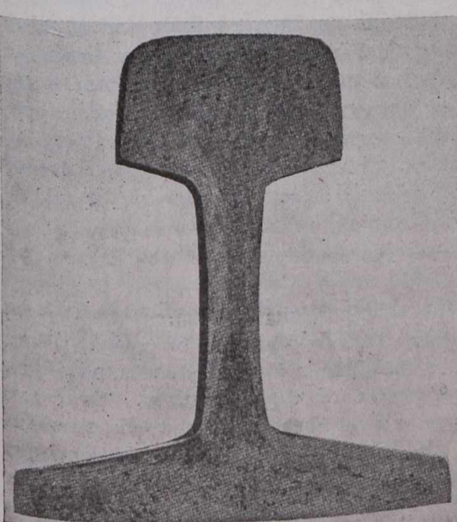
Fig. 4.—Photograph of Section in Fig. 3 After Being Etched.



Analyses.
Corner of head: .721 Carbon, .035 Phosphorus
Centre of web: 1.030 Carbon, .067 Phosphorus

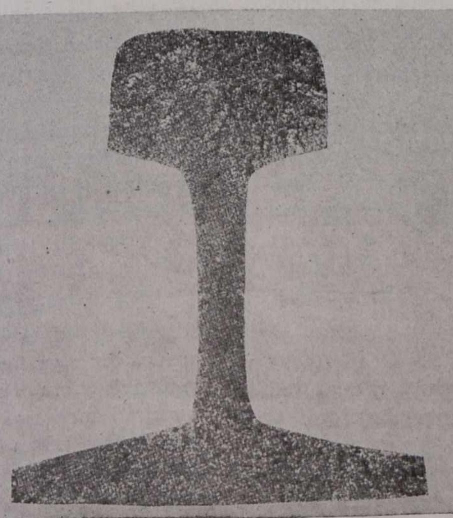
Fig. 5.—Photograph of Fracture Showing Evidence of Segregation Along Centre of Web.

railway companies have adopted their own, and the rail manufacturers have what are known as Standard Specifications, all seeking to secure good-wearing and safe rails. All of this has been accompanied by much discussion, and I know has resulted in much good; but we are still away from the desired certainty of safety.



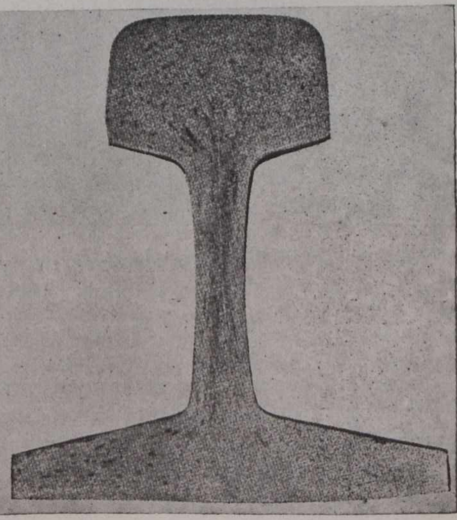
Analyses.
Corner of head: .721 Carbon, .035 Phosphorus
Centre of web: 1.030 Carbon, .067 Phosphorus

Fig. 6.—Photograph of Section in Fig. 5 After Being Etched.



Analyses.
Corner of head: .656 Carbon, .024 Phosphorus
Centre of Web: .888 Carbon, .045 Phosphorus

Fig. 7.—Photograph of Fracture Showing Evidence of Segregation Along Centre of Web.



Analyses.
Corner of head: .656 Carbon, .024 Phosphorus
Centre of Web: .888 Carbon, .045 Phosphorus

Fig. 8.—Photograph of Section in Fig. 7 After Being Etched.

I believe we can afford to let the chemical requirements remain as they are in most of the specifications. Their physical requirements as to finishing temperature also are sufficient, and most of them provide for sufficient drop-testing so far as determining the quality of the steel of the several heats as metal; but they do not go far enough to give protection against unsound castings (i.e., ingots). Practically all specifications require that the test piece shall be taken from the upper end of the rail made from the top of the ingot; and several require that after drop-testing if the piece has not broken it shall be nicked and broken to expose the interior, and if the interior of the rail shows any defects all of the A or top rails of the heat shall be rejected.

So far, so good. But each ingot is an individual or separate casting; and because one is sound, it does not prove that the others (say 4 in Bessemer or 29 in open-hearth practice) are also good castings. As showing what does happen, I give diagrams (Figs. 1 and 2) of two ingots which were cut longitudinally through their centres. With such variation as here shown, it follows that the test piece from one ingot would not be representative of the other one. Therefore, I favor drop-testing as now, and nicking and breaking those test pieces, and also a piece from the rails made from the upper end of each and every one of the other ingots, and accept the seemingly sound and reject the proven unsound A rails. And I would go further and provide that, where unsoundness is shown, another test piece shall be cut from the lower end of the represented A rail and nicked and broken. If it also shows unsoundness, then the B rail of that ingot shall also be rejected, and another piece cut from the lower end of that B rail, and, if unsound, the C rails condemned; and so on for the remainder, if any, of the ingot. This makes a practical way of determining how far the pipe or segregation has extended down the ingot, with the minimum destruction of merchantable rail. Such a plan of testing is not entirely new in principle, and was in part suggested by the late William Metcalf in 1908, when he was consulted by the Rail Committee of the American Railway Association. The additional test pieces can be taken from the rail ends which are made in hot-sawing the rails, and can be broken under much less cumbersome tools than the drop testing machine and at small cost.

As to what constitutes interior defects, I unhesitatingly specify not only laps or pipes, but also silvery or bright spots, or other indications of non-uniformity. Etchings and analyses of a great many examples of the latter have proved them to unfailingly indicate segregation. I give in Figs. 3 to 8 views of the sections of nickel and broken rails, and of the same pieces after having been polished and etched; also analyses of drillings taken from the indicated positions. Table I. shows the results of other analyses of such spots. These tell their own story.

Rails with segregated centres do not always fail under the drops test, nor does the elongation test which is required by some specifications indicate their existence, but, unfortunately, it has been demonstrated that rails with such hard centres fail through the softer surrounding metal breaking down and thus producing split heads and often broken rails.

I am fully convinced that, until sound ingots are commercially made, the safest procedure is to arbitrarily reject the upper part of every ingot for rail rolling. It has been demonstrated that high-carbon steel gives more satisfactory service in splice bars than softer steel; in fact it has been for several years the regular practice of some of the largest railway systems to use such steel, their chemical specifications being practically the same for both rails and bars. Undoubtedly this harder steel would also yield good results in tie plates and where the danger of interior unsoundness renders this steel undesirable for rails, said unsoundness, when existing, would not of necessity make it unsuitable for either splice bars or tie plates. These two articles would furnish a place for the use of a large part of the steel contained in the greater discard in the rail practice. Obviously its use would revolutionize the splice plate and tie plate making, but there have been many metallurgical revolutions and all of them have tended toward the betterment of the iron and steel industry.

It may be that present and future railway practice will require rails of heavier and otherwise different sections from the present ones, but we can never escape from the necessity of having them physically sound. As the section is increased, so must the work of rolling it decrease, and thereby the evil effects of want of homogeneity and unsoundness be augmented.

Table I.—Analyses of Segregated Rails.

Rail No.	Result of drop test.	Kind of steel.	Appearance of fracture on nick break.	Appearance of etching.	Cemical analyses: Mill ladle C.	P.	Drillings from centre of web C.	P.
1	O.K.	Bess.	Segregated	Unsound	.45	.10	.691	.165
2	O.K.	Bess.	Segregated	Unsound	.45	.10	.634	.152
3	O.K.	Bess.	Segregated	Unsound	.46	.10	.666	.138
4	O.K.	Bess.	Segregated	Unsound	.48	.10	.761	.173
5*	O.K.	Bess.	Segregated	Unsound	.45	.10	.797	173
6	O.K.	Bess.	Segregated	Unsound	.47	.10	.722	.142
7	O.K.	Bess.	Segregated	Unsound	.53	.10	.656	.145
8	O.K.	OH	Segregated	Unsound	.71	.029	.829	.043
9	O.K.	OH	Segregated	Unsound	.67	.040	.727	.059
10	O.K.	OH	Segregated	Unsound	.62	.022	.919	.042
11	O.K.	OH	Segregated	Unsound	.71	.039	.990	.060
12†	O.K.	OH	Segregated	Unsound	.64	0.28	1.009	.057

* Analysis drillings from corner of head gave carbon .439, Phos. .063.
† Analysis drillings from corner of head gave carbon .646, Phos. .023.

Plans for a tunnel under the city of Vancouver, beginning at the foot of Burrard Street on Burrard Inlet and running to the False Creek yards are being drawn by the Canadian Pacific Railway preparatory to their being presented to the railway commission for approval. This tunnel has been mentioned several times in conferences between the Canadian Pacific Railway and the city. It is being considered as a means of doing away with the present street crossings in the middle of Vancouver.

Early development of the coal resources of Central Alberta is expected. Mr. Andrew Laidlaw, of Spokane, and associates interested in the Jasper Park Collieries, have just returned from an inspection of their property. Over two hundred men are employed on the property, the entire output being taken by the Grand Trunk Pacific Railway for use on its locomotives. Mr. Laidlaw states that on completion of the installation of additional equipment at least five hundred men will be employed, and the output will be two thousand tons daily.

The Canadian Talc and Silica Company, which owns a talc mine and mill at Eldorado, has purchased a property just east of the village of Madoc, Ont., owned by Mr. J. H. Curley, and known as the Conley property. The president of the company is Mr. H. Hungerford, of Chicago. The intentions of the company regarding the newly-acquired deposit are not made known, but it is supposed that another mill will be erected in Madoc, and ground talc shipped from there.

THE PLANT OF THE NORTON COMPANY AT CHIPPAWA, ONTARIO.

