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HIGHWAY BRIDGES AND CULVERTS.

The question of municipal highway bridges and culverts grows in importance concurrently with the increased attention given to the matter of good roads; in fact it is the cost of these highway accessories that brings the cost of road improvement higher in one locality than another, and while thought and discussion is being given, in many municipalities, to good road construction, it is an established fact, as recently exemplified by the many disasters accompanying the spring freshets, that there is a dire need for general improvement in small bridges and culverts.

A recent bulletin issued by the Office of Good Roads, U.S., by Chas. H. Hoyt and William H. Burr, takes up the whole question of highway bridges and culverts in a concise manner. Some abstracts are presented herewith. A practice which has been in vogue and which has had an injurious effect, especially in the design of highway bridges, is the method of inviting bids upon the bidder's own plans without having a competent and disinterested engineer to pass upon the designs submitted. The total weight of the steel and the amount of shop work necessary to make good, strong connections determine largely the real as well as the economical cost of the bridge. The desire to secure the contract encourages the effort, under such conditions, to make the design light enough in weight to get the contract regardless of whether the bridge is designed to carry its load with a fair factor of safety.

Still a third matter which also has had an injurious effect upon the design of bridges, and which should be avoided in all cases, is the determination of those acquiring the bridge not to pay more than a fixed amount, which has been decided in advance, without sufficient information, such as reliable engineering inspection, preliminary plans, and estimates. The plan to be observed should consist of the following steps:—

(1) The services of a capable bridge engineer should be secured.

(2) The foundations should be tested to determine suitability, bearing power and economy.

(3) The location should be determined with a close approximation and a profile of a centre line made, showing also the results obtained by testing the foundations.

(4) The load which the bridge may be called upon to carry safely, anticipating reasonably the demands and growth of the future, should be decided upon. All highway bridges, at least those on main roads, should be designed to carry concentrated loads, such as road rollers or traction engines weighing from 10 to 15 tons each, with a reasonable factor of safety. Unfortunately for the traffic of to-day many of the present highway bridges were designed to carry only moderate uniform loads, and on this account for their light appearance and their inadequacy to meet present demands.

(5) After these facts have been determined, the engineer will be able to prepare plans for the foundations, abutments, piers, and the bridge itself, all of which may be designed to meet economically the conditions of the location selected. An estimate of the cost may be made and this should in all cases be used as the basis for an appropriation for the bridge.

The amount of attention and skill to be given to the foundations for any structure depends, first, upon the size and importance of the structure proposed, then upon the loads it must carry, and finally upon its type. To avoid misunderstanding, it may be stated that the word "foundation" is used throughout this bulletin to mean the natural bed or material upon which rest the footings for the piers or abutments for a bridge, or the walls or floor of a culvert. This bed may be either rock, sand, gravel, clay, or any other natural material, or an artificial foundation prepared of logs or other material, or it may be piles driven to support the structure.

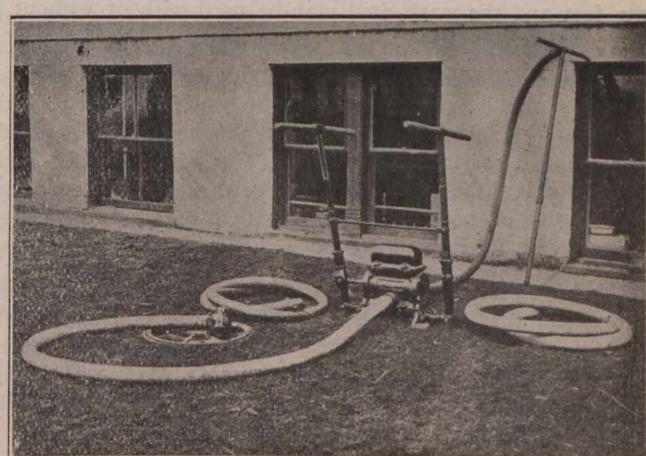

Fig. 1.—Wash-Drill Outfit for Testing Foundations.

For many of the smaller box culverts of spans varying from 2 feet to 8 feet and carrying only ordinary loads, the ordinary earth foundation is sufficient in most cases, with proper protection against undermining by currents of water. Where the streams are sluggish, however, or where the culverts are located in swamps and the foundations are soft and wet, a few logs from 10 to 12 inches in diameter, which are placed below in trenches and upon which the footings rest, add much to the stability of the foundation.

The logs, as shown in Figure 1, may be placed close together, or in many cases it will be sufficient to place them about 3 feet apart, centre to centre. The advantages of this type of foundation are that it distributes the pressure and tends to prevent uneven settlement or tipping of the side walls.

The suitability of foundations for the more important structures can be safely determined only by tests. This can be done best by digging test pits wherever conditions will permit. In this way a better idea can be gained of the actual material in the foundation than by any other method.

Where conditions do not permit test pits, an iron rod may be driven to depths of from 10 to 20 feet, unless rock is encountered before that depth is reached. This method, however, gives very little idea of the material through which the rod is driven. A somewhat better way is to drive down 1-inch extra heavy iron pipe, which may be cut into 4-foot lengths coupled together as driven. A driving cap should be provided and the driving should be done with wooden mauls. Pipe has been driven in this manner in the winter months to a depth of about thirty feet or possibly more. The pipe, after being driven, may be pulled out with a small chain and lever, so that a sample of the material through which the pipe was driven may be brought up inside it. This material can then be examined as the pipes are uncoupled and cleared out. Material that sticks in the pipe may be loosened by placing the four-foot section of pipe in a small fire sufficient to generate steam from the moisture in the material, which, as it expands, forces the material out of the pipe. Great care should be exercised to have only sufficient fire to generate the steam slowly, or otherwise the material may shoot out the ends with considerable violence, or the pipe may burst and the flying fragments cause serious injury to persons in the immediate vicinity.

One of the best ways to test a foundation is with a wash drill outfit, consisting of a drill point to which is coupled 1-inch iron pipe in four-foot lengths. Water is forced through this pipe by a double acting force pump. Tests have been made with such an outfit to a depth of sixty feet and the wash drill may be used with or without a jacket pipe.

Figure 1 illustrates a wash drill outfit suitable for this use and which consists of a double acting force pump, with a cylinder 5 inches in diameter, a 5-inch stroke, a 2-inch suction and a 1½-inch discharge. The pump is fitted with two 12-foot lengths of suction hose with a strainer, two 12-foot lengths of pressure hose, twelve 4-foot lengths of 1-inch extra heavy iron pipe, and a drill point.

The kind of material in the foundation determines to some extent the size of the footings for the structure, with due consideration to the weight to be borne and the bearing power per square foot of the material. Rock makes the best foundation and should be used when it occurs at available elevations.

A great many tests have been made to determine the bearing power of other materials, and, while there is much variation in results, the following figures are given as indicating the range of values obtained and, in the absence of more definite information, they may be used as allowable working loads:

Material.	Bearing power (tons per sq. ft.)
Quicksand and wet soils	0.05 to 1.0
Dry earth	1 to 1.5
Moderately dry clay	2 to 4
Dry, stiff clay	4 to 6
Sand	2 to 4
Sand, compact and cemented	4 to 6
Gravel, cemented	8 to 10
Rock	200

There is, however, no definite rule by which the bearing power of a material can be determined absolutely without applying test loads and noting the amount of settlement caused by them. With the smaller highway bridges and culverts, which are the commonest built, an experienced builder is usually governed by his experience and good judgment concerning the suitability of a particular foundation to carry the proposed structure, but for any structure involving a considerable expenditure a careful test should be made.

Arch bridges or culverts especially require an unyielding foundation and are more than likely to fail unless such is provided. Consequently, they should not be built except where a good rock or gravel foundation is to be had, or possibly where a satisfactory foundation can be made by driving piles. Attention should be called to the fact that piles may be driven in an inclined position, and thus be able to resist the arch action directly.

The bearing power of piles may be determined for practical purposes, where comparatively stiff material is found, by the following formula:

$$\text{Safe load} = \frac{2\ WH}{S + 1}.$$

Here W = weight of hammer in tons or in pounds (the safe load is considered as in the same unit); H = its fall in feet; and S = the penetration in inches under the last blow. Results thus obtained, when compared with actual tests, show that this formula has a factor of safety varying from 2 to 7 or 8. It can be used properly, however, for comparatively stiff material only, for in soft material where long piles are to be used, it fails to give rational results.

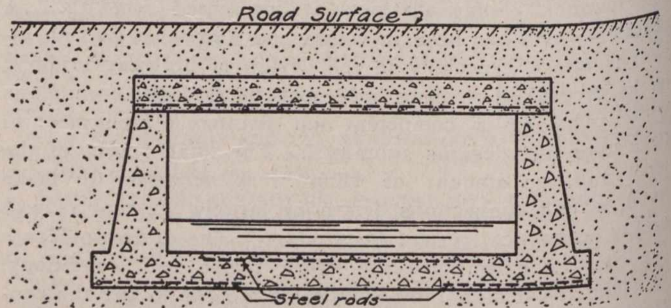

Fig. 1a.—Reinforced Concrete Floor, for Distributing Pressure Over a Greater Area and for Protecting Foundation from Erosion.

In locations where great depths of mud are found, piles are often driven that do not find a solid foundation, and the driving might be continued indefinitely, but, after leaving such piles for a few days, it is often found that several blows are required to start them again. This indicates that their bearing power has increased after the driving has stopped. It is a common practice to accept such foundations for certain structures as the best that can be secured, although they sometimes yield. In bridge construction, however, the success or failure of the structure depends much upon the foundation and too much care can scarcely be given to this part of the work.

It often happens that, after having tested the foundation and after considering the suitability of the material found, together with the elevation at which this material is available, it becomes desirable to shift the location of the bridge in order to secure a more economical substructure. For example, a suitable material for foundation may be found at a more convenient elevation in one place than in another, and this may materially reduce the cost of piers and abutments without injuring the alignment of the road seriously. In some cases it may even improve the alignment.

A survey and profile of the location should be made to establish the grade of the road. From these the amount of excavation and back fill may be determined, as well as other quantities, distances, and elevations needed in preparing plans and in the execution of the work.

The simplest type of bridge or culvert that will be considered here is the wooden plank floor bridge for very short spans. This may be strengthened for increased spans, up to certain limits, by supporting the floor upon logs or sawed timbers. The life of timber, especially in bridges and culverts, is at best only a few years, in some cases ten, but usually, in the flooring at least, it is not more than three years. The price of timber is constantly advancing, and the liability of accidents from misplaced, worn-out, or broken plank is very great. While a timber bridge admits of theoretical design, there is no real need for its use to be encouraged, and it is the purpose of this article to deal with types of construction of a more permanent and substantial nature, such as concrete and steel.

The simplest form of concrete construction for bridges or culverts is the concrete floor or slab, corresponding to the wooden plank floor mentioned above. The concrete slab may be used for greater spans than the plank floor, and it may also be strengthened for greater spans by constructing concrete beams beneath the floor to support it. This is then known as the "T-beam" type of construction.

These types of concrete construction may be strengthened further by placing steel rods, expanded metal, or woven-wire cloth near the bottom of the slab, and steel rods near the bottoms of the beams. The advantages of using the steel reinforcement are that it has a greater tensile strength than concrete and that its location in the lower part of the concrete slab or beam brings it into tension when the beam is loaded. (Fig. 2a.) Moreover the compressive strength of concrete is greater than its tensile strength, and therefore the steel strengthens that part of the concrete structure which is subject to tensile stresses and is most liable to fail first.

This method is therefore more economical and makes it possible to bridge greater spans, within practical limits of cost, than can be done with plain concrete alone.

The application of the concrete slab is to be found first in the construction of box culverts. (Pl. V., Fig. 2.)

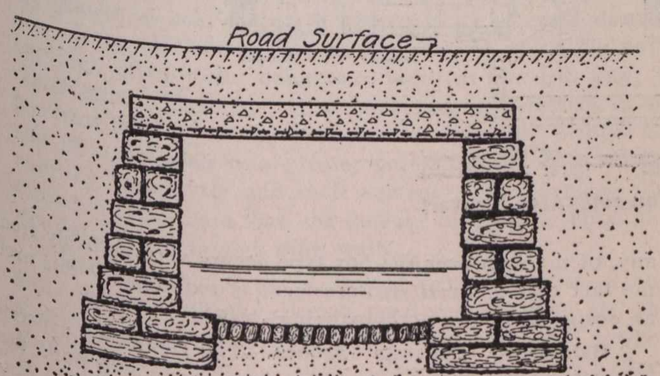

Fig. 2b.—Reinforced Concrete Slab on Masonry Abutments.

The box culvert gets its name from its similarity to a box with open ends. It has a floor, which may be of plain concrete or may be paved with stone. The two sides and wing walls at the two ends may be of plain concrete or reinforced with steel, but the cover and parapets should always be of reinforced concrete.

The sketch shown in Fig. 3a is made from a working plan prepared for a concrete box culvert, which has an opening 2 feet wide by 2 feet high.

This type of construction is practical under the majority of conditions for spans up to about 8 feet, which, as a matter of fact, forms a large percentage of all the culverts needed. Conditions may occur where it will be practicable to apply the box type, with some modifications, to greater spans than those mentioned, such as where the foundation is soft or liable to much erosion from swift currents. The floor may then be reinforced with steel, so that it will have greater strength to act as a beam to distribute the load over a greater area. It may also be extended back of the side walls to act as a footing. With suitable "cut-off" walls

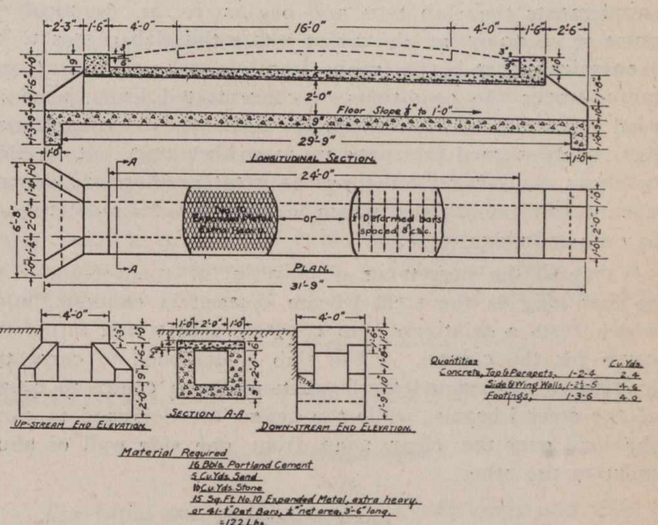

Fig. 3a.—Plan for a Concrete Box Culvert.

to prevent currents of water from running beneath this floor, the foundation will be well protected from erosion. Under such conditions this modified type, with further modifications in the cover, which will be discussed later on, may be practical for spans up to 20 or 30 feet. Figure 2a illustrates the principle under discussion. Here the reinforced concrete floor serves the same purpose as the logs, but the result is more permanent.