A very interesting plant for the manufacture of silicon-carbide was recently erected at Chippawa, Ontario, and has now been in operation about a year. Mr. Francis A. J. Fitzgerald has written an article which was published in Metallurgical and Chemical Engineering, describing this plant. We herewith present the description slightly re-arranged. We are indebted to Mr. Fitzgerald for the illustrations furnished.

In many ways the manufacture of silicon carbide is unique, the reason being that the properties of the substance itself are peculiar. If a piece of silicon carbide, consisting of an agglomeration of crystals just as they come from the furnace, is submitted to a sufficiently high temperature in an oxidizing atmosphere slow oxidation occurs, the silicon forming silica and the carbon burning to carbon monoxide gas. This may readily be shown by means of an oxy-hydrogen blow-pipe flame. If the flame is turned on the crystals for a short time and these are then examined they will be seen to be covered with minute globules of silica produced by the oxidation of the silicon carbide.

On the other hand, if the crystals of silicon carbide are heated to a sufficiently high temperature in a reducing or neutral atmosphere decomposition occurs without fusion, the silicon vaporizes and the carbon remains behind preserving the original form of the silicon carbide crystals. There is no evidence of fusion. Such an experiment may be performed in a carbon tube, which, of course, is heated electrically.

It is this peculiar property of silicon carbide which makes the conditions of manufacture unique and has thus led to the development of a furnace which to many appears at first sight rather a crude and inefficient apparatus. In most processes for the manufacture of carbides or other compounds which involve the reduction of an oxide, the resulting product is fusible and this simplifies in many ways the manufacturing process as compared with that of silicon carbide where the resulting product is infusible. In the production of a fusible material a moderately careful mixture of the reacting raw materials is satisfactory since slight inequalities or lack of homogeneity in the mixture will not cause trouble provided the proportions of the constituents are correct. The conditions of silicon carbide manufacture, however, are different.

The mixture used in the production of silicon carbide should contain theoretically 60 parts of pure silica sand and 36 parts of pure carbon. When these are thoroughly mixed and heated to a sufficiently high temperature a portion of the carbon combines with the oxygen of the silica forming carbon monoxide gas, and the silicon thus set free combines with the remainder of the carbon to form silicon carbide. During this process, however, the mixture as a whole is not fused. Certainly the sand fuses, but the volume of carbon mixed with the sand is sufficiently great to prevent the particles of silica from running together, but instead of that they react with the carbon in their neighborhood to form, first of all, a greenish-colored substance which shows no crystalline structure, and as the temperature is carried higher this is converted into the crystalline silicon carbide. There is naturally a considerable shrinkage of the mixture, for from a theoretical charge weighing 96 kg. only 40 kg. of silicon carbide are obtained, the remaining 56 kg. disappearing as carbon monoxide gas. The mixture then shrinks, but preserves generally its original form. If the heating is continued so that the temperature is raised still further the silicon carbide is decomposed, as already described, but still there is no fusion and ultimately the carbon which was in combination with the silicon is obtained as graphite.

If a mixture containing an excess of silica is heated a reaction occurs between the silica and the silicon carbide which results in the production of silicon, and this is just what happens in those parts of a silicon carbide furnace charge where there is an excess of silica, due to lack of homogeneity in the mixture.

A consideration of these facts leads to the conclusion that it would be difficult to manufacture silicon carbide in a furnace different in general principles from the well-known form that has been used for the purpose during the past 20 years. Moreover, it is not difficult to understand that the manufacture is one requiring very considerable care in order to obtain a satisfactory product and at the same time to get as large an output as possible.

In the design of the Norton Company's plant for the manufacture of "crystolon," the name given to its silicon carbide, the first consideration was the quality of product, the efficiency of the furnaces, by which is meant the output per kw.-hour, the labor cost and the cost of raw materials being deemed secondary matters. This must be remembered in considering the plant in order to appreciate it fairly.

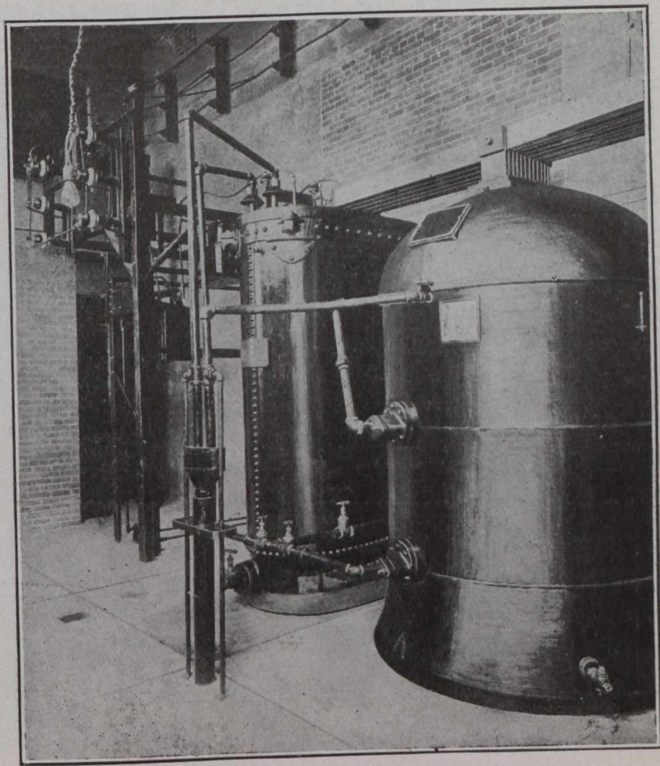


Fig. 1.—Arrangement of Electrical Apparatus in Crystolon Plant of Norton Company.

The Norton Company's crystolon plant is in Chippawa, Ont., about two miles above the Falls of Niagara. The current is supplied by the Ontario Power Company at 12,000 volts, three-phase. Since it was decided to use furnaces having a capacity of 740 kw. and to install only two units, it was necessary to use transformers with suitable taps for the Scott connection so that the three-phase current is transformed to two-phase. The transformers step down the voltage to 145. The secondary bus-bars then go to induction regulators by means of which the e.m.f. at the furnaces may be raised to 215 volts or lowered to 75 volts.

The arrangement of the electrical apparatus is shown in part in Fig. 1. The current enters the building in a room next the transformer room where it goes to the main circuit breaker and where the lightning arresters are set up. The cables from the main circuit breaker are then brought into the transformer room on brackets near the ceiling, as shown in the figure. A frame work, shown at the left, carries two single-pole double-throw switches so that the transformer, seen in the centre, can be connected to any one of the three-phases. The frame work also carries circuit breakers, of which one is connected in parallel with a water rheostat and can be tripped by hand, while the other is provided with an automatic tripping device. The reason for using the water rheostat is that it is frequently necessary to throw the current on at full load and this might cause dangerous surging if the circuit was closed by means of the oil circuit breaker.

To the right of the transformer in the figure is the induction regulator by means of which the voltage of the current is raised or lowered. The induction regulator is built like an induction motor and the secondary voltage varies with the position of the rotor. Its great advantage lies in the fact that there are no contacts as in other kinds of voltage regulators and the change of voltage is perfectly continuous. The disadvantage is that on account of the air gaps between the primary and secondary there is considerable magnetic leakage, and, consequently, the power factor of the circuit is apt to be low. This, however, is more than compensated for by the advantages which make a breakdown of the system highly improbable.

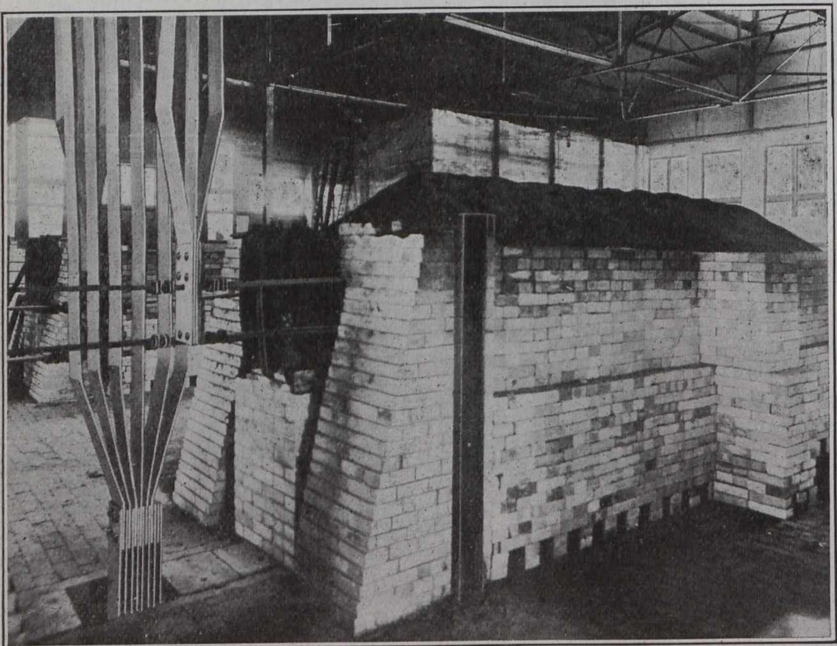


Fig. 2.—Electric Furnaces for Manufacturing Crystolon.

The busbars coming from the transformer and regulator are interlaced and pass through the wall of the transformer room to the furnace room, which they cross transversely. On either side of the busbar line are three furnaces, these forming one unit, Fig. 2. Between the terminals of each pair of furnaces on opposite sides of the busbar line bars are brought down, those of one polarity going down into a concrete trough which passes under the foundations of the furnaces, the other bars terminating on a level with the furnace terminals. The bars going into the trough come out at the other ends of the furnaces and can there be connected by means of cables to the terminals, as shown in Fig. 3.

The grounded ends of the furnaces, that is the terminals connected to the busbars passing through the trough, are kept permanently connected, but the other terminal is only connected to the busbars when the furnace is running. In starting a furnace the regulator is adjusted so as to have the maximum voltage at the furnace terminals and this brings the furnace to load, 700 kw., in a few minutes. The resistance still keeps dropping rapidly as the temperature rises, but by means of the regulator the rate of generation of energy is kept constant. Finally the resistance becomes very nearly constant and there is only a gradual fall to the end of the run. Although it is possible to decrease the e.m.f. at the terminals to 75 volts it is customary so to construct the furnace that the resistance at the end of the run requires an e.m.f. of about 80 volts.

It has been pointed out that an objection to the use of an induction regulator is its influence on the power factor of the circuit. It is found, however, that even with the large current of 9,000 amp. used at the end of the run the power factor is about 0.9.

The raw materials for the manufacture are brought in on a switch at the side of the building opposite to the transformer room. The sand and sawdust are taken from the cars and conveyed to large concrete storage bins by means of elevators. The coke is thrown directly into a crusher, and when the granular carbon for making the resistor used in the furnace is required the coke coming from the crusher is passed over screens which separate particles of the required size. The under size and over size particles of coke are carried to a buhr mill where they are finally ground and thence conveyed to a concrete storage bin.

In making the charge for the furnace a mechanical mixer is used and the mixture is emptied at once into the hand cars which convey it to the furnaces. These are built in the usual way with the mixture surrounding the granular coke resistor. The furnaces have an electrical capacity of about 700 kw.

This question is sometimes asked: "Would not larger furnaces result in more economical working?" It is a fact that the consumption of energy in a small silicon carbide furnace, say of 75 kw., is very large, about 10 kw.-hours per pound, and that in going to a larger sized furnace, for example 200 kw., the reduction in energy consumption is very marked. Again, increasing the size of the furnace to 700 or 800 kw. makes the working still more economical, but about here a point is reached where still further increase in size is of doubtful advantage. This is easily explained when certain of the peculiarities of silicon carbide are considered.

It has already been pointed out that the substance is infusible and that it must be formed between certain temperature limits. The result of this is that when a charge has been partially converted into silicon carbide, the heating resistor is surrounded with a cylinder of the carbide and consequently, the heat which is supplied to the charge must be conducted through this cylinder to the surrounding mixture. It is obvious that there is a limit to the thickness through which it is economical to transmit heat and that very large furnaces would demand such a great increase in the thickness of the silicon carbide cylinder that they would not be practicable. On the other hand, if the thickness of the silicon carbide cylinder is kept the same and the length of the furnace increased so as to accommodate the increased rate of generation, there is nothing gained in heat economy, since the radiating surface of the furnace is increased in proportion to the rate of generation of energy.

Another objection to very large furnaces is the increased difficulty in building with the care necessary to obtain a product of the highest quality possible. Lack of uniformity in the charge or irregularities in the resistor all tend to bring about the production of an inferior abrasive. It is for this reason that the most elaborate care is taken in the mixing of the charge and the construction of the furnaces at the "Crystolon" plant. Analyses of all the raw materials are made as soon as these are received at the plant, then in the Chippawa factory analyses of the raw materials are made twice a day and the mixture adjusted accordingly.

The equipment of the plant is very complete both as regards apparatus and personnel for carrying on research work on the working of the furnaces and methods of manufacture. This research not only covers chemical and electrical studies but also important thermal experiments. Some of the results of this work have been published by Saunders in an interesting paper read at the last meeting of American Electrochemical Society[1] in Boston.

The temperature measurements of the crystolon furnace are of great interest in many ways. They show what exaggerated notions of the temperature of the furnace have been formerly entertained and also the comparatively small range of temperature which can be utilized in making silicon carbide. As determined by Saunders the temperature at which silicon carbide crystals begin to form is only 400 degrees below that of decomposition. There is no doubt that for some processes 400 deg. would be a large range of temperature, but for a substance like silicon carbide, on account of its other peculiarities, outlined before in this article, it is not.

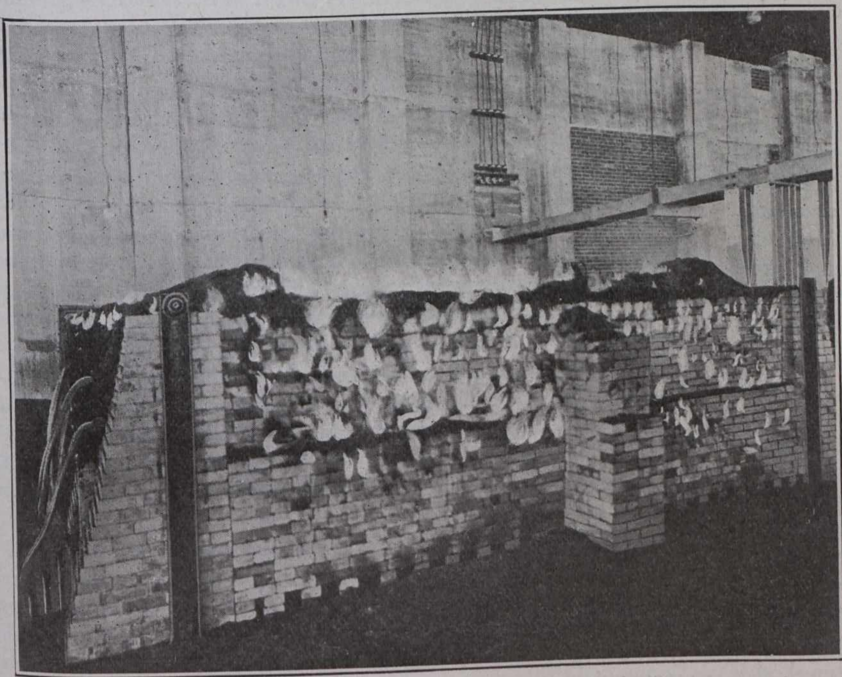


Fig. 3.—Electric Furnace for Manufacturing Crystolon.

The Norton Company's crystolon plant is used simply for the manufacture of silicon carbide, the material as it comes from the furnace being shipped to Worcester, where the crushing, grading and further manufacture is carried on. At first sight it might appear that the separation of the plant where the crude abrasive is manufactured from that in which it is made up into marketable form is not efficient, but experience seems to show that this view is not correct. The separating by no means interferes with active cooperation and at the same time permits of undivided attention to the production of a raw material of the highest quality without which the manufacture of a satisfactory finished article is possible.

[1]Met. & Chemical Engineering, Vol. X, No. 5, p. 287.

THE METHODS OF RESEARCH.*

By Edward P. Hyde.

The spirit of research now prevails. Research work is undertaken in our universities and colleges, both by faculty and by students; research departments are considered most important adjuncts to large progressive industrial organizations; research laboratories are being endowed by philanthropic citizens; and individuals everywhere, and in all branches of human knowledge are independently undertaking the investigation of problems of supposed practical importance or of personal interest. Inasmuch as effectual practice rests on the judicious application of established knowledge, whatever conduces to the enlargement or enrichment of our body of established knowledge is worthy of our highest respect and our most serious consideration. But side by side with this duty of encouragement and appreciation stands that other duty of careful discrimination between the research work that is thorough and genuine and the research work that is ill-advised and spurious.

Not long since the president and council of this society appointed a research committee to stimulate interest in the investigation of important illumination problems, to encourage sane and promising research, and to serve as a directive force in the development of the science of illumination. And it has seemed advisable to the papers committee of the society that a brief paper on "The Methods of Research" should be presented at this convention.

What is research? Knowledge comes to us at times unsought and unexpected. Discoveries are frequently fortuitous. But by research is meant the diligent, continued or laborious search after facts or principles. And the goal of research is truth. This is a most important point. Whatever may be the ulterior motive in the acquisition of truth, whether it is truth for truth's sake, as in the ideal of pure science, or truth as a firm foundation for judicious practice, as in the ideal of applied science, the immediate goal in all research work worthy of the name is truth. The methods of research must, therefore, be included in the methods involved in arriving at truth, and so we turn our attention for a while to a consideration of the methods by which we arrive at truth. Truths must be distinguished in two classes: (1) those truths which are known directly or of themselves, as our own bodily sensations and mental feelings; and (2) those truths which are known through the medium of other truths, as the theorems of mathematics. The former are the subject of intuition or consciousness; the latter, of inference. It is not the place here to discuss the metaphysical question of the dividing-line between truths which are known directly and those which are known by inference. Suffice it to say that practically all, if not quite all, of the truths of physical science are known through the medium of other truths and are hence the subject of inference.

What then are the methods of arriving at truth through inference? The logicians distinguish two methods, that of

*A paper read at the sixth annual convention of the Illuminating Engineering Society, Niagara Falls, Ont., September 16-19, 1912.

induction and that of deduction. Let us consider briefly first the inductive method. By induction is meant the process of drawing a general conclusion from particular cases. Thus the law of conservation of energy and the law of universal gravitation are great generalizations which cannot be proved, in the ordinary sense in which we speak of proving a mathematical theorem. They are expressions of our belief in the invariability of certain phenomena which have been found uniformly in a very large number of concrete cases. Many of us believe that so-called glare is deleterious to eye-sight. We have inferred this from observations of individual concrete cases. If true, it is an important truth in illumination arrived at by the method of induction. The exact verity of it, and the limits within which it applies, however, have not yet been definitely established.

This last illustration suggests the two processes by which we arrive at truth by the inductive method. These two processes are observation and experiment. By observation, as used here, is meant the passive observation of phenomena without effort to control or modify the phenomena in any way. According to the above illustration, if we merely note that certain individuals have been exposed to strong glaring light and have subsequently had eye-troubles, and infer from this the generalization that glare is deleterious to eye-sight, we are making use solely of the process of observation in our induction. If on the other hand we are not content with the results of passive observation of cases as they occur, but seek rather to control to some extent the phenomena by isolating certain factors and eliminating others, our process becomes that of experiment. Certain phenomena are not subject to control and may only be studied by the process of observation. Other phenomena lend themselves readily to experiment. It should be remembered, however, that each process has certain advantages and disadvantages even in the case of phenomena to which both processes may be applied. Thus the process of experiment is peculiarly valuable in cases where we desire to determine the various effects of a given cause, and the process of observation has corresponding advantages in cases where we seek to find the causes of a given effect.