The length of the spans over which reinforced concrete slabs may be built within the limits of practicability and safety depends much upon the loads to be carried. The depth and amount of fill over the culvert, which may distribute the effect of the concentrated load, is also an important factor.

On main roads, where concentrated loads, such as road rollers or traction engines, are to be provided for and the depth of fill over the culvert is sufficient only to provide a cushion of earth from 1 to 2 feet in depth, the concrete slab is practical for spans up to about 10 or 12 feet, while for greater spans than this, under these conditions, other types better adapted to the longer spans should be used.

Under conditions of less severe loading the spans for the slab may be increased up to 16 or possibly 20 feet, but it does not seem advisable to use them for these greater spans in view of the possibilities of a nominal future growth of traffic requirements.

In some localities conditions may be favorable for building the footings and side walls of quarried or suitable field stone laid in cement mortar. While these will not prove more satisfactory than good concrete, it may be a matter of economy to do this, because of the saving in expense in crushing the stone for concrete. The reinforced concrete slab may be built quite as well upon such walls.

There are also many cases where masonry walls are already built, but have a poor wooden floor for the bridge. These floors may be replaced with a substantial reinforced concrete slab, which will be permanent.

Traffic should not be allowed directly on the concrete surface of the slab. Consequently it may be necessary to take off the top of the masonry abutments, so that the slab may be set low enough to allow an earth cushion about 18 inches in depth to be placed on the concrete slab. There are also many other locations where the present bridge is set so low that it improves the grade of the road to construct the slab on the masonry abutments as they are found and then raise the grade of the road by placing the earth cushion over the slab (Fig. 2b.)

The reinforced concrete T-beam type of construction supplements the slab type and begins to be practical in point of economy at the point where the slab ceases to be economical—that is, for spans from about 10 to 12 feet and more—under the conditions of concentrated loads, such as road rollers or traction engines. This type of construction has been designed for spans up to 50 feet long, but whether or not it is practical for spans as great as that may depend upon several conditions, which must be carefully determined in each individual case.

One of the best types of culverts for spans from 10 to 30 feet long is the steel I-beam incased in concrete, upon which rests a relatively thin concrete slab which forms the cover for the culvert. The slab is designed to carry the load for a span equal to the distance from centre to centre of the steel I-beams, while the beams are designed to carry the load over the clear span from one side wall or abutment to the other.

working plan prepared in the Office of Public Roads for a 24-foot span concrete steel I-beam culvert.

Plain Concrete Arches.—The arch culvert is well adapted for locations in deep ditches or ravines, where there is an abundance of "head room," and it may be built over spans from 2 feet up. Many have been built over spans of from 50 to 75 feet in length. The Connecticut Avenue bridge in Washington, D.C., consists of a series of five arches, each 150 feet in span and built of plain concrete. A bridge in Germany has a single arch span of 215 feet, built of plain concrete. These two structures are rather exceptional, however, and are mentioned because of their general interest and not because it is intended to treat in detail of them or of structures of their magnitude in this bulletin. There are some noteworthy structures with a series of arches, and among them may be mentioned the railroad bridge at Rockville, Pa., which consists of 48 arches, each having a span of 70 feet.

The illustration shown in Fig. 3b is made from a working plan prepared for a plain concrete arch-culvert with a 6-foot span, which may be of service more often than those of larger spans.

The difference in the cost between an arch culvert for this span and that for a box culvert of the same span is not a matter of much importance. The advantage, if there is

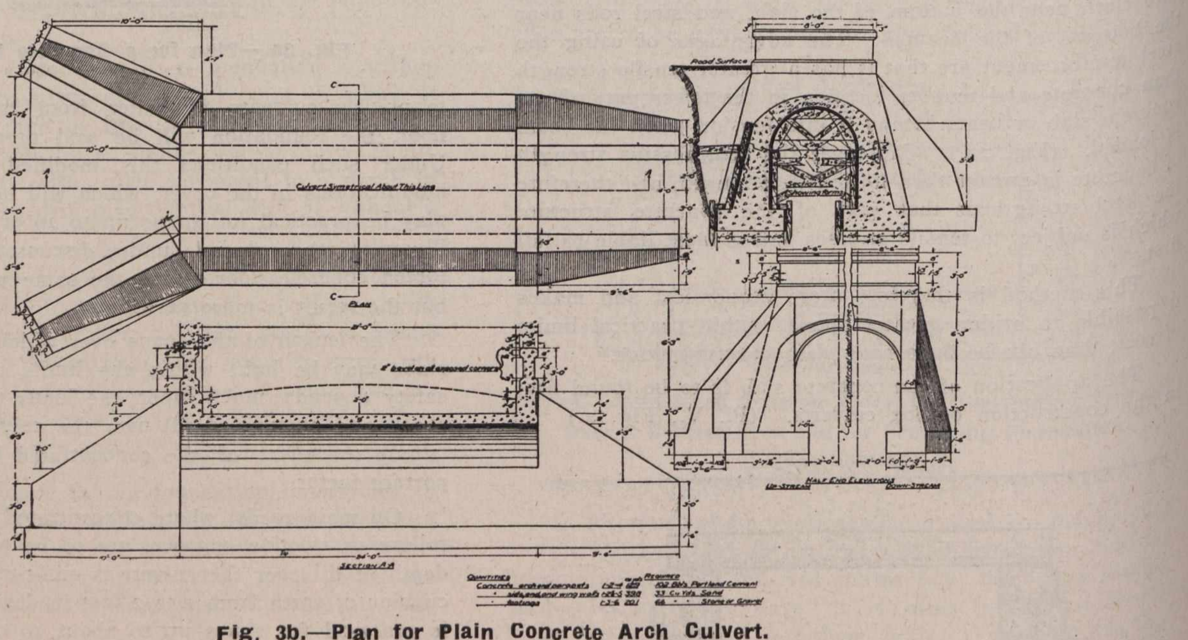

Fig. 3b.—Plan for Plain Concrete Arch Culvert.

Among the best features of this type of construction are its safety and ability to withstand severe and unfavorable conditions, such as the unequal settlement of abutments, which may cause cracks in the concrete that would cause other types to fail. In this type, however, the load is carried principally by the steel I-beams, whose strength is not destroyed by the settlement of the abutments.

Many structures of this type have been built without incasing the I-beams in concrete, but by merely painting the beams instead, to protect them from rust. The painting, however, must be repeated every few years, at some considerable expense. There is, of course, a great possibility that this painting may never be done, and the better way is decidedly to incase the beams in concrete during the construction, and thus protect them permanently.

This type also admits of arch construction between the beams for the floor system. By this means space may be saved in the depth of the floor system that may be of value in locations where the area of the waterway or the "head room" is a controlling factor. Plate VIII. is made from a

any, of the arch over the box type occurs very probably from the fact that no steel reinforcement is required for this arch as designed in the accompanying drawing.

Reinforced Concrete Arches.—The reinforced concrete arch has an advantage over the plain concrete arch in the fact that the curve of the reinforced structure may be made more nearly flat than the plain concrete arch, and thereby save in the total height of the structure. This permits it to be used where it otherwise could not. Under favorable conditions there may be an additional advantage in point of economy, although this can not be stated generally as true in all cases.

The steel reinforcement in the arch curves serves the same purpose as in the concrete slab—that is, to increase the strength of the arch rib where the concrete has excessive tensile stresses. In some cases, however, the concrete is also reinforced against compression. It is also possible, when steel reinforcement is used, to reduce the quantity of concrete in the arch rib from the amount that would be required for a plain concrete arch. The reinforced-arch type of construction may be used for practically the same spans as stated for the plain concrete arches.

Footings for piers, abutments, and wing walls may be required for the purpose of distributing the pressure caused by the weight of the completed bridge structure and its "loadings" over a sufficient area to keep the pressure per square foot within the amount that will be carried safely by the material composing the foundation. In some cases, where the wall is designed for a gravity section—that is, without reinforcement—no footings will be required. This occurs, for example, where the side walls rest upon rock for a foundation. If the wall is of the reinforced-concrete type, then footings are practically always required. The cause for many broken wing walls is the lack of suitable footings under them.

As a matter of practical convenience in construction, footings are very generally built to "true up" uneven places in the foundation, and they are built up to some convenient elevation upon which the walls or piers rest.

The width of the footing is determined from the load to be carried and the bearing power of the foundation material. Its depth is determined from its width and the load carried; and, if constructed of plain concrete or masonry, its depth should be equal to its projection from the pier or wall, or even greater. The depth of the footing required to carry a load may be reduced somewhat by the use of steel reinforcement placed near the bottom to strengthen the projecting portions of the footing.

Another consideration that must not be overlooked in the construction of the footings is their liability to be undermined. They may, however, be protected by "riprapping" or paving around them, or by "cut-off" walls across the stream to prevent erosion of the stream bed at the location in question.

In view of the practice of the past, there is great need for the consideration of the subject of abutments and wing walls.

In many cases abutments and wing walls have not been built at all, but the four corners of the bridge span have been set on cylindrical piers or posts with possibly only a few planks to hold the earth approach. The rapid destruction of the planks and consequent sinking in of the earth approach often make dangerous holes at the two ends of the bridge. This type of construction is defective in the fact that it does not protect, but subjects the bridge and also its approaches to a greater possibility of being washed away by high water and swift currents. The damage thus caused is often more than the amount required to build substantial abutments and wing walls.

The abutment serves a twofold purpose: First, it supports the end of the bridge span resting upon it; and, second, it acts as a retaining wall for the material composing the approach to the span. The wing walls, too, serve as retaining walls and as a protection to the banks or slopes of the approach to the bridge from erosion by the water currents.

The abutment must then be designed, first, to support its load after the bridge is in place, and, second, to act as a retaining wall to resist the overturning forces of the material back of it before the bridge span is placed in position.

The wing walls must be designed to act as retaining walls. It is not the purpose of this publication to give a technical treatment of the principles of design, and it may be sufficient to say that, as a general principle, the thickness at the bottom of a retaining wall should be at least 40 per cent. of its height. This thickness should be increased if the wall is surcharged—that is, where the filling back of it is higher than the wall.

Piers.—The discussion of the subject of piers falls properly under the question of economic design. Whether or not it is economical to construct piers depends upon the relative cost of the different spans, and also upon the size of the piers required. The area of the waterway and the liability of piers to destruction by ice jams, logs, or floods, and the kind of foundation available are important matters and any one of them may be a controlling factor in the design.

From two designs for a concrete bridge with a 40-foot span and a 20-foot roadway a difference of about $200 in the cost of the superstructure alone appears in favor of building two 20-foot spans, instead of one 40-foot span. From this amount the cost of the centre pier must be taken to determine which is the more economical plan. Estimating the cost of concrete at $8 a cubic yard, including forms, it is possible to use 25 cubic yards of concrete for the centre pier. This would limit its height to about 8 feet in order to make the cost of the two structures about the same.

ELECTRIC CRANES FOR STEEL MILL SERVICE.

By E. Friedlaender.*

The rapid and cheap handling of all kinds and sizes of material by means of electric cranes has greatly influenced the making of steel products and helped considerably to reduce cost. One man can produce only about 33,000 foot-pounds of work in ten hours, where by means of a crane the same man could perform easily ten times as much work in the fraction of one minute.

Electric cranes are not nearly so wasteful in power consumption as hydraulic cranes; power is used in direct proportion to load lifted; on hydraulic cranes, however, cylinders have always to be filled, regardless of whether the hook is handling full, light, or no load. Nevertheless, the large number of gears, shafts, bearings, ropes, etc., on electric cranes cause a great amount of frictional resistance, which should not be overlooked. Good lubricated cut gears have an efficiency of from 96 to 98%, but when dry worn and out of alignment as low as 92%. Each bearing causes a loss of from 1 to 7%, according to lubrication and alignment. Rope stiffness reduces efficiency from 1 to 3%, depending on the diameter of sheaves and drums.

The total mechanical efficiency of electric cranes hardly ever exceeds 65 to 75%, and, together with electrical losses in motors, controllers and conductors, brings overall efficiency down to 50 to 60%. It is, therefore, very important to use the least number of shafts, bearings and gears possible to reduce dead weight to a minimum, and, last, but not least, keep all frictional surfaces properly machined, aligned and well lubricated. This will not alone decrease power consumption, but at the same time reduces considerably the cost of maintenance and repairs of motors and controllers. The wrong application of brakes can also greatly increase power consumption on cranes and punish severely all mechanical and electrical parts. Motors should not work against friction of brakes, but be released from it on the first step of the controller. This is easily accomplished by the use of magnetic-actuated brakes, but is entirely dependent on the skill of operator with hand or foot brakes.

More important yet is the proper speed control of crane motors; their rapid starting, stopping and reversing by unskilled men is not only very wasteful in power, but also very hard on all machinery, especially electrical. The best

* Abstract of a paper presented before the Iron and Steel Electrical Engineers, New York.

remedy is, probably, to take the control out of the hands of operators and predetermine acceleration, speed, torque and current through magnetic switches. This means, however, extra complication and expense, but will in the end pay for itself.

In regard to working efficiency of electric cranes, wherever a great amount of material has to be handled the general rule of keeping material always **going in same** direction should be adhered to as much as possible. It is very inefficient and costly to handle small loads at very high speeds over long distances on large and heavy cranes. In deciding on the speed of different motions we should not lose sight of the fact that the normal load hardly ever exceeds one-fourth maximum load and speed should rather be made to suit normal load; work in foot-pounds should then be made the same for the maximum load. Series direct-current motors are better adapted to this than alternating-current motors and will give, for this reason, a better working efficiency.

The proper type of girders should be selected for the work to be done by cranes. Heavy double or single-leg gantries should not be used where fast and continuous bridge work is required. It does not matter whether box lattice, single-web, or rolled-beam section is employed for girders; all will give equal satisfaction if properly designed. It is erroneous to think that lattice girders on outdoor cranes are not so susceptible to wind pressure; experience has proven that the four rows of angle braces of girders cause as much resistance as plated girders of same capacity. The fish-belly girder allows material to be used to best advantage; the square lattice girder, however, is easier fabricated, as all sections at different points are alike; it makes a rigid and stiff construction, if properly braced, with the least dead weight.

Gears, bearings and shafting may be regarded as the most important parts of cranes. On their proper design depends largely the efficiency, safety and cost of maintenance of cranes. Wherever possible, worm, bevel, split and overhanging gears should be avoided. All gears should be of steel, with standard involute-cut teeth; all high-speed gears should be made of high carbon steel properly tempered and to run in oil-bath. No pinions with less than 13 teeth should be used, as they will run rough and are liable to be mechanically weak.

Although only one-half maximum load can come ordinarily on one tooth, for the sake of longer life and safety each tooth should be made amply strong to stand entire maximum load. As all gears on cranes are worked in either direction and continuously reversed, teeth should be made so strong that they will resist absolutely all bending stresses; otherwise crystallization and breaking of teeth would be the final result. One cannot recommend too strongly to run all gears, wherever possible, in oil-bath; the resultant noiseless and easy running of the crane, as well as better efficiency and lower cost of upkeep, would soon pay for it.