Unfortunately time does not permit an elaboration of the four ways in which the process of experiment may be used to arrive at truth, viz., (1) by agreement, (2) by difference, (3) by residues, and (4) by concomitant variations. I may only commend them to you for careful study and must then pass on to a brief consideration of the second method by which we arrive at truth through inference, viz., the deductive method.

We have discussed the inductive method first because it is the simplest and most direct method of arriving at truth by inference. Moreover, it precedes and underlies the deductive method, for the starting point of the latter consists of one or more generalizations which presumably have already been established. It is true, as John Stuart Mill says, that "if we had sufficiently capacious memories, and a sufficient power of maintaining order among a huge mass of details the reasoning could go on without any general propositions: they are mere formulae for inferring particulars from particulars." But we do not have such memories or powers of maintaining order among details, and so, in our processes of reasoning by the deductive method we start from generalizations arrived at by the inductive method.

The mode of investigation according to which we arrive at truth by the deductive meth:d consists of three steps: the first, one of direct induction; the second, of ratiocination, or reasoning; and the third, of verification. The inductive method consists merely in inferring from the particular to the general, but in the deductive method, starting from previous inductions the process of ratiocination is applied, and as a result of this operation conclusions are reached which are subject to direct verification. It is a mistake to suppose that the conclusions of deduction are distinctly new, in the sense that they were not contained in the underlying inductions involved in the reasoning, and yet the truths arrived at by the deductive method may be, and usually are new in the sense that they were not recognized in the inductions which formed the basis for the reasoning. As an example of this the science of geometry may be mentioned. The theorems of geometry are all deducible from the axioms or postulates which are inductions, but in which one fails to recognize a priori all the theorems deducible from them.

The third operation in the deductive method, viz., verification, is of marked importance as we shall see later on in the more specific consideration of the methods of research.

It is evident, from the hasty outline given above that these two methods of arriving at truth by inference are not independent. The basis of the deductive method is a previous induction. The two methods are interdependent. A young or complex science will partake more of the character of an inductive science, as compared with an older or simpler science. A new science has few inductions to serve as the premises of deduction, but even in a new science an effort is made to reason from the hypothetical generalizations already reached to conclusions which on being verified by observation or experiment, strengthen the inductions from which they were deduced. Thus science grows.

I regret the necessity of this somewhat academical discussion of the methods of inference, but I see no other way of prefacing the ideas which I desire to present in regard to "The Methods of Research." As has been said, the goal of research is truth, and hence the methods of research are none other, in their general character, than the methods of arriving at truth by inference. Let us now apply the principles, which have been presented, to the consideration of the methods of research.

There are two general methods of research; that of induction, and that of deduction. The former is the method of observation and experiment, and the inference from the concrete to the general. The latter is the method of hypothesis or theory, ratiocination and verification. Let us consider these two methods more in detail.

The inductive method consists of observation and experiment. In a new science little is known, the observations are limited, the experiments are few. There is little opportunity for ratiocination or reasoning; the greater need is for the accumulation and collection of facts in generalizations which may subsequently form the basis of ratiocination. To use the illustration referred to above, we are not prepared to reason from the induction that glare is deleterious to eye-sight because this induction itself is scarcely out of the domain of empiricism. We are investigating the matter; we are making observations and carrying out experiments. We are collating facts. We are doing research by the inductive method. In the development of all science, but more particularly in the development of the newer or more complex sciences, this method of research finds most valuable application.

I would further distinguish two ways of carrying out research by the inductive method which I shall call respectively the definitive and the non-definitive methods. The distinction between these two methods is best shown by reverting once more to our illustration of the effect of glare. An investigator of this subject might carry out his research in either of two ways. He might, for example, lay out a definite scheme of attacking the problem. He might study experimentally first the effect of glare on visual acuity, then its effect on speed of reading, then its effect on fatigue, and so on. He might attempt to study by the process of observation the intensity of the glaring light, the angle at which it is incident on the eye, the period over which the patient has been subjected to the glare, and the relation of these elements to the resultant eye-injury. In either of these two cases, both of which are examples of research by the inductive method,—one by the processes of experiment and one by the process of observation—the investigation has proceeded according to a definite plan, has followed a definite scheme. Such research by the inductive method I would call definitive.

On the other hand many investigations are carried out by the non-definitive method, and many investigators have a tendency to work in this way. Thus, in the illustration of the study of glare, an investigator might set out to study the problem without any definite scheme of attack, or any preconceived notions of the casual relations between the resultant effects and the possible causes. He would, in a more or less random fashion, vary the conditions and note the result, and attempt ultimately to discover the important element in the problem. The method is haphazard, fortuitous, non-definitive. And yet at times it is most valuable. Moreover, it should be emphasized that in research by the inductive method the process is seldom entirely definitive or entirely non-definitive. The investigator with the scheme is ever alert, or should be ever alert, to recognize some unsuspected phenomenon which flashes out into prominence as important. And the schemeless investigator will always, or should always follow up any phenomenon which attracts unusual attention.

The two processes are interwoven, and very few, if any, researches are made exclusively by one or the other. And yet it is very easy to point to investigators who tend to work according to one or the other of the two processes. I am at a loss what to say regarding the relative merits of the two methods. The non-definitive method is at times, and in the hands of certain investigators, of the greatest value, but I see no way of laying down rules for procedure according to this method. Since it is more or less haphazard there can be no rules. We must rely entirely on the personal equation of the individual. The definitive method, on the other hand, is conformable to a formula of procedure. Inasmuch as the general scheme of procedure by the definitive inductive method has much in common with that of the deductive method, I shall give the formula for the two at the same time.

We now turn to a consideration of the deductive method of research. This is the method of hypothesis or theory, ratiocination and verification. We have seen that this method of arriving at truth consists in argument from previous inductions or generalizations to conclusions which are subjected to verification by observation or experiment. This is peculiarly the method of the mathematical sciences. The verification confirms the conclusion and strengthens our belief in the generalizations which served as premises. These generalizations may be generalized facts as in the classical illustration—All men are mortal; or they may be generalized principles such as the theory of gravitation or the nebular hypothesis. A general principle which possibly or even probably underlies or explains certain phenomena is frequently termed a hypothesis. Arguing or reasoning from this hypothesis certain conclusions are derived. These conclusions are put to test by observation or experiment. If the conclusions are not confirmed the hypothesis is shown to be false and not to be a true induction or generalization. If the conclusions are found to be true, the hypothesis is strengthened. If the deductions from the hypothesis are found consistently to be true the hypothesis becomes a theory, and is classed with the other great principles of the science.

Just as it is impossible to lay down rules for carrying out a research by the non-definitive inductive method, so it is impossible to lay down rules for deciding upon the scheme of a research according to the definitive inductive method, or of determining upon a specific deduction according to the deductive method. These things are matters of individual creative imagination and not subject to formula. Granted, however, a definite scheme of research (definitive inductive method) or a deduced conclusion (deductive method) it is quite possible to lay down a general formula which will be helpful in carrying out the experimental work. Such a general plan of procedure is outlined below:

1. Exact definition and statement of problem.
2. Study of literature pertinent to the problem.
3. Determination of experimental method.
4. Choice or design of apparatus.
5. Isolation of specific phenomenon to be studied, or of quantity to be measured, and elimination of complicating phenomena or quantities.
6. Preliminary investigation of instruments used.
7. Investigation and discussion of sources of error.
8. Careful analysis of results.
9. Justifiable conclusions.

In an early paragraph of this paper emphasis was laid on the fact that the goal of research is truth. Whatever may be the stimulus for the attempt to ascertain the truth, whether it be truth for truth's sake, or truth as the basis of sound practice, the immediate object in every true research is truth. It seems expedient in concluding the paper to return to this subject to reiterate the importance of the right attitude toward research, and to sound a word of caution against those two classes of investigators whose well-meant efforts serve rather to retard than to assist the development of science. The charlatan, the impostor needs no consideration, but there are genuine men whose contributions in the name of scientific research are more fundamentally and permanently harmful than the wild claims of the charlatan. I refer to the narrow, incompetent investigator and to the broad speculator. The former can see but one side of a problem, and his incompetency is further reflected in his restricted ability to impose the proper limitations on his conclusions. The latter is continually inferring generalizations from inadequate data, or deducing conclusions from non-established inductions. There is a place for hypothesis, and there is need of speculative imagination, but he who confuses speculative hypothesis with established principles and leads others into such error is inhibiting the development of science. And it is very difficult to counteract the effect of such unjustifiable speculation, for it is usually in the domain of limited knowledge, and his is a thankless task who urges the inadequacy of fact to justify the speculation, but who is unable himself positively to controvert the speculation. Let us all endeavor to be more severe critics of our own work, and more discriminating critics of the work of others.

HUDSON BAY RAILWAY RISKY.

"The Hudson Bay Railway undertaking is of so risky a nature and its ultimate success is so problematical that it should be operated by the Dominion Government until its real value has been demonstrated," said Sir Donald Mann at Winnipeg. "When the Canadian Northern started we had the choice of going north to the Bay or east and west. We chose to go east and west, and I think the result has justified our judgment. But you can never tell, and the result is uncertain. Undoubtedly, there will be a large fish trade from the north and valuable mineral deposits may be found along the right-of-way, as happened in the case of the Ontario Government road, making the line of incalculable worth. Add to this that there is bound to be considerable through traffic, freight and passenger, the element of risk is materially reduced. But I think that the right course is being pursued."

THE "BOOSTER" PUMP SUPPLIED THE GREAT WESTERN RAILWAY WORKS AT SWINDON.

We give below a brief description of an interesting plant which the Great Western Railway Company have just recently installed in their works at Swindon.

The plant consists of a "Victoria" turbo pump supplied by Messrs. Jens, Orten, Boving & Company, of 9½ Union Court, Old Broad Street, E.C., coupled up to a Bruce Peebles motor.

The pump takes the water from an elevated tank at a pressure varying up to 20 lbs. per sq. inch, and delivers into a pipe-line of more than one mile in length, to which the nozzles for the work's fire system are connected, boosting the pressure up to about 120 lbs. The pump is thus inserted into a pressure water, and is therefore constantly primed and always ready for immediate starting up. It is flexibly coupled up to a D.C. motor of the protected shunt wound, commutating pole type running at 1,300 r.p.m. and with an output of 90 h.p.

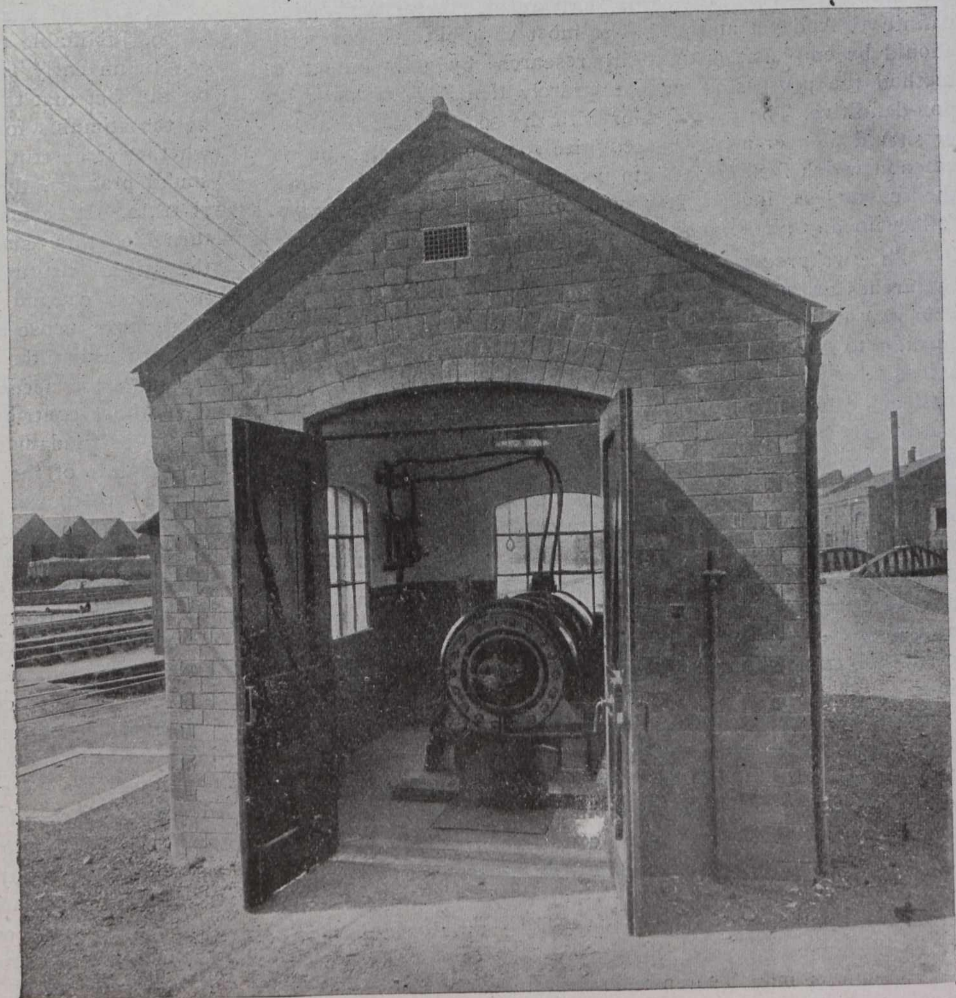
The pump and motor are erected in a separate station, as shown in the accompanying figure, and are operated from the central power house some considerable distance away, starting up being done by a hand-operated liquid starter fitted with field discharge resistance.

The pump is so designed that it requires no attendance whatsoever beyond the provision of the necessary lubricant for the bearings. There are no cocks or other regulating devices of any description fitted to the pump which would require adjustment in order to overcome endthrust and consequent heating of bearings so often met with in other turbo pumps, especially when they are working against a pressure different from the normal. The patent trust balancing device fitted in this pump adjusts itself automatically to such changes of pressure as will of necessity occur in case of the number of nozzles used in the fire service is altered or in case other supplies are taken from the main.

It cannot be emphasized strongly enough that freedom from endthrust is a convitio conditio sine qua non for a fire or booster pump as the reliability of such installations depend on this particular feature owing, as stated above, to the frequent variations of duty. It was this particular feature of freedom from end thrust which induced the railway company to employ a "Victoria" turbo pump in spite of the extra expense attached, and in order to satisfy themselves that the pump would comply with their requirements in this respect it was subjected to a severe trial on site.

A sluice valve fitted to the end of the delivery pipe, after being fully opened, was closed entirely, thus causing a pressure wave of well over 150 lbs. sq. in. in the long delivery pipe, i.e., a pressure considerably above the maximum pressure the turbine pump could ever produce. On the other hand, this pressure wave was of necessity followed by a heavy momentary decrease in pressure while the pump was running. These fluctuations of pressure continued for some time owing to the inertia of the long water column in the delivery pipe, but during all these changes of load, whch constitute the severest pressure test to which a turbine pump can be put, the Victoria pump did not show any signs of heating, but proved to be balanced perfectly.

Another feature, indispensible with pumps that should require practically no attendance, is the absence of a high-pressure stuffing box. Pumps containing high-pressure glands are unsuitable for this kind of work, as these glands often require tightening and careful attention, for if set too tightly, as is often done with a view to minimize the leakage inevitably connected with high-pressure glands, the shafts or shaft sleeves become unduly worn and troubles through heating of the gland may occur, not to mention loss of efficiency caused by the friction of the packing.



View of Pump Station.

With this condition the "Victoria" turbo pump fully complies as there is no high-pressure stuffing box in this pump, as only low-pressure exists in the last chamber of the pump which, in fact, forms a self-contained unit.

Efficiency tests carried out in site showed a pump efficiency of 75 per cent., the heads being measured by means of pressure gauges, the current consumed by means of indicating volt and ammeter, and the quantity of water measured by a Siemens water meter, fitted to the delivery pipe The above efficiency is calculated on the basis of the motor maker's guarantee.

APPLICATIONS OF OIL-MIXED CONCRETE.

About a year ago Mr. Logan Waller Page, director of the Office of Public Roads, United States, made public the results of certain investigations which he had been conducting into the properties of oil-mixed concrete as a waterproof material. A summary of his findings was published in *The Canadian Engineer* of October 12, 1911. Since that time the experimental work has been progressing steadily and the latest results are published in bulletin No. 46 of the Office of Public Roads, which was issued on August 8. The first part of the report deals principally with the laboratory and service tests which were covered in detail in the issue of this journal previously referred to. The results of these laboratory investigations may be summarized as follows:

The oils used were a fluid residual oil and a cut back oil asphalt. The damp-proofing properties of concrete mixtures containing oil have been demonstrated very definitely by laboratory and by service tests which establish this material as one of great merit for certain types of concrete construction. It has also been shown that the admixture of oil is not detrimental to the tensile strength of mortar composed of 1 part of cement and 3 parts of sand when the oil added does not exceed 10 per cent. of the weight of the cement used. The compressive strength of mortar and of concrete suffers slightly with the addition of oil, although when 10 per cent. of oil is added the decrease in strength is not serious. Concrete mixed with oil requires a period of time about 50 per cent. longer to set hard than does plain concrete, but the increase in strength is nearly as rapid in the oil-mixed material as in the plain concrete. Concrete and mortar containing oil admixtures are almost perfectly non-absorbent of water, and so they are excellent materials to use in damp-proof construction. Under pressure, oil-mixed mortar is very efficient in resisting the permeation of water. Laboratory tests show that oil-mixed concrete is just as tough and stiff as plain concrete, and furthermore its elastic behavior within working limits of stress is identical with that of plain concrete. The bond or grip of oil concrete to steel reinforcement is much decreased when plain bars are used. Deformed bars, however, and wire mesh or expanded metal will reinforce this material with practically the same efficiency as in ordinary concrete.

The remainder of the report is given over to a discussion of the proper uses of the oil-mixed concrete and detailed instructions are given for specific cases. There is also an appendix devoted to the results of physical tests of oil-mixed concrete:

Oil.—For oil-mixed concrete, petroleum residuum oils conforming to the specifications given below have been found to give good results in both laboratory and service tests:

(1) The oil shall have a specific gravity of not less than 0.930 nor greater than 0.940 at a temperature of 25 deg. C.

(2) It shall be soluble in carbon disulphide at air temperature to at least 99.9 per cent.

(3) It shall contain not less than 1.5 nor more than 2.5 per cent. of bitumen insoluble in 86 deg. B. paraffin naphtha.

(4) It shall yield not less than 2.5 nor more than 4 per cent. of residual coke.

(5) When 240 cu. cm. of the material is heated in an Engler viscosimeter to 50 deg. C. and maintained at that temperature for at least 3 minutes, the first 100 cu. cm. which flows out shall show a viscosity of not less than 40 nor more than 45.

(6) When 20 grams of the material is heated for 5 hours in a cylindrical tin dish 2½ in. in diameter by 1 in. in height, at a constant temperature of 163 deg. C., the loss in weight shall not exceed 2 per cent.