All brackets and bearing supports should be made strong enough to avoid deflection of shafts and their binding in bearings. Where, on account of the light weight, it is impossible to prevent working and twisting of bearings, they should be made of swivelling type and be self-aligning.

The use of roller or ball bearings on cranes for mill work cannot be recommended, and should only be allowed where, on account of hand power, friction must be reduced to a minimum.

It is surprising that more use is not made by crane builders of oil-ring bearings similar to those on motors. Cranes equipped throughout with such bearings are always ready for work, much cleaner, do not drop oil on men and objects below, run easier and quieter, with less power consumption and cost of maintenance.

Cranes are generally handled much rougher than any stationary machinery and require continuous attention. They are naturally located in very inaccessible places, often high up, very hot, and dirty and smoky. Proper means should always be provided to give easy access to them without necessitating climbing of ladders or building columns; good stairways with railing, platforms and galleries on top for necessary inspection and repairs should always be furnished with crane structure. Crane girders should always have walks all around girder, and, if possible, trolley, to prevent slipping or falling from crane.

The use of over 275-volt currents on cranes cannot be recommended, as accidental touching of conductors is liable to be fatal. Even where electric shock is not dangerous, it may cause serious injury through fall by fright; therefore, bare conductors should be avoided as much as possible or be plainly marked by some bright colors. Means for preventing cranes from running away and wrecking themselves through wind pressure or accidental starting of motors should always be provided.

The proper location and arrangement of operator's cab is of great importance. Over yards, when material is often obstructing clear view, where operator handles material by means of grab buckets or lifting magnets without any assistance below, cab is best mounted direct on trolley. Man trolleys can be operated at higher speeds; manual brakes can easily be provided to control trolley and hoist motion, and crane can be wired easier and cheaper. Locating cab in centre on one side of crane, instead of on end of girder, gives operator often a much better view.

Crane motors are called upon to work mostly under very trying conditions, such as shocks, vibrations, frequent starting, stopping and sudden reversing, high lowering speeds, overloads, and many others, not to mention dirt, heat, rain and, last, but not least, lack of attention.

The ordinary commercial motor has been found unable to withstand continuously such conditions, and special mill-type motors had to be developed by motor builders for this work. Through co-operation with operating men, all weak, defective and undesirable features have been remedied, and there should be no trouble in getting crane motors which will stand operating conditions of mills and at the same time reduce cost of maintenance and repairs to a minimum.

Motor frames are now made entirely of steel and allow easy access and removal of armatures and fields, being split horizontally through field castings and bearings. The spider construction makes it possible to renew shaft or commutator without touching windings. Shafts are made much heavier, with larger keys and taper ends; core is pushed on spider instead of on shaft in such a way that it cannot get loose and damage windings or leads. Ample ventilation with very low core losses is provided; brush-holders have adjustable tension springs, bearings are arranged for oil-ring lubrication. Insulation is almost fire-proof and will stand higher temperatures than on standard motors.

The poor commutation of high-peak current has always been a defect of crane motors, and caused frequent renewal of brushes and commutators. The introduction of interpoles on all crane motors has greatly helped to improve commutation and do away with rough and worn commutators, short-circuiting of bars, and final grounding of motors and burning of controller contacts, as well as blowing of fuses. Sparking and flashing over at brushes even with three times full-load current is not often encountered in interpole motors. The slower speed of these motors allows quicker acceleration and stopping, with less braking effect and current consumption.

The usual practice of rating railway motors after one-hour full-load run with maximum temperature not to exceed 75 degrees centigrade, is the one that should be adhered to in most instances, especially on bridge and trolley motions, where, on account of fast acceleration of large and heavy masses, current values are liable to become very high. The half-hour rating will give motors large enough for cranes, which are generally not worked so hard and steady; as, for instance, in shops, engine rooms and over machinery in mills.

It should not be overlooked that the rate of temperature rise of crane motors is slow, in order to meet the one-hour rating, but that the maximum temperature is often finally exceeded and liable to deteriorate insulation if surrounding temperature is excessive, as is often the case in mill buildings. Manufacturers of electric machinery should state the maximum temperature their apparatus can be submitted to without any danger of injuring insulation, also what influence continuous high temperatures would have finally on motor windings.

In deciding on the proper size of a motor for certain work, not only weights, speeds and efficiencies should be taken into consideration, but, on account of rating of motors, the time of work and rest and average speed and load should be given attention. The great speed variation of series direct-current motors under changeable load should also be considered in determining size of motor, independent from the power required. The maximum speed of motion is always considerably higher than the mean speed, and could, of course, be reduced by accelerating and stopping in less time, but this would increase load of motor and necessary braking power and make wear and tear on gears, shafts and brakes heavier.

As the combined mechanical and electrical efficiency of cranes is only about 50 to 60%, not more than 22,000 foot-pounds of work can be gotten out of a 1 h.p. motor for crane work. This may give a somewhat bigger motor on small cranes, but would hardly be objectionable, as such cranes are working generally faster and more continuous than large cranes and are subjected to rougher treatment.

As the capacity of direct-current motors is mainly limited by the rise in temperature and motors are liable to exert torque greatly in excess of the capacity of the crane and cause serious breakdowns, devices should be provided to limit torque and current to a predetermined maximum and stop the motor before any harm is done.

In lowering a load the motor is assisted by the descending weight and is liable to attain very high speed, causing sparking and flashing at brushes and often serious injury to armature and field windings. The controller should, therefore, be arranged to prevent the speed from exceeding twice full-load speed. Alternating-current motors do not permit speeds much in excess of synchronous speed and can be counted on to take the place of mechanical retaining brakes. Operators, however, must be careful and not shut off power, as the motor would then be liable to attain very high speeds.

The alternating-current motor has encroached more and more into the field of the direct-current motor and successfully replaced same where speed and direction of rotation is constant. Their introduction for crane work, however, has been slow, for many reasons.

The series direct-current motor has speed-torque characteristics especially well adapted for crane service. To give similar characteristics to the alternating-current motor much of the simplicity and advantage of the alternating-current motor had to be sacrificed. The simple squirrel-caged motor had to be changed to a wound-rotor motor with slip ring and brushes. On account of closed slots, windings are tedious and difficult to put in place and to form into the required shape. Open or semi-closed slots would greatly simplify winding, but decrease efficiency of motor.

The maximum starting torque is not as great as on direct-current motors and regulation much poorer, as speed will exceed very little synchronous speed, even at no load and if maximum torque is exceeded the motor is liable to pull out and stop entirely, and cannot start again unless load is decreased.

The large magnetizing currents of alternating-current motors under all load conditions are liable to heat them up considerably when worked steadily, and must not be overlooked. These wattless currents do not represent energy and do not increase power consumption, but will heat up motors, transformers, generators and conductors. Voltage drop should be avoided as much as possible on alternating-current motors, as torque varies as the square of the applied electromotive force; this, of course, means heavier conductors on cranes and feeders than for direct-current cranes, where drop in voltage affects mainly speed, not torque. Efficiency at light loads decreases rapidly, and it is, therefore, advisable not to make motors too large for the normal work.

Although alternating-current cranes can handle a load just as delicately as direct-current cranes, they cannot perform as much work, i.e., act as quickly as direct-current cranes. Only the maximum loads can be hoisted at the same speed on both cranes, the speed of light loads and lowering being much higher on direct-current cranes. The suggestion of slowing down alternating-current motors for heavy work by means of resistance and of speeding up for light loads, to approximate direct-current crane work, means larger motors and lower operating efficiencies.

Single-phase commutator motors have about the same characteristics as series direct-current motors, and are better adapted for crane work than three-phase synchronous motors. However, they have been very little in use on account of complicated construction of motor and their inability to commutate large currents.

Since the introduction of electric motors on cranes and their ability to generate electric energy, great efforts have been made to use the generative control and do away with mechanical retaining brakes. The very same characteristics, which make series motors and their rheostatic control best adapted for crane work, are very detrimental for regeneration and do not permit very readily lowering step by step by means of dynamic braking. The self-excited series generator is slow in building up its field with resistance in circuit, allowing load to descend until the field is strong enough. Unless the operator handles the controller properly and the weight is sufficient to overhaul the drum, this rheostatic dynamic-brake control is hardly satisfactory.

By giving the series motor shunt characteristics, dynamic-brake control has become almost perfect. The operator can handle the controller as usual, and is able to lower either the empty hook or the maximum load step by step at any desirable speed. By driving the armature and field in two separate circuits and exciting fields separately, counter electromotive force can be lowered or raised above line voltage as desired. This, however, requires large rheostats in addition to controller resistance and brakes, which will release the motor when current is at its minimum value. The use of shunt brakes, or placing of series brakes with resistance directly across the line, would easily overcome all trouble.

OVERHEAD CHARGES.*

By Prof. Mortimer E. Cooley, Dean of the University of Michigan.

In the valuation of the property of public service corporations aggregating $1,100,000,000, I have had the honor to serve both the public and the corporation. By far the greater part of my work along these lines has been done for the public; and having in the beginning and for about seven years worked exclusively for the public, I naturally approached the problems from the side of the public and, it might be said, as against the corporation. It very soon became apparent, however, that either the contentions of the corporation were sadly at variance with the facts or the public was densely ignorant of the true state of affairs; and henceforth the real problem was to discover as nearly as might be the common ground upon which there could be no serious disagreement.

It must be said at the outset that the responsibility for misunderstanding rested largely if not wholly with the corporations. Their business is of a technical character and not readily understood by the layman without explanation, and the corporation official had not in the past felt called upon to make explanations, at least not of the kind inspiring confidence in the public mind. This is now seen to be true, and while not too late for correction the failure to comprehend its importance, even its necessity, at an earlier date has led to the very serious controversies of to-day, wars they might be called, between the public and the public service corporation. The public is fighting for what it honestly believes its rights and the public service corporation is fighting for existence.

Setting aside the mistake which has been made in the past of keeping the affairs of the corporation in a sealed book, any fair-minded man who will make a study of the problem with all the information now available must inevitably reach the conclusion that the present attitude of the public toward the public service corporation is as much at fault and quite as blamable as was the secretiveness of the corporations in the past. The public, slow to wrath, is a mighty force when once aroused and can no more be resisted than the ocean tide. It, however, reaches its height and begins to ebb in due course, and it remains to be seen whether in the future we shall profit by the experience we are now having and establish conditions far more stable, so stable in fact that a similar situation cannot again arise. Much swifter progress could be made in bringing the war to an end if the fight could be carried on by the master minds on both sides. History reveals that unfortunately that is not the way wars are conducted. Politics has prolonged many a war and delayed the re-establishment of peaceful conditions after the war itself was ended. The political charlatan thrives at such times and seeks to maintain the conditions necessary to his nefarious existence. But he is not the only parasite; there is also the unprincipled expert, scientific expert he calls himself, whose expertness lies in being able to set up an array of figures in apparent proof of any result desired or required of him by his boss. If anything he is more dangerous than his boss, because his weapons are figures juggled to suit his purpose, and only to be refuted by an expert on the other side, who, however honest he may be, is sure to be considered by the partisan equally unprincipled.

Opportunity for the Accountants and Engineers.—The real forces effective to end this conflict between the public and the public service corporation are the accountants and engineers—not to end it, perhaps, but to point the way so that the man who really desires to be fair may have before him the facts upon which to base his judgment. The public as a whole is honest and fair—it is only individuals who are dishonest and unfair—and once the ignorance of the public has been dispelled the true and correct solution will be in sight. But the engineer and the accountant, while in the main honest enough, are not to escape responsibility in some measure for their ignorance.

The engineer has not always dared to tell the whole truth, fearing it would not be believed, and that his reputation would thereby suffer. He has therefore told but a part of the truth, and now when the necessity for the whole truth is imperative his task is much increased, he being obliged to explain his earlier position. In many, and it is to be hoped in most, cases this earlier position of the engineer was due to ignorance of the real facts, or more likely to knowledge of only a part of the facts. It is only comparatively recently that the engineer has been called upon to work with the accountant and the financier in the development of all the facts in the creation of the property of a public utility corporation. Is it therefore to be wondered at that the public has remained in ignorance?

The accountant's share of the responsibility cannot be said to be due to ignorance or to any fear that his reputation might suffer from a disclosure of all the facts. It is repugnant to the average mind to wrestle with the mass of figures required in setting up the details of accountants. It should be possible for the man of average intelligence to enter an account and find there the essential things required in comprehending the cost and the value of a property and the expenses of operating and maintaining it. It should not be necessary for an expert accountant to spend months digging through accounts for the necessary data upon which to base costs and values. This criticism does not bear to-day with the force it did in earlier years, because of the study and effort on the part of accountants for a number of years past to devise methods or systems of accounting which will afford almost at a glance any particular kind of information desired. The accountant has rather been the custodian of facts, the keeper of the storehouse as it were, but now he must perform the additional task of preparing the facts for consumption. The facts required by the public at this time are in themselves simple enough; the difficulty lies in devising means to disclose them so that they can be easily comprehended.

Appraisals of Property.—The public desiring to inform itself as to the cost and value of a public utility property requires an appraisal to be made, that being the simple and obvious way to go about it. Prior to 1900 the principal appraisals of this class of property were of water-works. In practically all cases this investigation was made to discover the value of the plant with a view to taking it over from private to municipal ownership, the condition for the transfer being usually set up in the franchise. These appraisals were usually made by engineers, it being customary for the municipality and the company each to choose one or two and these to choose another who should act as chairman and cast the deciding vote in case of a tie. All too frequently the appraisers entered upon their work as advocates, each for the side choosing him, and the appraisal became a controversy, which had finally to be settled in the courts. The decisions handed down have become the law of the land which, while almost wonderfully good in the majority of cases, is not altogether applicable as precedents to many of the cases arising to-day.

The chief object in those days was to arrive at the value of the property, which included the so-called "going value" of the property. "Goodwill" was another element considered.

*Abstract of paper read before the American Electric Railway Accountants' Association, Atlantic City, N.J.

But to-day, and since 1900, appraisals are made not alone to discover the value of the property, but the cost as well. The appraisal to-day is not so much for the purpose of transferring the property from private to municipal ownership, although that is the alleged object in a few cases, but for the purpose of taxation and rate making and to determine the extent to which the issuance of securities can be authorized. Obviously it is to the interest of the corporation to have a low value for taxation and a high cost for rate making and the issuance of securities. But of course both cannot be had except as the facts justify them. And right there is the first obstacle encountered by the public and the corporation in coming to an understanding. The public fails to see any difference between the cost and the value and argues, not without some show of reason, that if the property has a certain value for taxation it surely ought not to be different for rate making and the issuance of securities. The fact that the corporation fights to keep its figures down in the one case and up in the other no doubt contributes in no small degree to the attitude of the public toward it. It is, therefore, important to discover first if there can justly be any difference in the two cases and, second, if so to what extent can such differences properly exist.