Mixing.—For most purposes where damp-proofing is required 5 per cent. of oil based on the weight of cement in the mixture is all that is necessary. A bag of cement weighs 94 lb., and consequently, for each bag of cement used in the mixture, 4.7 lb. or about 2½ quarts of oil are required. The sand and cement should be mixed dry. Water is added to the mixture and the mass again mixed to a mortar of mushy consistency. Oil is then measured out and added to the mortar, and the mass again turned until there is no trace of oil visible on the surface of the mortar. Particular care should be taken to continue the mixing until the oil is thoroughly incorporated in the mixture. The oil-mixed mortar is then combined with the stone or gravel previously moistened and the mass is again turned until all of the stone is thoroughly coated with the mortar and the mass is uniformly mixed throughout. Should only oil-mixed mortar be desired, the process is similar to that above described except that no stone is added.

In a machine mixer the cement, sand, and water are first mixed to a mortar when alternate batches of oil and stone are added until the required quantity of oil is mixed, and then the remainder of the stone is added and mixed.

Uses.—All of the laboratory and service tests thus far made on oil-mixed mortars and concretes are indicative of a wide future usefulness for these materials, principally in damp-proof construction. There are many types of structures through which the permeation of moisture is ruinous to either the appearance or the efficiency of the construction, or is seriously detrimental to the health of either animal or human life. The efflorescence due to the leaching out and subsequent carbonization of the lime on the surface of a concrete wall might well be prevented by the incorporation of an agent capable of excluding all moisture. Again, the dampness of many cellars, with its danger to health, could have been prevented had the walls and floors been damp-proofed. The following types of structures might be damp-proofed at an exceedingly slight extra expense by the incorporation of a small amount of the proper kind of mineral oil residuum with the mortar or concrete used in construction: Basement floors, basement walls, watering troughs, cisterns, barns, silos, concrete blocks, roofs, stucco, and numerous important engineering constructions.

Basement Floors.—There are many basement floors which are continuously damp, owing to the percolation of moisture from the underlying soil. Concrete and mortar, as ordinarily made, are neither perfectly non-absorbent nor waterproof, so that ground water readily finds its way through to the basement and causes a very insanitary condition.

A floor which will remain perfectly dry may be constructed at a cost but very slightly higher than that of the ordinary basement floor by the incorporation of a petroleum residuum oil with the ordinary concrete mixture. The following method of construction, using an oil-cement mixture, is suggested as one which will prevent the permeation of moisture even from a very wet subsoil.

It will be well, if the underlying soil is very wet, to lay a 6-inch foundation of sand, cinders, broken stone, or gravel, compacting these materials well by tamping. In addition it will be of advantage to employ drain tiles in this porous foundation, leading them to a sewer if possible. On top of the foundation should be laid a 4-inch layer of concrete mixed in the proportions of 1 part of Portland cement, 2½ parts of sand, and 5 parts of broken stone or gravel. Before the concrete base has hardened, a top or wearing coat of mortar mixed in the proportions of 1 part of cement and 2 parts of sand or stone screenings and containing 5 per cent. of oil (2½ quarts per bag of cement) should be laid. This top coat, because of its non-absorbent character, will give perfect protection from underlying moisture, and moreover it will build a floor which will dry out very quickly after washing, since practically none of the washing water will be absorbed.

It might be thought that the addition of oil to the mortar-wearing coat would tend to make the surface slippery. Such, however, is not the case; nor is the appearance very much different from that of an ordinary cement floor. Should joints be provided for expansion and contraction, it will be necessary to fill them with a good bituminous filler to prevent the entrance of water.

Many cellar floors now made of Portland cement concrete are giving trouble owing to the permeating moisture. They are continually damp and, owing in part to the constant evaporation from their surface, they are cold. Such a condition may be remedied by the application of an oil-mixed mortar coat to the surface of the old floor. Before attempting to lay the new wearing surface, the old floor should be scrubbed thoroughly clean and should be made thoroughly wet. The bond between the old and the new work will be improved if the old surface be roughened with a stone hammer. A wash composed of 1 part of hydrochloric acid and 5 parts of water may be used to clean the surface. This will dissolve some of the cement from the old work, leaving the aggregate exposed. The acid solution should be left on not longer than half an hour, when it should be completely removed with clean water. The surface should then be brushed with a wire or stiff scrubbing brush to remove any particles of sand which may have become loosened because of the dissolving of the cement.

A mortar composed of 1 part of cement and 2 parts of sand and containing 5 per cent. of oil will be sufficiently non-absorbent for the new wearing coat. To strengthen the bond it will be well to apply a wash of grout, made by mixing cement with water to the consistency of cream, before laying the oil-mixed mortar coat. For the ordinary basement floor a 1-inch layer of mortar will prove of sufficient thickness. It will be necessary to keep the new mortar damp for at least one week in order that it may attain its proper strength.

Cellar Walls.—The entrance of moisture through the walls is another common source of damp basements. The water pressure in the soil adjacent to the wall is very seldom of great magnitude, so that a non-porous material and one that is at the same time impermeable under moderate pressures is the logical one to use for this type of construction.

A concrete mixture in the proportions of 1 part of cement, 2½ parts of sand, and 5 parts of gravel or broken stone, together with 10 per cent. of oil based on the weight of cement in the mixture, should prove amply rich for most situations. A wall of these proportions, 12 in. thick and provided with a spread footing, will withstand a pressure of 6 ft. of earth. When supported at the top by floor joists, a much thinner wall may be used with safety. A 6-in. wall 7 ft. high may be used to withstand 6 ft. of earth pressure. Generally speaking, such a thin wall should be reinforced by rods spaced about 2 ft. apart in both directions. Smooth rods should not be used in oil-concrete mixtures, however, since the bond or adhesion of such rods is practically nil. Any of the many types of deformed bars, made especially for reinforcing, may be used with perfect results. Care should be taken that the earth is not filled in against the back of the wall for at least four weeks after pouring the concrete, unless the wall is braced on the inside by allowing the inner forms to remain in place.

Many basement walls now built of stone, brick, or concrete are giving trouble through leakage. The application of a plaster coat of oil-mixed mortar in the proportions of 1 part of cement to 2 parts of sand, together with 5 per cent. of oil, and mixed with enough water to form a rather stiff mortar, will prove an efficient remedy for this trouble. The surface to which this mortar is to be applied should be roughened with a stone hammer, if the old wall is of concrete, or the mortar joints should be raked out to a depth of half an inch from brick or masonry walls. The acid wash previously described should be applied to cleanse the surface thoroughly, after which the loose particles must be removed with a wire brush or a stiff bristle brush. It will be impossible to obtain a water-tight coating if it is applied while water is seeping through the wall. It will be well to wait for the dry season, when the ground water is reduced to its lowest level, before attempting to waterproof by plastering. Should water appear to be coming through a well-defined crack in the wall, calking with oakum or cotton may be resorted to in order to stop the leakage until a plaster coat of oil-mixed mortar can be applied. It will be necessary to mix the mortar for plastering to a rather dry consistency, and it should be troweled hard in order to obtain a hard, dense waterproof surface. A wash of cement and water mixed to the consistency of thick cream and applied before the oil-mixed mortar coat will aid the new mortar in adhering to the old work. The old wall must be thoroughly wet before the new mortar coat is applied.

Watering Troughs.—The use of oil-mixed concrete in the construction of watering troughs will be found to give excellent results in maintaining them in an absolutely water-tight condition.

For this purpose a mixture of 1 part of Portland cement, 2 parts of clean coarse sand, and 4 parts of gravel, ranging in size from ¼ in. to 1 in. is recommended. The mixture should likewise contain 10 per cent. of oil based on the weight of cement and should be mixed to a jellylike consistency. It will be well to provide wire-mesh or steel-rod reinforcement for the bottom and walls. Care should be taken to puddle the concrete into place thoroughly and to trowel or spade the material adjacent to the molds. This flushes the mortar to the surface, making it smooth and dense, and rendering a finishing coat of plaster unnecessary. Should a very smooth surface be desired, an effective finish may be obtained by applying several paint coats of oil-mixed cement grout made as follows: Enough water should be mixed with cement to form a paste of soft, putty-like consistency. To this paste should be added 3 per cent. of oil, based on the weight of dry cement in the mixture (a 10-quart bucket of dry cement requires about a pint of oil for this purpose); and the whole should be mixed until the oil is entirely combined with the other ingredients. The paste may now be thinned down with more water to the consistency of cream, after which it may be applied with a stiff brush to the previously dampened concrete. A second coat of this oil grout should be applied after the first coat has hardened. care should be taken that it does not dry out too quickly by applying it to the dry concrete or exposing it to the direct rays of the sun. A tank built as described will be absolutely water-tight, and, furthermore, the waterproofing will have cost almost nothing in comparison with the costs of the other materials.

Cisterns.—For waterproofing cisterns, oil-mixed concrete will prove of great benefit. It is absolutely necessary that cisterns which are buried in the ground be waterproofed to prevent contaminated ground water from seeping in, as well as to prevent the cistern water from escaping. Buried cisterns of rectangular shape should be reinforced to resist the earth pressure, which tends to bulge the side walls inward when the water runs low. The reinforcement should, therefore, be provided on the inside or tension side of the walls. The earth pressure will prevent the tank from cracking when it is full of water.

For cistern construction a mixture composed of 1 part of cement, 2 parts of sand, and 4 parts of gravel or broken stone, together with 10 per cent. of oil, is effective. The inner faces of the cistern should be painted with an oil-mixed cement grout applied with a stiff brush and rubbed well into the face of the wall. Two coats of this grout, containing about 3 per cent. of oil, should be used.

Barns.—Barns constructed of concrete are gradually coming into use, because of their durability, cleanliness, resistance to fire, and economy. It is essential that the interior of these structures be kept free from moisture, and for this reason it is well to waterproof the concrete mixture entering the side walls and flooring. The side walls, unless waterproofed, have a tendency during a long beating rain to absorb and retain much moisture, and this moisture penetrates to the interior.