It is not so much my purpose in what follows to say what ought or ought not to be done as to indicate the things which must receive consideration in determining what ought or ought not to be done. The average individual thinks of the value of a public utility property as consisting merely of the things which can be found and inventoried; in other words, he thinks of the value as being made up of the physical elements only. For many it is quite a long step to add any intangible elements or to consider the capacity of the property to earn a return on the investment. The farmer, for instance, in placing a value on his land unconsciously considers how much of the different things can be raised, the first element of value being its earning capacity. Then he considers the physical structures, house, barns, fences, drainage equipment and stock and other things which he has had to add from time to time, and for which he has had to invest capital in one form or another. I venture to say that if a complete analysis of a farming property could be had, starting from the beginning, most if not all of the elements, or their equivalents, would be found the same as in a public utility property. The first thing, therefore, is to realize that the value of such a property does not lie in the physical elements alone, independent of their earning capacity.

Point of View of the Utility.—It aids materially in one's quickness of understanding to assume one's self to be the corporation and then to take the steps successively as they come in building up the property, putting it into operation and carrying it along until it becomes self-sustaining. One readily comprehends the outlay necessary to acquire the rails, the ties, the overhead work and the power plants and the labor involved in their installation. One does not, however, so readily comprehend the other outlays which, although they are not seen as tangible elements, are just as much present as the tangible elements themselves. These other outlays are in general grouped under the name of "overhead charges." The term is somewhat elastic; its scope will be greater or less, depending on the extent to which certain charges are considered as a part of the physical structure itself. For instance, the elements of contingencies and contractors' profits, if not included in the cost of the physical structure itself, would have to be considered as overhead charges; both are present and must appear in the cost somewhere. The practice of valuators is not uniform, some preferring to include those two items in the cost of the physical structure and others to separate them and add them as a percentage. Occasionally an appraisal has been made with no separate charge appearing to cover contractors' profits, but in such cases the unit costs have included them or the items have been taken from the contracts awarded on bids invited for the work. The contractor's bid includes, of course, both his allowance for contingencies and for profits.

A usual allowance for contractors' profits is 10 per cent. on the cost of the work. The item of contingencies varies with the nature of the work. There should, indeed, be two items of contingencies, one a construction charge, the other an inventory charge. The former may vary in an inventory from 1 per cent. to 2 per cent. to as much as 20 per cent. or 25 per cent. An example of a low percentage for this item might be found in the cost of a power unit the contract for which calls for the unit completely installed and operated for a time before acceptance, but in such a case the contract price includes a liberal charge for contingencies, as no contractor would think of undertaking the work without protecting himself against unforeseen expenses incident to such work. The same thing is true in the case of cars which are delivered on a contract. An example of the higher percentage may be found in a foundation or in a job of piping or station wiring. Making due allowance for varying conditions, an average charge of 5 per cent. on the cost of all items to cover construction contingencies is as low as it is safe to go. In the same way and for similar reasons another 5 per cent. should be added to cover inventory contingencies, making a total charge of 10 per cent. for contingencies.

It has been frequently argued that little or no allowance should be made to cover omissions from the inventory, the reason given being that the work has been done and all the items can be found and listed. But such is not true in fact. When the costs were figured in the first place complete plans and specifications were available, and quantities could be taken off and the difficulties of construction studied in detail. In making the inventory almost always no plans and specifications are available and there can be no comprehensive study from the work as done which will lead to the results obtained from a study of the plans without a liberal allowance to cover contingencies. Indeed, it frequently has been found desirable if not necessary to recreate the plans from the work as done before undertaking to value the structure. Numerous instances might be cited to show that even a total of 10 per cent. was an insufficient allowance to cover all kinds of contingencies. The use of a smaller percentage can be justified only when the unit costs have been determined from similar plants the actual costs of which were known, and in such cases the contingency item or a part of it will be found in the unit costs themselves. But even when the unit costs are such as to cover construction contingencies there remains the inventory contingency which must be added to complete the cost of the physical structure as it is listed in the inventory.

The charge for engineering likewise is a desirable item. Engineering usually covers the making of surveys, plans, specifications and estimates, inspection of materials and the supervision of actual construction work as it progresses. There should be added a charge for engineering in connection with each general item of the inventory which, depending on the nature of the work, may vary from 1 per cent. to 2 per cent. up to 10 per cent. and even more. Then there should be added to the cost of construction a general item of 2 per cent. or more to cover engineering not assignable to individual parts of the inventory. The total charge for engineering will in some localities not exceed 4 per cent. or 5 per cent., but in other localities it will go much higher.

Many of the earlier appraisals went no further than to include the cost as determined from an inventory, to which was added an allowance for contingencies and engineering.

The depreciation of the physical elements due to wear and exposure to the elements was then determined usually by assigning to each element a life and considering its age at the time of the appraisal. The result thus obtained was called the physical value of the plant, and to this were added any "going value," if it could be determined, and sometimes another value, that of "good will." The appraisal was then considered complete. While such a value, an approximation at best, might have sufficed in the older days of liberal dividends and little or no scrutiny of the affairs of a corporation, it in no way meets the conditions as they exist in these days of public demand. The public service corporation is no longer free to do merely the things which its management considers advantageous to do from the standpoint of insuring dividends. It is compelled to do things which involved expenses of such variety and magnitude that in some cases not only are the profits reduced to a point of practically no dividends, but there are insufficient net earnings to pay the interest on the bonded debt. It is this condition of things which renders it all-important both for the public and the corporations that the elements of cost and of value in a public utility property be made perfectly clear. This is the great problem of the day and it is all-important in that it affects the life itself of the public utility. It is equally important whether the utility be owned and operated by a municipality or by a corporation. The public service corporation is but the agent or servant of the municipality, and what affects one must of course affect the other.

Full Understanding Required.—The first thing necessary, therefore, for the man who would attempt to regulate the conduct of his agent or servant is to fully understand what is required of him. If a man has been successful in his own business it was due to careful study and a mastery of details. It passes comprehension that such a man should assume to direct or control a business about which he has but a smattering of real knowledge. If every man would apply or allow to be applied to a public utility the same principles which he applies to the conduct of his own affairs there would be little to complain of. What, then, are the things which the honest man should understand if he is to act wisely in the regulation of a public utility? Let that man put himself in the place of the public service corporation and see for himself the things it would be necessary to do. Imagine that he starts at the beginning. He is an active, perhaps a prominent, man in his community. He conceives that an electric street railway system would be a good thing for the community. He talks it over with some of his friends, the matter is carefully canvassed and the public sounded to discover whether there is any real demand for street cars. This may have taken several months, and required considerable time to be given to the project either by the man himself or some one employed for the purpose. Thus is a preliminary expense incurred.

It having been determined that a street car system is desirable in the interests of the public, its promoters must consider whether it would be desirable in the interests of the man who has money to invest. That is settled at once by the rate of return likely to be realized by the investment. Such a rate must be sufficiently attractive to divert money from other channels, and moreover the rate must be sufficient to meet any additional hazard not encountered in the ordinary channels of investment. A careful study must then be made of the routes, the necessary surveys and general plans worked out preparatory to obtaining a franchise. Thus a further item of expense is incurred. The franchise being obtained, it is necessary to obtain consent from property owners, which may be a very heavy item of expense. All of this work may have taken a year or several years. It is the development period of the project and all items of expense legitimately incurred are proper elements of cost to be charged to the property. Such items of expense do not appear in the inventory of physical elements of a property, and they are therefore an overhead charge. The extent of this charge necessarily varies greatly with the locality. Property consents alone have been found in some localities to run as high as $2.50 per front foot; in such a case the preliminary or development charge might easily reach $20,000 or $30,000 per mile, which would represent a percentage quite beyond belief by the average man. It is not yet practicable in most cases to separate the item of the development period so as to discover whether it might fairly be represented by a percentage of the cost varying between any definite limits. This item is altogether too frequently ignored even by experienced appraisers; or if not ignored it is included in the item of organization expenses, which item also frequently includes legal expenses. When so included the combined items may vary from 2½ per cent. to 5 per cent. and more, depending on locality.

The items of insurance, both fire and casualty, are now quite generally recognized as proper charges, the amount varying usually from one-half of 1 per cent. to 1 per cent.

Interest during construction curiously enough does not appear to have been thought of in the earlier days of appraisals, but the man of business knows without any argument that money cannot be borrowed without interest. The only question is on the time it should run. Six per cent. is accepted ordinarily as the rate, and the time is one-half the construction period. If, therefore, the construction period be one year the rate would be 3 per cent. of the total amount expended, assuming that the expenditures start from zero and mount uniformly to the total at the end of the year. The construction period in a street railway system is ordinarily taken as the time required to complete the power plant. This in a plant of any magnitude may be from two to three years. Along with interest the taxes must be included or set up separately, and it should not be forgotten that the interest item must also include the interest on the expenses incurred during the development period. Thus in a plant in a large city the interest charge might easily reach 9 per cent. or 10 per cent.

A BOOK OF VERSE.

Poetry is not much in the engineer's line. The Methodist Book and Publishing Company, Toronto, however, have just issued a volume entitled "Rhymes of the Survey and Field," which will appeal to those of the engineering profession who have been connected with outdoor and survey work. The author, Mr. G Blackstone Field, is an engineer at present engaged on surveys for the Canadian Pacific Railway in the vicinity of Wilker, Sask. The Rhymes deal with different phases of the fieldman's life in camp and on the road, and are written in a style very similar to Robert W. Service's poems.

PEAT FUEL IN DENMARK.

An English syndicate is spending large sums of money trying to develop coal turf from the Danish peat bogs. It has been estimated that Denmark can thus supply itself with fuel for 100 years to come, the bogs in this country containing about 300,000,000 tons of turf suitable for heating purposes.

The company is building its first factory in Zealand, where work has already started. The company has a capital of several million dollars and it is said that its operations will be extended to France, America, Russia, Siberia and China.

SELECTION OF A WATER-WHEEL UNIT.

By O. B. Coldwell.

INTRODUCTION.

One of the most interesting problems with which the engineer of a company utilizing water power has to deal is the selection of the hydraulic equipment for his plant.

With the exception of the tangential wheels used in high head work on the Pacific Coast and a few sections of the United States, it might be said that, for a good many years, most of the water wheels used in this country were located on streams near tide water and operated at heads below 60 feet (18 m.) Water wheels during this period were manufactured very largely along so-called "cut and try" lines and there were no well-developed principles of design. The experience gained during these early years of water turbine building and the knowledge derived through testing and operating such wheels has contributed very largely to the development of the art of water wheel building as it is known to-day.

Water wheels of this early period were for the most part used in mills of one sort or another to drive machinery which did not demand a very high degree of speed regulation. High efficiencies were occasionally obtained, but usually but for one point of load or for an exceedingly short range of load.

In recent years, due to the more general utilization of the water powers of the country and to the perfection of high-tension transmission of electricity, there have been many developments on the upper stretches of our power streams where the slope in feet per mile is very much greater and higher heads are more common. The operating heads of these plants range from say 60 to 400 feet (18 m. to 122 m.) for intermediate heads, from 400 to 1,000 feet (122 m. to 305 m.) for high heads and from 1,000 to perhaps 2,500 feet (305 m. to 762 m.) for extreme high heads.

Changed conditions are now met with. Many of these modern plants are of the hydroelectric type, requiring a nicety of regulation which was not known in the early period. Economy in the utilization of water becomes an important factor due to the characteristics of stream flow and the necessity of utilizing the available water to the maximum possible extent for the purpose of keeping the cost down to a minimum. In many such developments that part of the total cost brought about by the fixed charges on the investment exceeds greatly the part due to operation, and it is, therefore, important that the output be as large as possible. On account of the characteristics of the loads ordinarily imposed upon hydroelectric plants, the extent to which water can be stored has a marked influence upon the cost of generation in such plants.

Due to the various important factors mentioned above, there has been gradually perfected the highly specialized engineering science of water wheel design.

The object of this paper is not, by any means, an attempt to tell how to design a water wheel, but rather to discuss the features entering into the particular design which will best meet the conditions for which it is intended, and to point out the information which should be furnished by the purchaser to the waterwheel designer to enable him to plan the most efficient unit.

Although we have passed from the earlier period mentioned above into the later, in which a more thorough appreciation of the water wheel problem is required, it still remains a fact that in many instances very little engineering is being used in the selection of water wheels. This is perhaps due to a certain extent to the practice of manufacturers themselves in issuing trade catalogues. Those catalogues contain information regarding the discharge of water and horse power developed at given heads by various sizes of runners, but do not take into consideration such factors as variations in speed, variations in head, or other features which may have a large influence on the selection of the proper wheel. As a result, due to the custom of relying on catalogues in the past, many water wheels at present are being ordered directly from these catalogues without due regard and study being given to the conditions which should enter into the selection of the wheel.

In the following discussion an attempt is made to show that in general more thought should be given and more precise methods applied in selecting water wheel units.

Elementary Hydraulic Principles.—Having made the foregoing presentation of the scope it is intended to cover in this paper, there will now be brought to your attention a few elementary hydraulic formulas which will be employed later in the discussion. The elementary principles which are involved in these formulas should preferably be known and understood by the one selecting the wheel in order that he may properly cope with the questions which he should solve and be able to more intelligently place his order. The formulas given here are not, by any means, all of the formulas which enter into the complete solution of the hydraulic problem.

To begin with, a water wheel is a device which is placed in the path of falling water for the purpose of abstracting energy possessed by the water, due to its fall and weight, and delivering as much as possible of same to the shaft as mechanical energy.

The energy possessed by the water may be expended and made manifest as power as follows:

1. By allowing a quantity to pass from a higher to a lower level practically without velocity.

2. By the momentum possessed by a quantity of it traveling at a velocity caused by the head.

3. By pressure of the water due to head acting on an area through a space.

What usually takes place is a combination of these ways of expending hydraulic energy and making it manifest as power.

Total head is the difference in elevation between head-water and tail-water and is usually expressed in feet. This total head may be divided in general into three parts, as follows: friction head, discharge head, and effective head.

Friction head is that part of the total head which is applied in overcoming the friction in the water passages leading to and away from the wheel, as in the passage away through the racks, entrance to penstock, in the penstock itself, through the guides and buckets, and in the discharge tubes.

Discharge head is the head at which the water leaves the draft tube and enters the tail-race. In well designed wheels this is usually of small magnitude, but it is readily seen that this head is an absolute loss.

Effective head is the part of the total head left to be applied to the wheel itself for effecting the energy transformation after the friction and discharge heads are disposed of.

In the case of Francis turbines, the effective head includes the draft head or effect of draft tube; a tangential wheel has no draft tube.

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*A paper presented at the Pacific Coast Meeting of the American Institute of Electrical Engineers, Portland, Ore., April 16-20, 1912.

Friction head loss in a steel pipe is found approximately by the following formula:

$$\text{Friction head} = \frac{l\ v^2}{3{,}000\ d}$$

l = length of pipe in feet.
v = velocity in pipe in feet per second.
d = diameter of pipe in feet.

When the quantity of water available in cubic feet per second and the effective head acting on the wheel are known, the approximate horse power is given by the following formula:

$$\text{h.p.} = \frac{\text{quantity} \times \text{effective head}}{11}$$

This assumes a wheel efficiency of 80 per cent.

The stream flow upon which the plant rating is based should receive careful consideration and study. If possible, accurate flow data over a number of years should be obtained. Many expensive mistakes have resulted from not giving sufficient weight to this matter.

Other fundamental formulas which might be mentioned here are:

$\text{h.p.} \propto \sqrt{h^3}$

$\text{rev. per min.} \propto \sqrt{h}$

Quantity in cubic feet per second varies as $\sqrt{h}$

Velocity in feet per second $= c\sqrt{2gh}$ where c is a constant having values dependent upon conditions of discharge. It is unity in value when water is discharged freely through a perfect nozzle, and in such a case, the velocity is the same as that acquired by a freely falling body and equals approximately $8\sqrt{h}$.

It might be said that the formula $v = c\sqrt{2gh}$ is the most important of all hydraulic formulas, as it enters into all calculations and designs of water wheels.

Types of Water Wheels.—We will now briefly mention some types of water wheels and the principles on which they act.

a. Gravity Type.—This type of wheel includes breast, overshot and undershot wheels. The efficiency of these wheels is often quite good, but the speed and power are extremely low, and this type is, therefore, not adapted to ordinary present-day conditions. We will, on this account, give it no further consideration.

b. Impulse Wheels.—This type of wheel includes the Pelton and Girard wheels. They are kinetic energy wheels, that is, the momentum of the mass of water in its impact with the runner buckets is the main principle utilized in the energy transformation.

In the Pelton type, the water strikes tangentially upon the buckets, while the Girard types, the water passes through the runner radially outward; an extremely careful design is necessary for this type.

c. Francis Type.—This wheel is a combined potential and kinetic energy wheel, the water passing either inwardly or outwardly through the runner. The wheel rotates partly from velocity action and partly from reaction due to pressure and consequent acceleration in the buckets. The so-called Smith, American, Holyoke, Jolly, Hercules, McCormack and Victor turbines are well-known wheels of this type. They received the above names years back when the so-called "cut and try" methods were used rather than theoretical design. This does not mean that these wheels are not good wheels. Much credit is due to the enterprise and achievements of the pioneer manufacturers responsible for their development.

Design and Calculations.—Hydraulic principles properly applied bring the design of a water wheel within the full grasp of the engineer. Hydraulic formulas contain many constants and coefficients, and it has taken time, patience and experience to gain a correct knowledge of the proper values of these. But once having gained a knowledge of them for various types of nozzles and surfaces, a full knowledge of velocity relations and correct design can be arrived at.

In general, the calculations necessary in designing a water wheel runner will be left to the manufacturer and will not be taken up here, but we will discuss briefly the manner in which the speed of a turbine runner is affected by the angles of the buckets and guides, as we will use this later.

Reference may now be made to the sectional drawings Figs. 1, 2 and 3, and the corresponding runners, Figs. 4, 5 and 6. These sketches show the general designs of the guides and runners for three types and angular relations of same. The diameter is the same for each runner.

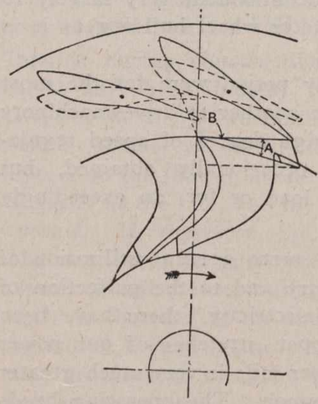


Fig. 1.
(See Fig. 4 for Runner.)

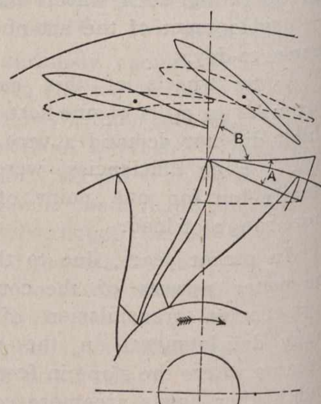


Fig. 2.
(See Fig. 5 for Runner.)

Let A equal the angle between the tangent of the periphery of the runner and the direction of the flow of the water as it leaves the guides.

Let B equal the angle between the tangent to the periphery of the runner and the entering edge of the runner bucket.

Let V equal peripheral velocity of the runner in feet per second.

Let H equal effective head in feet.

Led D equal diameter of runner in feet.

Then

$$v = 52\sqrt{H}\sqrt{\frac{\sin(A+B)}{\sin B \cos A}} \text{ (approximately)}$$

$$\text{rev. per min.} = \frac{60\ v}{3.41\ D}$$

A consideration of these two formulas clearly indicates that the diameter of the runner and the rev. per min. depend upon the angles chosen. Therefore, with a given diameter, to obtain rev. per min. angles must be chosen to suit and the design of the bucket made to correspond.

It is convenient to use in the process of design a head of one foot as a basis for calculations. Having made calculations for unity head, values for other heads are readily obtained by using the three fundamental formulas given heretofore.

$\text{h.p.} \propto H^{3/2}$

$\text{rev. per min.} \propto H^{1/2}$

$Q \propto H^{1/2}$

The choice and design of a particular type of runner to suit some given fixed condition can be based upon what is known as "specific speed" of the runner. The formula for specific speed is

$$K = \frac{\text{rev. per min. } \sqrt{H}}{H \sqrt{H}}$$

and may be defined as: the speed at which the runner will operate when delivering unity horse power under unity head.

A given specific speed comprehends a particular design of one type of runner only. The designer fixes the angles A and B for each particular specific speed and thereby arrives at standard designs based upon specific speed. Probably no two designers would use precisely the same angles, and, therefore, velocity relations, bucket widths and openings will vary in runners intended to give equivalent performance. The variation, however, is not great.

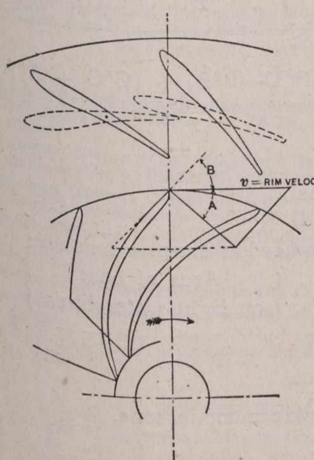


Fig. 3.
(See Fig. 6 for Runner.)

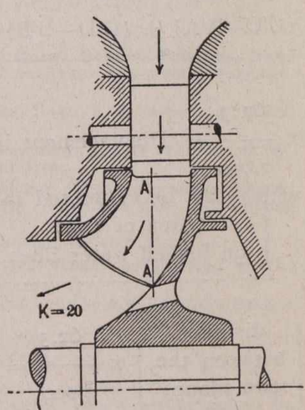


Fig. 4.
(See Fig. 1 for Section A-A)

Let us consider Figs. 1, 2 and 3. Fig. 1 is a runner of low reaction type which would be used on relatively high heads. Notice that the angle A of water leaving the guides is small, and the angle B of the bucket is greater than 90 degrees. These angles are selected to give a low peripheral velocity of the runner. If the values of the angles, which are approximately 14 degrees and 110 degrees, are used in solving the velocity equation given above and H is taken as unity, it will be found that v equals about 50 feet per second for this particular runner.

Fig. 2 is a runner of moderate reaction and is a type which would be used on lower head than the runner of Fig. 1. The angles in this case are selected to give a higher peripheral velocity of the runner. If values of the angles A and B, which in this case are approximately 23 degrees and 73 degrees, were substituted in the velocity formula, it would be found that v equals about 56 feeet per second.

Fig. 3 is a runner of high reaction, and would be used on lower heads than the runner in Figs. 1 and 2. The angles in this case are selected to give very high peripheral velocity. Their values are approximately 42 degrees and 46 degrees and the value of v if worked out by the formula is found to be about 71 feet per second.

A comparison of Figs. 1, 2 and 3 shows that as the type of runner changes from low reaction to high reaction the bucket angle changes from a forward curved bucket to a backward curved bucket. It is, therefore, evident that in order to get a high peripheral velocity, a backward curved bucket must be used.

Comparison of Figs. 4, 5 and 6 shows that in the case of the low reaction runner the width of the bucket is small, while in the case of the high reaction runner we have a very wide bucket for the accommodation of the larger quantities of water necessary. For relatively low power wheels, angles are used to give relatively low speeds, since these wheels are ordinarily used on high head work and small quantities of water are met with. For relatively high power wheels angles are used to give relatively high speeds since these runners are ordinarily used on low heads.

It will be noted that the runner in Fig. 4 is one with a specific speed of K = 20; in Fig. 5, K = 45; in Fig. 6, K = 75.

Francis turbines can be used for values of K as low as 12; for lower values tangential wheels should be used. This limiting value, however, is not well defined.

A manufacturing company ordinarily has available a number of types of runners, each of which has a particular value of K. Each one of these types is used for certain conditions and what is good in one case would probably not be suitable in others. The reasons for this will be brought out more in detail later on.

Fig. 7 is entitled "Comparative Efficiency Chart." On this chart the load on the runner is plotted in per cent. of its full load, while the efficiency is plotted in per cent. of the efficiency at which the wheel operates at full load. Curves for K = 20, K = 45 and K = 75 are plotted. It is readily seen on examining these curves that the efficiency will depend very greatly on the type selected. Let us say that we have a type No. 2 wheel installed, that is, a runner with K = 45; it will be noted that when this runner operates so as to give 60 per cent. of its full load the resulting efficiency is 103 per cent. of its efficiency at full load. If its full load efficiency is say, 82 per cent., then the efficiency of this runner when operating at 60 per cent. of full load is 103 × 0.82 = 84½ per cent.

Type No. 1 is used on high head work, No. 2 on medium head work, and No. 3 on relatively low heads. It is readily seen by examining the comparative efficiency chart that the efficiency which will be obtained by the employment of these different types varies through a considerable range.

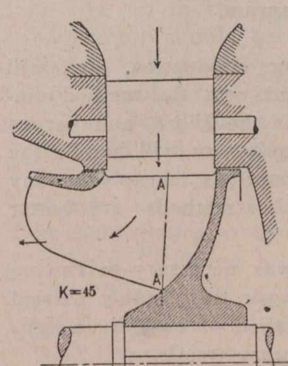


Fig. 5.
(See Fig. 2 for Section A-A)

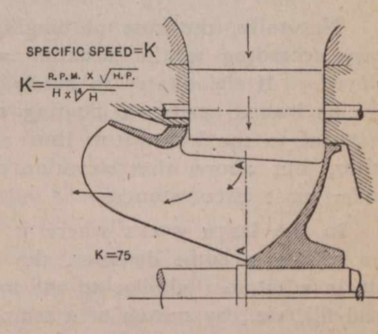


Fig. 6.
(See Fig. 3 for Section A-A)

A runner with K = 45 could not be used for very high head work and would, therefore, not enter into consideration for a plant which is going to operate at, say, 600 feet (180 m.) head. The principal reason why this runner could not be used with a head of 600 feet is that it would be structurally weak for that purpose. In the same way it is readily seen that a runner with K = 75 would not be suited for the high head work. On the other hand, a runner designed for a high head wheel with K = 20 could be used on a lower head, but in all probability would not be so used for many reasons.

(To be continued.)

THE BUILDING OF BREAKWATERS.

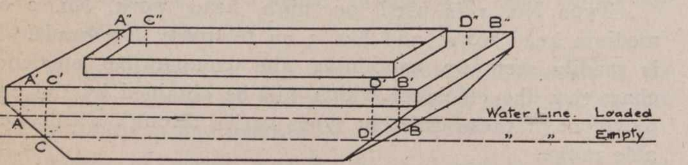
In a discussion of Mr. H. F. Alexander's paper on the "Building of Breakwaters at Lake Erie Ports," presented recently to the American Society of Engineering Contractors, Mr Howard J. Cole presents some interesting remarks. An abstract of his discussion presented to the society is given below.

Owing to the fact that rubble mound breakwaters are the most easily built and cheapest, and can be readily repaired after settlement or damage by storm, this type of construction is quite generally used.

The subject is of special interest owing to the activity in harbor improvements caused by the approaching completion of the Panama Canal. This activity is particularly noticeable on the Pacific Coast of South America, where the governments, with great foresight, are making strenuous efforts to increase their harbor and port facilities to provide for the trade that is sure to follow the opening of that canal.

Some of these governments have already completed the preparations for considerable work of this nature, and most of the plans call for breakwaters of the rubble mound type, with some modifications to fit conditions of each port Sometimes the rubble is topped with monolithic concrete block of 30 tons weight.

In the case of the Manzanillo breakwater, the rubble was obtained at a quarry twenty miles away from the work and cost the owner "in situ" $6.30 per metric ton. In a breakwater at Bar Harbor, Maine, that has been under construction, at intervals, since 1889, the stone, thus far, has cost the U.S. Government slightly over $1.00 per ton. These are in both instances contractor's prices, and include the actual cost and his profit.



Displacement Diagram.

Naturally, the cost of handling, production, etc., will vary according to the situation and with the method employed. If the quarry is handy to the shore, and barges can be loaded easily, a floating equipment will handle the material to the low water line about as cheaply as any other, but above that elevation other methods are better under most circumstances.

In the large works where it was necessary to convey the rubble to some distance, the work was largely carried out in a manner similar to the method of building a railroad fill, viz., by means of a temporary trestle.

On some work, where the writer was engaged, the materials (stone and sand) were delivered on deck scows and the displacement obtained in the following manner:

The exact dimensions of the scow were measured by steel tape and the point A′ plumbed up from A, similarly B′, B″ and A″ were obtained, and the distance A′ B′, A″ B″, A′ A″ and B′ B″ likewise measured by steel tape; the depths A A′ and B B′ and corresponding depths on the other side of the boat were carefully measured by a graduated rule and noted on a sketch of the boat. When the latter was empty the point C′ was plumbed up from C, D′ from D, and again on the further side, and the four dimensions corresponding to the loaded measurements recorded. From a comparison of the depths (light and loaded), and with the complete measurements taken, the displacement was computed as hereafter shown.

The length A′ B′ and A′ A″, and the other two corresponding measurements were obtained direct on the scow deck, and the depths were obtained by taking the difference between the readings loaded and light and the displacement thus figured.