If oil in amount to 5 per cent. of the weight of cement be mixed with the concrete used in the side walls, this damp condition of the interior becomes impossible, because the admixture of oil prevents the penetration of the moisture.

Barn floors should be waterproofed by the addition of oil as previously described. A damp-proof floor has the advantage of remaining dry and hence warmer, because there is no evaporation from the surface. It is likewise more sanitary than an ordinary concrete floor because of its non-absorbent character.

Concrete Blocks.—The use of concrete blocks in the building trade is yearly increasing. Much criticism has been heaped on the building block, and in many cases the criticism has been just. It is recognized that many concrete block houses are damp, owing to the fact that the walls are very porous, and absorb and retain much moisture after a heavy, beating rain. A building block generally need not be waterproofed against water pressure, but it should, however, be rendered proof against the permeation of water by absorption. The use of a small quantity of mineral oil in a concrete block renders it extremely non-absorbent, so that even after a hard rain there is no danger from damp walls. In a 1:2:4 mixture, 5 per cent. of oil is a sufficient quantity to waterproof properly against absorption.

Roofs.—Portland cement mortar mixed with mineral oil and reinforced with steel-wire mesh may be advantageously used in the construction of roof slabs. These slabs could be assembled in place on the roof after they had attained sufficient hardness. Reinforced concrete tiles may also be advantageously made with Portland cement concrete mixed with a small percentage of mineral oil residuum.

Stucco.—Portland cement stucco is widely used in the construction of many residences. This type of canstruction is economical, and, moreover, with it many beautiful effects are possible. The term "stucco" is given to the exterior finish coat, which may be applied to brick, stone, concrete, hollow tile, or frame construction. According to the finish desired and the kind of surface to be covered, the stucco is applied in two or three coats. The first, or scratch coat, should be mixed in the proportions of 1 part of Portland cement and 2 parts of clean, coarse sand, with enough water to form a good, stiff mortar. If 5 per cent. of oil is added to this mixture, the scratch coat will be permanently waterproof. While this coat is still wet, it is roughened with a stick or trowel over the entire surface. The second coat, which may be of the same proportions, is plastered on after the first coat has set sufficiently to support it. The use of oil in this coat may be omitted if desired, and it may be given a rough-cast finish by using a trowel covered with burlap or carpet.

This second coat may also be applied by throwing it on with a wooden paddle. This produces a rough surface known as a slap-dash finish. A pebble-dash surface may be obtained from the use of pebbles ¼-in. in diameter, mixed with cement in the proportions of 3:1, with a mixture that is quite wet. This mixture is thrown on the second coat while it is still soft and the result is a very pleasing surface. When a pebble-dash finish is used, the second coat, as well as the scratch coat, may be mixed with oil. In most constructions the second coat will be found superfluous, because a sufficiently thick coating is usually obtained from the first application of oil-mixed mortar.

When stucco is applied to stone or hollow tile, care should always be taken to have the surface well moistened or otherwise a great deal of water will be absorbed from the mortar coat, and so greatly weaken it and cause contraction cracks to form.

Engineering Construction.—There are many important engineering constructions in which oil-mixed mortar or concrete may be advantageously employed. Among them may be mentioned aqueducts, buildings, burial vaults, boats, foundations, gutters, mausoleums, roofs, sewers, trough, tanks, and wells. In some constructions a coat of oil-mixed mortar is effective, while in others oil-mixed concrete may be used throughout.

It is confidently believed that, if carefully prepared, oil-mixed concrete is used in structures of any kind requiring damp-proofing—and in such structures careful work is a very important factor in the result—there will be no difficulty experienced from leakage and the structures will have been damp-proofed at very little extra expense.

Summary of Conclusions.—The following conclusions as to the effect of the oils used in cement and concrete may be drawn from the investigations into the physical properties of oil-mixed concrete:

(1) The tensile strength of 1:3 oil mixed mortar is very little different from that of plain mortar, and shows a substantial gain in strength at 28 days and 6 months over that at 7 days.

(2) The times of initial and final set are delayed by the addition of oil; 5 per cent. of oil increases the time of initial set by 50 per cent. and the time of final set by 47 per cent.

(3) The crushing strength of mortar and concrete is decreased by the addition of oil to the mix. Concrete with 10 per cent. of oil has 75 per cent. of the strength of plain concrete at 28 days. At the age of 1 year the crushing strength of 1:3 mortar suffers but little with the addition of oil in amounts up to 10 per cent.

(4) The toughness or resistance to impact is but slightly affected by the addition of oil in amounts up to about 10 per cent.

(5) The stiffness of oil-mixed concrete appears to be but little different from that of plain concrete.

(6) Results of tests for permanent deformation indicate that no definite law is followed by oil-mixed concrete.

(7) Oil-mixed mortar and concrete containing 10 per cent. of oil have very little absorption and under low pressures both are waterproof.

(8) Oil-mixed mortar containing 10 per cent. of oil is absolutely water-tight under pressures as high as 40 lb. per square inch. Tests indicate that oil-mixed mortar is effective as a waterproofing agent under low pressures when plastered on either side of porous concrete.

(9) The bond tests show the inadvisability of using plain bar reinforcement with oil-concrete mixtures. The bond of deformed bars is not seriously weakened by the addition of oil in amounts up to 10 per cent.

EUROPEAN DEMAND FOR COPPER.

For the past few days Europe has been buying copper metal, and one of the large selling agencies in New York has sold 10,000,000 pounds at 17¾ cents per pound.

A NEW WATER PURIFICATION PLANT.

The city of Fargo, North Dakota, has recently installed a new water purification plant, the water supply being drawn from the Red River.

Originally water was used from the Red River for all purposes. It was hauled about the city and sold as a commodity. At a later date, about 1879, a pumping station was installed and water supplied through mains laid under a franchise by a water company. This source of supply and method of distribution was satisfactory until the water shed became settled and the river became contaminated by the run off from farms and possibly from sewage from the growing cities situated on the river above this city.

There were other objectionable features of the water for a domestic supply and in the early 90's a number of artesian wells were put down in the western part of the city. These wells produced a supply of good water but it was exceedingly hard, and considerable discussion was carried on from time to time as to the desirability of using a water carrying a large amount of mineral solids in solution.

The difficulty of obtaining a satisfactory supply of water led to many investigations as to ways and means of bettering it. At length the city engineer, Mr. Frank L. Anders, was directed to prepare plans and specifications for a rapid sand filtration plant. A brief description of the plant adopted, based on matter contained in Mr. Anders' latest report, is here given.

The river intake is substantially constructed of cedar piling faced with fir sheet piling to prevent any movement of finely divided silt into the wet well. The outer end of the intake is constructed so that water will be taken from as near the surface as seems desirable. It is also fitted with a screen made of flat boiler plates, which will prevent any leaves or sticks from entering the intake. The intake is connected to a wet well by two 18-inch cast iron pipe lines. The well is constructed of concrete, and in two sections. Either section may be cut out of service for cleaning for one of the purposes of the well is to catch mud before it enters the suction line. The well is fitted with the necessary valves for changing the course of the water from one chamber to the other.

From the wet well to the low lift pumps the distance is about 800 ft. and connection is made between the two by an 18-in. suction line. This line is cast iron flanged pipe and at the upper end is connected to two low lift pumps. These pumps comprise that part of the plant that lifts the water from the river and delivers it to the purification plant. The pumps are the centrifugal vortex type, built by Lawrence manufacturing Co., and are driven by Sturtevant turbines directly connected to them. The combined capacity of the two pumps is 5,000,000 gals. per 24 hours. The low lift pump pit is a concrete structure, its floor elevation being 880 and the top of the roof 906. It is 22 ft. in diameter. Ample space is obtained in the pit for the installation of another pump at some future time if necessary.

Upon leaving the low lift pumps the water is conducted through a 16-in. discharge line connected to the mixing chamber. At this point it is treated with a solution of lime for the purpose of softening it. The mixing chamber is built of reinforced concrete, and is 23 ft. wide, 53 ft. long and 18 ft. deep. It is fitted with vertical baffles that cause the water to flow up and down through them, traversing a distance of over 1,000 ft. and being kept in a state of agitation in order that the chemical reactions may be completed. This process is one of the most important that takes place in the plant, and one that will have the greatest bearing on the acceptability of the purified water.

Upon leaving the mixing chamber, the water passes into sedimentation basin No. 1. As it enters this basin a coagulant may be added which also has a very important function to perform. The coagulant, which may be either sulphite of iron or sulphite of aluminum, decomposes and forms a hydrate, also known as floc. This is a light snow-flakelike material, which makes its appearance soon after the addition of the coagulant to the water. The cross section of the basins are such as will give a very low velocity to the water, and this is necessary in order that the floc may settle and leave the water clear. The proper design of these basins is an important part of the work, for the greater part of water purification is done in them. As the floc forms and settles, it enmeshes and carries with it most of the turbidity and a great part of the bacteria, thus relieving the filters of a heavy load they would otherwise have to carry.

There are two sedimentation basins, each with a capacity of about 1,000,000 gals. In case the chemical reactions and subsequent settlement is completed in basin No. 1, the water may be conveyed to basin No. 2 and thence to the filter. Or, if the reactions are completed in No. 1, the water can be conveyed from it directly to the filters. The mixing chamber can be cut out entirely and the basins used with it or the two basins used in parallel. In order to prevent after deposits from the lime action, raw water can be added as the treated water passes from the basins. This is sometimes necessary and is the most effectual device known for this purpose.

A conduit constructed of concrete conveys the water from the sedimentation basins to the filter house and thence along the centre lines of the pipe gallery in front of the filters. Connecting the conduits to the filters there are inlet chambers fitted with proper valves to conduct the flow of water into the proper chambers.