By averaging the lengths A′ B′ and A″ B″ and multiplying by the width A′ A″, also averaging the lengths C′ D′ and C″ D″ and multiplying by the width C′ C″ and multiplying the average of these two by an average of the differences between the load lines (C′ C—A′ A, etc.,) at the four corners, one obtains the cubical feet of displacement, which multiplied by 62.5 and divided by 2,000, gives the displacement in net tons and is expressed in figures thus:

$$\frac{\left\{\frac{A'B' + A''B''}{2} \times A'A''\right\} \times \left\{\frac{C'D' + C''D''}{2} \times C'C''\right\}}{2} \times \frac{(C'C - A'A) + (D'D - B'B) + (D''D - B''B) + (C''C + A''A)}{4} \times \frac{62.5}{2{,}000} \doteq \text{Displacement in tons}$$

which can be expressed in a somewhat simpler manner:

$$\frac{\left\{\begin{matrix}\text{Area of boat}\\ \text{on loaded water lines}\end{matrix}\right\} \times \left\{\begin{matrix}\text{Area of boat}\\ \text{on light water lines}\end{matrix}\right\}}{2} \times \left\{\begin{matrix}\text{distance}\\ \text{between the}\\ \text{two planes}\end{matrix}\right\} \times \frac{62.5}{2{,}000} = \text{Displacement in tons.}$$

SEWAGE DISPOSAL.

A new municipal enterprise which, it is expected, will have far reaching effects on the problem of sewage disposal is to be inaugurated at Bradford, England, where new machinery for extracting marketable produce from the city's sewage is being put into operation.

Last year, the corporation made a profit of $150,000 from the grease recovered from the sewage, and it is anticipated that at the new works at Esholt, the annual profit will be raised to $250,000. The total sales of these products up to last year reached $500,000.

Besides grease, a market has been found for the pressed cake which remains after the grease has been recovered, and large quantities of this have been exported to be used as fertilizers in France, South America and other countries. The cake has even been in demand as fuel during the recent coal strike and has been used as such in local factories.

Material reductions are made in the freight rates on the Temiskaming and Northern Ontario Railway in a schedule which will take effect on May 20th. The rates are equalized over the system so as to conform with the standard mileage tariff for Eastern Canada, and both for local traffic and through shipments charges are considerably lower.

The revision of existing grades and surveys for the double tracking of the Canadian Pacific Railway main line between Vancouver and Calgary, a distance of over 600 miles, is now under way. The work is in charge of F. F. Busteed, former general superintendent of the British Columbia division, who has established headquarters at Kamloops. Actual double tracking between this city and Port Hammond is now in progress.

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The Canadian Engineer absorbed The Canadian Cement and Concrete Review in 1910.

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CONTENTS OF THIS ISSUE.

THE LATE JUDGE MABEE.

The death of Judge Mabee is a severe blow to the country. Natural ability and wide judicial experience placed him in an exceptional position for filling the chairmanship of the Dominion Board of Railway Commissioners, and during the past four years he has filled this difficult office as few men could.

The office of chairman of this Board is one which demands executive and administrative, as well as judicial powers. The Board was created in 1903 for the purpose of allowing of quick decisions without the hampering and restricting procedure of the courts. To be successful in operation the chairman of the Board must be a man of rare tact, quick judgment, administrative power, and forceful character. This in no mean measure had Judge Mabee. As a result, the Railway Commission has attained a strength and dignity, and its jurisdiction has been enlarged, until the work entailed is most wearing on the chairman.

Judge Mabee's death will be most deeply regretted both by the public and by the railways, to both of whom he was eminently fair, and by whom he was universally admired.

THE ENGINEER AND THE CONTRACTOR.

It is now generally accepted by the engineering profession that to secure the best results in the construction of any work there must be a cordial spirit of co-operation between the engineer and the contractor. The engineer's attitude towards the contractor will be reflected in the finished work. In a recent paper Mr. Charles T. Main, consulting engineer, of Boston, gives expression to certain opinions of what he thinks should be the attitude of the engineer. Mr. Main says:—

> "Reliable contractors are honest, and intend to live up to the plans and specifications. No contractor should be expected to give any more than is called for by the plans and specifications. Some contractors estimate low in the expectation of being able to get by with something inferior to what is called for. All men are human, and most are careless, and for these reasons it is essential to have as much inspection on a job as is necessary to see that the intent of the plans and specifications is carried out.
>
> "This work of inspection and of interpretation of plans and specifications should be done with the exercise of a good deal of judgment, with a mind open to the interests of both the owner and contractor, with clearness and firmness. In many cases where claims are made by the contractors, it is due to the fact that they are not familiar with the plans and specifications. In many cases, however, there may be a conflict or a chance of more than one interpretation to be put on them. In the decision of all of these questions the engineer should assume a judicial attitude and render his decision with fairness to all parties interested. His decision may not be satisfactory to either party, but it must be clear in his own mind that he has done right thing to all.
>
> "No one can see more clearly than he all sides of these questions and reach a proper decision. Sometimes that decision may not reflect any credit upon his own work, but it should be

met fearlessly, if the fault lies in the preparation of the plans and specifications.

"Care should be exercised in the preparation of specifications, so that they will describe the class of work and grade of materials which are intended and expected with clearness and conciseness. A better class of work should not be called for than is required for a particular purpose, nor should it be called for with the idea that something inferior will be obtained which will pass. Just what is desired should be called for in the specifications and demanded by the inspector on the work.

"The attitude of the inspector, or better, the resident engineer, should be one of assistance rather than of criticism."

If the above is accepted as a basis for the guidance of the engineer in his dealings with the contractor, there is no question that much good will result to both sides, and, while we feel that conditions are improving steadily, still there remain many ways in which by a conciliatory attitude the mutual relations of the two parties can be improved.

REFORESTATION AND THE FLOW OF STREAMS.

A number of factors enter into the question of the flow of streams, among which may be named precipitation, rainfall and snowfall; the extent and contour of the drainage area, nature of the ground and condition of the soil; condition of the surface (forested or clear), and the presence of storage reservoirs, either natural or artificial, in the stream. The whole question of river regulation has been given little attention in Canada, although it is one of considerable importance to the economic development of the country. It is generally believed that forest growth on the head waters of a stream tend to afford more uniform flow, for with the ground cleared the water quickly gets to the streams and flows away, with the consequent result of floods at certain times of the year and low water at other times.

While it is believed that the forests have a more or less great effect in equalizing the flow, there has been little accurate data to justify any statement on the subject. A bulletin was issued recently by the University of Wisconsin which deals with the flow of streams and the factors that modify it. This bulletin, while dealing primarily with Wisconsin conditions, is of considerable interest to Canadians.

Professor Mead, who had charge of the work of preparing the bulletin, draws the following conclusions, which are applicable more particularly to our conditions. He states that if forests have any effect on stream flow that can be assigned a practical value, such effects must be manifest by an actual change in the conditions of flow when deforestation occurs, but that in general the cutting of timber in Wisconsin has had no material effect, either favorable or adverse, on the high water, mean water, or low water flow of the stream, or on the regularity of such flow; that if any effects on stream flow have resulted from deforestation, they have been entirely counteracted and obscured by the drainage of marshes, the clearing of farm lands, the second growth of timber and brush, or other similar occurrences, and that in so far as all evidence examined is concerned, there is nothing to show that the planting of forests in Wisconsin would in any way add to or take away from the quantity or regularity of stream flow or decrease of flood heights.

These results, as authoritative data, show that in general little benefit can be expected from reforestation for the regulation of our streams. The construction of storage reservoirs appears to be the logical step for any system having for its aim the equalization of the flow of our streams. A good deal of emphasis has been heretofore placed upon the theoretical advantages to be gained from reforestation, and the studies of Professor Mead will undoubtedly do much to dispel false assumptions and to direct investigation of the subject along the right lines.

CONCRETE BLOCKS IN NEW YORK.

The following specifications were recently adopted for concrete block in Greater New York:

Hollow concrete building blocks may be used for buildings not more than three stories nor more than 36 ft. in height, under the following conditions:

No hollow concrete blocks shall be used unless made of the following composition: One part Portland cement, and not more than five parts of clean, coarse, sharp sand and gravel, or a mixture of at least one part of Portland cement and not more than five parts of crushed trap rock or other suitable aggregate approved by the superintendent of buildings. The aggregate shall be of such fineness as to pass through a one-half inch ring and be free from dirt or other injurious matter, and Portland cement shall be a true Portland and be up to the standard requirements set by this bureau.

All concrete blocks shall be cast true and square, and be of uniform shape and thickness when laid in courses. No such blocks shall be used until complete and satisfactory tests have been made by the manufacturer under the direction of the superintendent of buildings, and until an approval for the use of such blocks has been obtained.

No blocks shall be approved that do not at the age of 28 days develop a compressive strength of at least 1,500 lbs. per sq. in. of net section.

In no cases shall the hollow spaces of the concrete block exceed 33⅓ per cent. of the cross-section of the block. The thickness of walls or webs of such blocks shall not be less than one-fourth of the height of the blocks but in no case less than 1½ inches.

The thickness of walls for any buildings where hollow concrete blocks are used shall not be less than is required by the building code for brick walls. All such walls shall be laid in Portland cement mortar. All outside walls below grade must be filled in solid. No walls composed of hollow concrete blocks shall be loaded in excess of 100 lbs. per sq. in. of the gross section of the wall—that is, no deduction being made for hollow spaces in figuring the area.

Where beams or girders rest on such walls, suitable templates of iron, steel, or stone shall be provided under their ends, or the blocks under them shall be solid. Concrete lintels spanning an opening over 3 ft. 6 in. wide shall be reinforced by steel bars.

Every block must have stamped thereon the name of the manufacturer or the manufacturer's mark.

All walls of hollow concrete blocks, and beams used in same, must be anchored in accordance with Sections 41 and 60 of the building code.

EFFECTIVE STRESS IN BELTS.

In a recent issue of Zeits. des Vereines deutscher Ingenieure appears an account of tests on the limits of effective stress in belts of various materials. An abstract of the article appears in the April Journal of the American Society of Mechanical Engineers. Such tests require a large expenditure of time because overloading of a belt can be discovered only from the appearance of a permanent elongation, and an identical elongation is also found in a new belt which has not yet reached its state of resistance. Since, however, several hours are required for a belt to reach that state, there is always a danger in short tests with new belts of taking phenomena of the state of resistance for those of overload.

Tests of Link Belts.—The tests were made on two link belts of equal width, but unequal thickness, made up of links pressed out of specially prepared fibre, and provided with leather rims. The tests have shown that at a speed of 15 m (say 50 ft.) per sec., the total stress on the tight side of the belt must not exceed 30 kg per cm (166 ft. per in.) of width of belt, but at higher speeds may go as high as 35 kg per cm (193 lb. per in.) of width of belt. Link belts have been introduced because they combined the strength of double with the flexibility of single belts, and gave strong belts which could be used on pulleys of small diameter. These tests have shown that for speeds up to 20 m (65 ft.) per sec. link belts are far superior not only to single, but even to double, leather belts, but at higher speeds the centrifugal tension in the heavy link belt decreases the allowable useful load very materially, and at speeds over 30 m (98 ft.) per sec. link belts cannot be economically used at all.

Tests of Leather Belts.—For speeds up to 15 m (50 ft.) per sec. the total stress in the tight side of the belt did not exceed 23 kg per cm (say 126 lb. per in.) of the width of the belt, while for speed of 30 m (98 ft.) per sec. the total useful tension rose to 26 kg per cm (143 lb. per in) of width of belt.

Americans often assert that belts which are turned out with the hair side to the pulley last longer than when turned with the flesh side to the pulley, as is usual in Germany. Tests made by the author have shown that in belts turned with the hair side to the pulley: (a) the tension ratio, or ratio between the tension on the tight side and that on the loose side hardly exceeds 2, while in belts running with the flesh side to the pulley it can exceed 3; (b) the highest allowable tension is more than 3 kg per cm (12.6 lb. per in.) less than in the case of belts with the flesh side toward the pulley; the speed cannot be made more than 30 m (98 ft.) per sec., against 50 m (164 ft.) with belts with the flesh side toward the pulley. This shows that it is in every respect disadvantageous to let the belt run with the hair side toward the pulley. A belt running in that way probably wears out sooner because, as was pointed out by C. O. Gehrkens, such curvature reverses the way in which the hide grew on the animal.

Tests of High-Speed Belting.—A double cemented leather belt, 45 mm (1.8 in.) wide, stood very well a total tension on the tight side of 67.1 kg per cm (370 lb. per in.), at 60 m (196 ft.) per sec., and broke only when the tension rose to 95.9 kg per cm (say 530 lb. per in.). The allowable useful stress kn can be deduced from the formula

$$kn = (kT - kf) \times 3/4$$

where kT is the total stress on the tight side, and kf the centrifugal tension.

Tests on Belt Fastenings.—In the tests with woven belts it was found that, as the speed of the belt transmission increased, the allowable useful stress diminished owing to the influence of the belt fastening, which at speeds from 25 to 30 m (81 to 98 ft.) per sec. caused such vibrations and uncertainty of run that it proved to be impossible to exceed the speed of 30 m (98 ft.) per sec. The influence of the fastening is due to the following causes: (a) through the centre of gravity of the fastening describing on the pulley a semi-circle, an additional centrifugal tension is developed equal to

$$k'f = \frac{G}{bl} \cdot \frac{v^2}{g}$$

this additional centrifugal tension is thus a function of $\frac{G}{bl}$, or weight of unit area of the fastening, and that indicates the advisability of arranging the fastening in such a way that its weight be distributed over as large an area of the belt as possible; (b) the rotation of the fastening in coming on and off the pulley produces in it a moment of torsion which in its turn produces in the belt an additional centrifugal tension. This tension becomes negligible if the fastening is made of flexible steel bands, softer steel bands lasting longer than hard ones.

A REINFORCED CONCRETE INFILTRATION WELL AND PUMPING PLANT.*

By Frederick N. Hatch, Jun. Am. Soc. C.E.

In this paper will be given a brief description of the design, equipment, and construction of a pumping station recently constructed for the Chesapeake and Ohio Railway at Silver Grove, Ky., as a part of the terminal improvements carried out by the company with which the writer is connected.

It was estimated that the ultimate quantity of water which would be required to supply the terminal would not exceed 1,000,000 gal. per 24 hours, and that the demand would be at a fairly uniform rate throughout that period. As the terminal is near the bank of the Ohio River, water was to be obtained from that stream and delivered to two 100,000-gal. tanks on towers 45 ft. high.

The Ohio River at this point is subject to an extreme variation of about 69 ft. between low and high stages, and it was necessary to design a plant which would operate satisfactorily at any stage. It was also desirable that the plant should be as nearly automatic in its operation as possible, as it would have to be about 700 ft. from the nearest shop building.

Test borings, made at several points on the river bank, showed that the top soil is underlaid by sand and gravel, and that the river bed is in the same formation. With this in mind, it was decided to sink a well on the bank and provide openings in it so that it would receive water by infiltration from the river through the intervening sand and gravel. It was expected that water obtained in this way would not contain much suspended earthly matter, though the Ohio is a turbid stream during high-water stages.

The sounding taken at the point at which the well was finally located showed the different strata to be as follows, the elevation given being that of the top of each stratum:

* Paper presented May 1st, 1912, to American Society of Civil Engineers.

	Elevation.
Extreme high water in the river	407.3
Surface of ground, loam and sand	376.0
Loam and clay	361.0
Gravel, with some sand	354.0
Sand, with some gravel	343.0
Extreme low water in the river	338.1
Fine white sand	330.0
Bed-rock	291.0

The bottom floor was fixed at Elevation 328.0, or 10 ft. lower than extreme low water, and the motor floor is above the highest stage of water.

The pumping requirements and conditions are as follows:

Minimum capacity	700 gal. per min.
Maximum static head	127 ft.
Minimum " "	66 ft.
Discharge	through 1,000 ft. of 8-in. cast-iron pipe.

The pumps are to be driven by electric motors taking 3-phase, 60-cycle, 440-volt current; the motors are to be controlled automatically by the water level in the tanks; and all equipment is to be in duplicate.

Constant-speed, centrifugal pumps were selected on account of the great variation of effective head, and the fact that pumps of this type have a low starting torque, which is favorable to automatically-controlled, alternating-current, motor drive. The pumps are 5-in., constant-speed (1,140 rev. per min.), top-suction, vertical, single-stage, centrifugal turbines, manufactured by Henry R. Worthington. At low-water stages each has a capacity of 700 gal. per min. against a total head of 142 ft., and requires 43.5 motor h.p. to operate it; at high water, against a total head of 104 ft., the discharge is 1,150 gal. per min., and the required horsepower is 50.5.

Each pump is driven by a Westinghouse 50-h.p. squirrel-cage type, induction motor, mounted on a cast-iron base on the motor-room floor. Each motor is controlled by a separate automatic starter, the two starters being mounted on one board and connected to the power line so that only one motor can be operated at a time. The solenoid switches of the starters are actuated by single-phase current controlled by a float-switch on one of the tanks. In order to prevent too frequent operation of the pumps, the float-switch is arranged so that it does not close until the water level has fallen to a point 5 ft. below the top of the tanks.

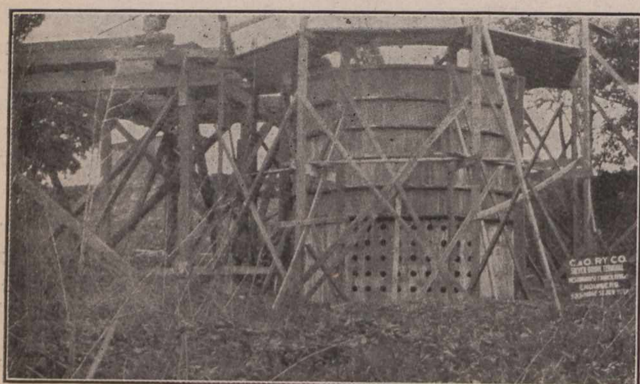


Fig. 1.—Lower Part of Shaft Before Sinking, Showing Openings Through Which Water is Admitted.

The shafts connecting the pumps to the motors are held in alignment by guide-bearings, adjustable in all directions, attached to rigid, built-up beams. The entire weight of the shaft and any possible unbalanced thrust of the pump impeller is carried by a marine-type thrust-bearing, mounted just below each motor. Flexible couplings prevent any of the weight of the main shaft from being transmitted to the motor rotor shaft and its separate thrust-bearing.

The entire shell of the well, including the motor-house and roof, is of reinforced concrete. The shell was designed to be sunk as an open caisson below the ground level. Sufficient reinforcement was provided to prevent the walls from pulling apart in case the upper part of the shaft should be held by the forms or the friction of the earth, while the power part was free. Besides providing for the erection stresses, the walls and bottom were reinforced to withstand any possible unbalanced earth or water pressure.

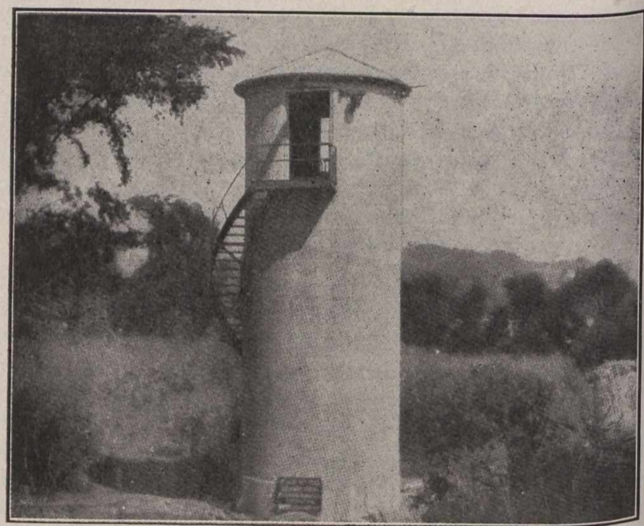


Fig. 2.—Completed Infiltration Well.

The motor-room floor was designed for a live load of 400 lb. per sq. ft. plus the concentrated loads of the motors, shafts, etc.

Water is admitted to the well through 63 openings formed by pieces of 5-in., wrought-iron pipe extending through the walls of the well below the low-water line. The aggregate area of the openings is 8.75 sq. ft. These openings are shown on Fig. 1, the photograph having been taken just after the sinking of the shaft began. Inside the well these holes are enclosed by a steel-plate chamber designed to withstand the unbalanced hydraulic pressure on the inlet side during high-water periods, with the inside of the shaft dry. A 24-in. sluice-gate, to control the inflow of water, is mounted on the side of this chamber. The gate is operated by a geared stand on the motor-room floor. To insure the proper spacing of the inlet chamber anchor-bolts, and also to provide an even joint surface, a steel angle companion flange was made with the flange of the chamber as a template. This companion flange was built into the concrete wall, and the anchor-bolts, which had enlarged ends tapped inside for 1-in. tap-bolts, were held in place by tap-bolts extending through the forms. A sheet-lead gasket was inserted between the companion flange and the flange of the chamber.

There is an opening, enclosed by a pipe railing, in the motor-room floor to give access to the lower part of the well, and steel ladders extend from bottom to top, inside.

The built-up beams for supporting the shaft guide bearings were designed for rigidity, and were set in pockets left in the walls of the well during construction. As the cover-plate serves as a walkway for inspecting the guide bearings, each beam has a pipe railing along one side of it.

A single I-beam, suspended above the motor-room floor and the hatchway, and extending as a cantilever beyond the entrance platform, serves as a track for a 4,000-lb. trolley provided to handle any of the heavy equipment.

An outside spiral steel stairway gives access to the head-house. The brackets supporting the stairway were built into pockets in the outside of the walls of the shaft.

The estimated weight of the well complete with its equipment is 530 tons, while the gross buoyancy during extreme high water, with no water inside the well, is about 465 tons, leaving a margin of stability of 65 tons, if the friction between the earth and the lower part of the shell is neglected.

Fig. 2 is a view of the completed well as seen from the land side. Fig. 3 shows the general design of the well with the equipment; but minor details have been omitted, and, to avoid confusion, some parts have been shown out of the true section.

Construction.—After leveling off the site, the steel-plate, cutting shoe was set up, and the forms were erected over it. The forms were of ⅞-in. sheathing nailed to waling pieces cut to radius. Those for the outside of the wall were supported by the posts of the working platform, and were held together, in sections, by steel bands arranged so that they could be loosened to allow the wall to slip through them. The inside forms were hung from cantilever brackets on the working platform, and were held in position by removable cross-braces, a construction which permitted the free use of the entire interior during the periods when excavating was being done.

The reinforcing rods were put in position, and a section of concrete about 5 ft. high was carefully placed and allowed to set. The forms were then loosened, and the material was excavated from the inside by a ¾-yd. orange-peel bucket handled by a derrick. As the excavation progressed the wall gradually sank. The operations of placing concrete and excavating were carried on alternately until the foot of the shaft reached its final position. The shell sank very freely through the earth, and it became necessary to provide some means of checking its descent at the proper place. This was accomplished by forming a concrete collar, integral with the wall, just above the ground level, and then taking a part of the load off the cutting shoe by blocking between this collar and the ground surface. The collar was designed to carry a large part of the suspended weight of the well if necessary. By the use of the collar the sinking of the wall was stopped at the proper place, and there was no settlement while the sand was being removed from beneath the cutting shoe.

Before the shaft reached the water level, the intake chamber was bolted in position and the sluice-gate was attached to it. When the excavation reached the water level, a large pulsometer pump was used to remove part of the water and fine sand.

As the flow of water through the open bottom of the shaft was too great to be handled by pumps, a diver was sent down to level off the bottom of the excavation and place the reinforcement for the rough bottom of the well; he also distributed the concrete for this bottom. After allowing the concrete to harden, the well was pumped dry and the finished bottom was put in.

The upper part of the shaft was constructed by raising the forms by stages as the wall was completed, and no conditions unusual to the construction of similar structures were encountered.

After the shaft was completed, the steel, guide-bearing supports were placed, leveled up, and grouted in place. Great care was required in getting the supports and bearings perfectly level and plumb, so that the vertical shafts would run smoothly.

This pumping plant has been in operation for some time, and it has been found, as anticipated, that the water reaching the interior of the well is free from suspended earthly matter, although at times the river has been quite turbid. At no time has there been a shortage of water in the well, even when the pump was running at its rated capacity and the river stage was very low.

The construction of that part of the well below the ground level was accomplished in 18 working days, and the entire part above ground in 6 working days.

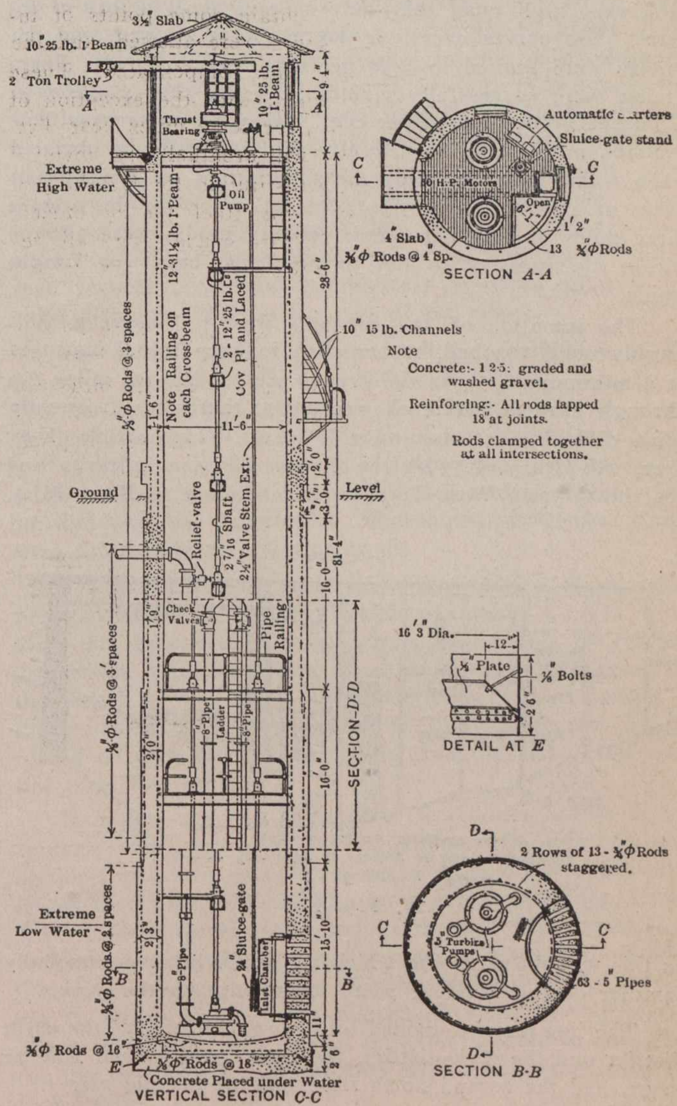


Fig. 3.—Reinforced Concrete Infiltration Well.

As the construction of the well was only a small part of the work done at Silver Grove, and as the entire job has not been closed up, only approximate costs can be given. The figures show the actual costs of construction, and do not include engineering, drafting, and other overhead charges.

Grading and excavating	370 cu. yd.	at $1.65
All concrete, including reinforcement, material	280 " " "	3.15
All concrete, including reinforcement, labor	280 " " "	3.85
All forms, material, and labor	at $2.85 per cu. yd.	
All steelwork, fabricated and otherwise, material	28,000 lb.	at $0.052
All steelwork, fabricated and otherwise, labor	28,000 " "	0.022
(Costs of steel include painting.)		
All equipment, piping, wiring, etc., in place		$6,200

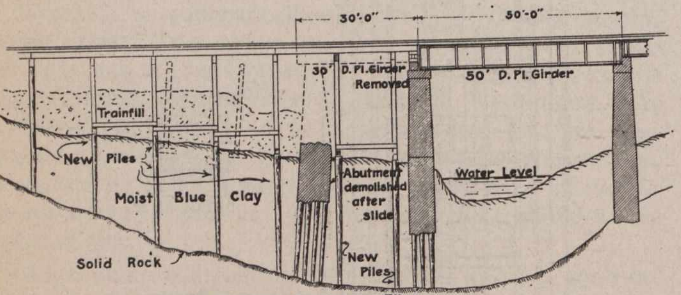
This pumping station was designed, constructed, and equipped by Westinghouse, Church, Kerr and Company, of New York.

EMBANKMENTS AND FOUNDATIONS—TORONTO-SUDBURY BRANCH C. P. R.*

By A. C. Oxley, S. Can. Soc. C.E.

The Toronto-Sudbury Branch of the C.P.R. was constructed in the years 1905-1909, and, as the standards were of a very high type, they may contain some points of interest. No curves over four degrees were allowed, and the grades were limited to 3/10 per cent. compensated. These grades were successfully maintained, with the exception of a pusher grade of 8/10 per cent., for some miles near Tottenham, mile 37. This difficulty will eventually be obviated when traffic demands it by the substitution for freight purposes of eight miles of 3/10 per cent. track for the present three miles of 8/10 per cent. Velocity grades were allowed within the limits of 10 and 30 miles per hour for freight trains.

The intention of the company was to insure a thoroughly solid roadbed, rather than to keep initial expenses at a minimum, and, as the greater part of its 225 miles ran through a rock and muskeg country, there was frequently some difficulty in attaining this result. This article, however, will deal only with the district between miles 22 and 182, north from West Toronto, from Bolton to Byng Inlet,



Bridge Abutment Resting on Piles Demolished owing to Sliding of Blue Clay Soil During Trainfilling

Fig. 1.

as this was the part with which the writer became personally familiar during his four years' experience on the work.

The line may be divided into two sections, viz., the earth district and the rock district, the first running from mile 22 to 92, and the second north from mile 92 to mile 248.