The filters are four in number, completely installed, and two more can be completed at a small additional cost. They are constructed of reinforced concrete throughout, and are 17 ft. by 21 ft. in area. Each will have a capacity of 1,000,000 gals. per day, exclusive of wash water.

The filters are furnished with a cast iron manifold system set in concrete. On top of the manifold there is laid 10 ins. of a carefully graded filter gravel and 30 ins. of a carefully prepared silica sand. Wash water boxes, two in number, run longitudinally with the filters.

The treated water passes on to the sand from the inlet chamber, thence through the sand, gravel, manifolds, drains and controllers to the clear well, where the purified water is stored until required for use. The clear well is underneath the filters, protected from all contamination and fitted with baffle walls to keep the water in circulation.

The filters need cleaning at certain periods, and this will be accomplished by reversing the flow of water through the sand and conveying the dirty water through a sewer to the river below the dam. The sand is agitated during washing by air conveyed to it by a suitable pipe system.

The most important parts of the plant installation are the filter controllers. Careful consideration was given to all the types of controllers now in use and it was decided to use the Earl filter controller. The advantages of this piece of apparatus are many, and it has no equal for the duty it is called upon to perform. Its action is such as to keep the clear well full of water at all times and it will meet the varying rates of consumption without the attention of the operator.

The head house is located directly west of the filter house, and is a two-story structure of brick and concrete. In the basement there is located the wash water and air pumps, bathroom, machine shop, etc. The laboratory, superintendent's office, chemical controllers and part of the solution tanks are on the first floor, while the second floor is devoted to storage of chemicals and their preparation for addition to the raw water.

No function of a water purification plant is more important than that of properly adding the chemical solution to the raw water. The rate of consumption of water in the city of Fargo varies from about 500,000 gals. to probably about 4,000,000 gals. per 24 hours. The raw water has to be treated to meet this varying rate, and the usual method is to pass the chemical solution through an orifice having a known discharge. This orifice needs the attention of the operator in order to meet the varying rate of raw water discharge. It is at once apparent that the operator cannot do this, however faithful he may be, for he does not, at all times, know what conditions he has to meet. The whole problem is satisfactorily solved by the installation of the Earl chemical feed controller. This device automatically meets, at every instant, the varying rate at which the raw water may be passing into the mixing chamber and the proper chemical is at all times fed to the raw water at a rate proportionate to the consumption. By the use of this device over-dosing and its ill effects are eliminated, as is also under treatment of the water. The operator can rest assured that the water is at all times being properly treated.

The plant is constructed throughout of reinforced concrete, except the buildings, which are faced with Twin City terra cotta tile and lined with common brick. The roofs are trussed with steel, sheathed with fir and finished with green glazed tile.

NATIONAL STEEL CAR COMPANY.

The National Steel Car Company has been incorporated for the purpose of building and operating a plant for the manufacture of wood and steel freight cars. The location of the plant will be at Hamilton, Ont., and the head office at Montreal. The authorized capital is three million dollars seven per cent. cumulative preference stock, and three million dollars common stock, of which $1,500,000 par value preference and $2,000,000 par value common will be issued. The amount issued is considered adequate for the building, equipping and operating of a thirty-car plant, while sufficient stock is retained for future growth. The principal Canadian railroads experience considerable difficulty in placing orders with existing firms for a quick delivery, and this the National Steel Car Company begins business with an existing demand for its products. The estimated average earnings working at sixty per cent. of its capacity is given as $400,000, which is sufficient to pay the 7 per cent. dividend on the preferred stock, and leaving $295,000 available for common stock dividend.

The management of the company will be in the hands of Mr. Basil Magor, president of the Magor Car Company, Passaic, N.J., who is resigning that position which he made a success, believing in the possibilities offered in Canada. Mr. A. Butze, for many years purchasing agent of the Grand Trunk Railway, will act as the company' purchasing agent.

The cost of construction of the plant has been estimated by Messrs. Barclay, Parsons and Klapp, consulting engineers, as $649,730. The house of issue is Messrs. Brouse, Mitchell, members Toronto Stock Exchange, Colborne Street, Toronto. Sir John Gibson, Sir Henry Pellatt, C.V.O., Toronto; Messrs. W. K. Price, New York; C. H. Cahan, Montreal; M. H. Coggeshall, New York; M. Davis, Montreal; Basal Magor, Montreal; W. Barclay Parsons, New York; W. G. Ross, Esq., Montreal; J. J. Scott, and W. Southam, Hamilton, have consented to act as directors.

TO USE LOCAL WOODS IN BRITISH COLUMBIA

An idea with regard to wood creosoting was laid before the forestry branch, province of British Columbia, by Mr. Skinner, who has charge of the construction of the C.P.R. docks in Vancouver.

These docks are being built of eucalyptus wood brought from Australia. This wood is preferred because its gummy quality enables it to resist the teredo longer than will any of the native woods of British Columbia. The Douglas fir, however, if properly creosoted, will last longer than the eucalyptus. Moreover the Crow's Nest coal, it is said again, on Mr. Skinner's authority, is the best in America for creosoting purposes. These two factors combined seem to him to offer opportunity for a new industry. The idea is especially interesting to the forestry branch because if creosoted blocks can be introduced as paving material, there will be a chance to utilize much of that part of the tree which is now left in the bush and wasted.

MUNICIPAL POWER PLANT FOR GRAND MERE, QUE.

The corporation of Grand Mere, Quebec, has awarded to Allis-Chalmers-Bullock, Limited, Montreal, the contract for the complete hydro-electric power plant for municipal lighting and power purposes. The plant will include a single horizontal turbine 500 h.p. 600 r.p.m. under 100 feet head and an alternating current generator 300 k.v.a., 3-phase, 60-cycle, 2,200-volt, 600 r.p.m. with direct connected exciter 125-volt, 600 r.p.m. The turbine will be in cast iron spiral case with quarter turn and single discharge. The runner will be of bronze cast in one piece, the guide vanes of steel and the inside parts bronze lined. The unit will be compact, easily operated and thoroughly up-to-date and will have an over-all efficiency of 80 per cent. The contract also includes an oil pressure governor, step-up transformers from 2,200 to 11,000 volts, step-down transformers from 10,000 to 2,200 volts. Service transformers 2,200 to 110 volts. Switchboards and other auxiliary apparatus. Messrs. Surveyer and Frigon were the consulting engineers.

PERSONAL.

MR. R. B. LAMB has resigned his position as consulting engineer with the Crown Chartered Mine.

MR. RALPH STOKES has been appointed as assistant to Consulting Engineer Mein, of the Canadian Mining and Exploration Company.

MR. L. S. COCKBURN, a graduate of the University of Toronto in engineering, and MR. E. L. WENGER, B.Sc., have become partners under the firm name of Wenger & Cockburn, consulting engineers, with headquarters in Regina, Sask.

MR. R. D. BROWN, city engineer of St. Catharines, Ont., has resigned from his position in order that he may be free to accept a position offered him in the services of the government, under Mr. Weller, superintendent of the new Welland Canal.

MR. E. S. JENISON, formerly with the Henion & Hubbell Company, of Chicago, Ill., has been appointed manager of the pulp department of the Canadian Fairbanks-Morse Co., Limited, who are now the exclusive sales agents in Canada for the triplex and power pumps, as well as the other lines manufactured by the Goulds Manufacturing Co., of Seneca Falls, N.Y.

MR. A. H. BERGER, until recently the secretary-treasurer of the American Spiral Pipe Works, has organized the Standard Spiral Pipe Works of Chicago. The latter company will manufacture reinforced spiral steel pipe with interlocking seam and smooth inside, for water supply, irrigation, derdging, pulp mills, etc. Mr. Berger made a trip West recently and demonstrated the merits of his pipe to a number of prominent engineers in British Columbia.

MR. C. M. WATERMAN, treasurer of The Eugene Dietzgen Company, manufacturers of drawing materials and mathematical and surveying instruments, left Toronto last week for a six weeks' tour of Western Canada, in the interests of his firm. The Canadian business of The Eugene Dietzgen Company has been growing very rapidly within the past year and, while West, Mr. Waterman will undoubtedly find many further opportunities for expansion.

COMING MEETINGS.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, TORONTO SECTION.—First regular meeting will be held at the Engineers' Club, 96 King St. West, on Friday evening, October 4th, 1912, at 8 p.m. Secretary, W. E. Young, 212 King St. West, Toronto.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Annual Assembly will be held at Ottawa, in the Public Library, on 7th October, 1912. Hon. Sec'y, Alcide Chaussé, 5 Beaver Hall Square, Montreal, Que.

THE CANADIAN HIGHWAY ASSOCIATION.—Meeting will be held in Winnipeg, Man., October 9th to 12th. Secretary, P. W. Luce, Room 4, Cunningham Block, New Westminster, B.C.

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

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

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

ENGINEERING SOCIETIES.

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

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

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

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

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

VANCOUVER BRANCH—Chairman, C. E. Cartwright; Secretary, Mr. Hugh B. Fergusson, 409 Carter Cotton Bldg., Vancouver, B.C. Headquarters: McGill University College, Vancouver.

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

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

MUNICIPAL ASSOCIATIONS

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

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

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

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

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

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

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

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

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

UNION OF MANITOBA MUNICIPALTIES.—President, Pipestone, Man.: Secy-Treasurer, Reeve Cardale, Oak River, Man.

CANADIAN TECHNICAL SOCIETIES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CANADIAN STREET RAILWAY ASSOCIATION.—President, Jas. Anderson, Gen. Mgr., Sandwich, Windsor and Amherst Railway; Secretary, Acton Burrows, 70 Bond Street, Toronto.

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

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

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

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

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

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

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

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

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

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

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

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

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

ONTARIO ASSOCIATION OF ARCHITECTS.—President, A. F. Wickson; Toronto. Secretary, H. E. Moore, 195 Bioor St. E., Toronto.

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

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

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

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

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

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

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

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

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

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

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