On the south, or earth section, little difficulty was encountered either with foundations or embankments. Eventually all streams and gulleys will be bridged either by steel viaducts, or by concrete arches and embankments, but at the time a number of permanent timber trestles were built, several of them containing an average of 500,000 F.B.M. The bents of these trestles rested on piles driven to an average depth of 20 feet or more, and the only settlement that has occurred has been on the ends of the trestles, where the bents rested on mud sills on the made embankment.

A curious instance of an over-refinement of engineering occurred at the Nottawasaga River trestle. The trestle is about 700 feet long, with a maximum height of 110 ft., and is located on the short tangent between two reverse curves. The trestle itself has an average elevation of 10 or 15 ft. below the general track elevation in the immediate vicinity. This is overcome by the use of 2,000 ft. of velocity grade of 6 or 7/10 per cent., resulting in a high rate of speed for the consolidated locomotive that passes over it. This will easily be remedied, however, when the trestle is replaced by a steel viaduct, either by building the viaduct higher or by slightly reducing the little summits adjacent to it. The curves also may be somewhat lessened by turning the new viaduct in a direction more nearly parallel with the tangents.

In the earth section water openings were either concrete or glazed tile pipes for small drainage areas, with concrete arches for larger ones. The pipes, on the whole, were very satisfactory, except that in a number of instances insufficient allowance had been made for their becoming reduced in area by being partially filled with water-washed sand; it was, therefore, necessary, under these circumstances, to replace 18 or 24-inch pipes with 4 ft. arches. The rule was to "camber" as high as the drop would allow, and the adjustment of the soil under the embankment was usually sufficient to take out quite a large curve, as "shrinkage" seemed to be due not only to the settling of the deposited embankment, but chiefly to the sagging of even firm clay in such a way as to cause a low spot in a pipe laid flat, and the consequent tendency of the pipe to clog. The culverts were the standard 1905 and 1906 types of concrete arches made in 20 ft. sections, to allow settlement. Piles were used in exceptional cases, a row under each side, but the general practice was to divert the stream far enough to secure firm soil.

In the rock country, practically all openings of eight feet or less were built up of the excavated rock and laid without mortar, those over four feet in width being made double, with the top constructed of flat-lintel stones. These proved entirely satisfactory in the great majority of cases, as they were laid on solid rock a little to one side of the original stream.

We will now proceed to deal with the rock section, discussing particular points in the order of their mileage from the south end. At mile 102, near Buckskin, a rock embankment about 10 ft. high crossed a fairly dry muskeg, in which the rock was about 50 or 60 ft. down. No cross-waying was ever permitted, as the intention was to have the rock embankment cut its way through the thin mattress of the dry surface of the muskeg; in this case the rock remained on the surface for about a year, and then gave way during train-filling. Some time was spent in filling it, as its depth allowed the train gravel to move sideways, but eventually bottom was reached after 3,000 Hart car loads of gravel had been placed in it. The only real objection to its sinking, when it did, was that the gravel used was high-grade surface gravel, which had to be hauled about 40 miles, as track-laying had not then proceeded far enough to reach the more northerly, and thus more convenient, sand pits.

The only midway divisional point was at Muskoka, mile 126 from West Toronto. As this point was in the rock district the grading for it was rather heavy, the finished yard occupying an area, apart from the main passing siding, of about 3,000 x 300 ft., much of which was solid rock that had to be lowered about ten feet. Water was obtained from the nearby Stewart Lake, but, as it is not allowable to pollute the Muskoka waters, the sewers had to drain into the swamp on the other side of the track.

The general mode of procedure through the rock country was to make the rock cut only about a third of the embankment, as this quantity of rock would have sufficient weight to cut its way vertically through the mattress, and as soon as bottom was reached the remainder could be made by train-filling. The efficiency of this method of forcing the sink-holes through is shown by the fact that, train-filling once completed, the percentage of derailments has been at least as low on this new roadbed as on that of sections twenty years old or more. This brings up an important question. If the intention is to have the weight of the rock cut its way through the mattress, and as it is only when

*Paper read before Canadian Society of Civil Engineers.

it has done so and reached solid bottom that the earth filling becomes really effective, would it not be advisable, in some instances, before placing the rock fill, to cut right through the mattress parallel to the centre line, for instance, in the case of a thirty-foot embankment, to cut two longitudinal ditches forty feet apart, and thus allow that whole section to sink vertically without deforming the surface at the side? Almost every case of deformation is caused by the sand or gravel floating sideways, and it does not become solid for some time.

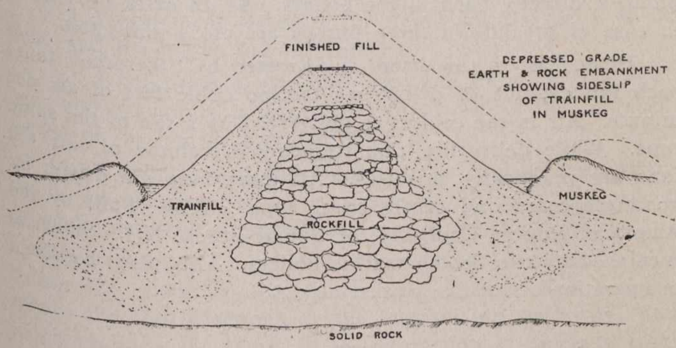


Fig. 2.

Depressed temporary grades of 3 per cent. were allowed. In many cases small hillocks of rock were cut away to allow the temporary grades to descend to the centre of the larger gulleys.

At mile 124, during train-filling, a low rock embankment, while carrying an engine, gave way suddenly, and the engine sank with such force as to shear the nuts in the track for a distance of 1,000 ft. or more. Between miles 112 and 142 a number of embankments were train-filled from temporary trestles, and little trouble was experienced, although in many cases it was found necessary to lower the level of adjacent small lakes in order to give more solid bearing to the toes of the slopes.

At Richmond Lake, mile 101, south from Romford, the lake level was about fifty or sixty feet below the level of the track. A rock embankment rested firmly on the solid rock below, but was not carried up to grade, a trestle being used above water level. The water would probably seep through the rock fill, but, in the event of its not doing so, it would easily flow through the trestle at high water. At mile 76, south from Romford, occurred one of the heaviest train-fills of the line, the depressed grade being no less than twenty-five feet at a maximum below the final grade, and, as it was necessary in filling to cover the toes of a rock embankment up to thirty feet in height, at least a quarter of a million yards of earth must have been used in this one-half mile of fill.

At mile 75.5, south from Romford, a temporary trestle beside a lake had been train-filled, but the water had apparently dissolved the embankment and caused lateral slipping. The lake was small, and the lowering of its level about four feet left the toe dry and firm.

In many instances, where a comparatively dry muskeg was to be crossed, provision was made for thickening the dry supporting mattress by ditching and lowering the level of the water table. This was generally effective, provided there was solid soil in the mattress, but not invariably. At mile 70.5 from Romford, the track crossed a muskeg about two thousand feet long and from twenty to forty feet deep, with an embankment when completed about four feet high. A drainage ditch was dug, leaving the water table only about four feet below the level of the surface soil. The track crept very badly and made "sun kinks," elevations taken during the passage of a train showing track undulations of one or two-tenths. The track was made safe for traffic and prevented from creeping by the substitution of 14-ft. bridge ties; later it was diverted to a side hill of solid rock and made thoroughly solid.

At mile 66.7, south, in order to make secure a muskeg, which for its length gave considerable trouble, a depressed grade was built, with a rock embankment about 10 ft. high, the lowest point of which was a maximum of about 20 ft. below the intended finished grade. In this case, although soundings showed a depth of 50 ft. or more to bed-rock, the weight of the rock embankment was not in itself sufficient to slice through the surface mattress. This was somwhat unfortunate, as it was always found that, although earth alone would eventually reach a firm foundation, yet, owing to its specific gravity being so low, it had a great tendency when placed by train-filling, to move horizontally rather than vertically, causing the mattress to bulge upwards for some distance out from the toes of the slope.

The writer was not present until the completion of the filling of this sink-hole but, although it had a length of only 600 ft. and had to be lifted to a height of 20 ft. above the depressed grade, a fill of 30,000 yards had raised it only 3 ft. Fortunately, by the use of spreaders, the embankment while sinking retained a good surface and alignment, and no difficulty was experienced in running passenger trains over this temporary velocity grade.

The next large fill occurred at the crossing of the Magnetawan River, the valley of which was about 3,000 ft. wide. With the exception of three girder spans this valley was crossed by a timber trestle about 40 ft. high. In this case the length of the trestle helped to reduce the unit cost of filling, as it was possible to fill from temporary grades placed on each side of the trestle, and thus leave the main line open for traffic.

It might now be interesting to mention a few of the bridges, with reference to foundations. On this 160 mile section, with two exceptions, there were no steel bridges larger than plate girders; the exceptions were at the Severn River, where there was a 200 ft. through Pratt truss, and at Parry Sound, where there was a viaduct 1,700 ft. in length. The largest span consisted of two Howe deck trusses of 165 ft. span. In the earth district all concrete was carried below frost line and rested on piles; while in the rock country the piers in almost every case rested directly on the rock itself.

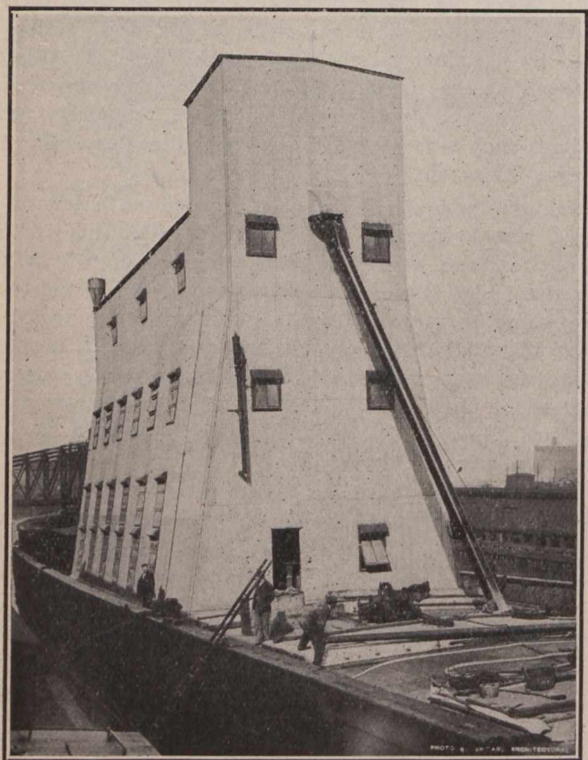
During the construction of the Parry Sound viaduct a simple method was adopted to eliminate delay. The track was paralleled at the points by the C. N. O. Railway, and running rights, or rather haulage rights, were given by that railway over a four-mile section through Parry Sound. In this way it was possible to lay some twenty miles of steel north of the Sound during the construction of the viaduct, at the same time leaving the bridge contractors a mile or more of blind main line for bridge yard purposes. The only difficulty occurred at one of the abutments at the South Nascoutyong River. In this case the abutment was carried to a depth of 10 or 15 ft. below the surface of the ground, and piles were then driven to bed-rock, about 20 ft. further. Back of the abutment was a temporary trestle about 30 ft. high resting on mud sills, the soil being an alluvial clay, which was kept moist by the presence of a stream less than 100 ft. away. No trouble was experienced with the abutment until train-filling had proceeded for some time on the temporary trestle, when the earth filling caused a flow of the clay sub-soil, and, although the bases of the piles remained in their places on bed-rock, the flowing of the clay caused the abutment to tilt forward, necessitating its demolishment. No further attempt was then made to fill the embankment, but piles were driven and a trestle constructed, both in place of the temporary trestle, and also between the abutment and the next pier, the new trestle replacing a short girder span.

In this case, even if the pier had been constructed just as it was, had piles for the temporary trestle been driven at once, the clay might possibly have been so firmly anchored that there would have been little, if any, horizontal movement.

ARMOUR FLOATING DRIER PLANT.

The Armour Grain Company has just completed probably the largest grain drier there is in the world at an investment of not far from $200,000. To build the drier they purchased and used the lake steamer "Helena," which has been in the grain-carrying trade on the Great Lakes. The length of the vessel is 310 feet and its beam 34 feet. It has a carrying capacity of about 125,000 bushels of grain. Upon this boat an Ellis drier has been constructed with a drying capacity in the neighborhood of 75,000 bushels in twenty-four hours.

The machinery is so constructed that grain can be put aboard the drier from any elevator, and, after drying, the steamer "Helena," with her own steam, can go to any point and discharge into any vessel, elevator or railroad car with her own machinery. In this manner there is avoided the necessity of unloading at an elevator having a marine leg.



Armour Floating Drier Plant.

In addition to the grain-drier constructed aboard the steamer "Helena," there is considerable storage capacity, which has been constructed with hopper bottom bins with conveyers, which will take the grain from this storage into the drying machinery. After being dried the grain can either be discharged from the steamer "Helena" or put into the storage bins aboard the boat itself. The whole plant has been constructed under plans and patents furnished by the Ellis Drier Company of Chicago.

The equipment aboard the boat is complete in every way, including electric lights, a laboratory furnished with moisture testers and other devices needed in a grain-drying plant.

A brief description of the drier equipment will prove interesting at this point. The driers are arranged in a battery formation, two six-unit machines to a battery. Directly in line with the driers are located the coolers, composed of two six-unit machines. Each battery is 28 ft. 4 in. in height by 10 ft. 2 in. in width. Both driers and coolers are constructed entirely of steel. Connected with each drier are steam coils of a special design for the utilization of exhaust steam. In connection with the coils are two automatic feed pumps and receivers, which take care of all water of condensation and pump it directly back to the boilers. As an extra precaution in case of breakdown these pumps are cross-connected.

Heated air to the driers is delivered by "Sirrocco" fans, each fan capable of delivering 110,400 cubic feet of air per minute. Air to the coolers is delivereed by a fan of the same type. While delivering this tremendous volume of air the fans are practically noiseless. All three fans are driven by an angle compound centre crank type engine, built by the American Engine Company, of Bound Brook, N.J. Steam is furnished by two Scotch marine boilers. This plant has been in operation about five weeks.

STANDARD SEWER SPECIFICATIONS.*

By E. J. Fort and A. J. Provost, Jr., New York City.

No standard specification for sewer construction which has been generally recognized or adopted as such, has up to the present time been produced and the specifications in use by even the largest and most important municipalities, vary widely in many of their most important provisions. Difference in local conditions would, no doubt, warrant special provisions in regard to some of the more important details, but there would seem to be little reason why, in the most important particulars, standard requirements may not be applicable.

Materials of construction of acceptable quality are usually available.

The functions to be performed by the finished structures are substantially the same, and if the structures are designed to be permanent, as economy and expediency would generally require, the standards of excellence in the materials and workmanship employed, may well be uniform.

Specifications for sewers of extraordinary size and special design will generally require addenda supplementing the standard specifications to meet the requirements in each particular case, while for pipe and masonry sewers of ordinary size, standard forms should ordinarily suffice.

It is the opinion of your committee that the complete instrument designed to govern every detail in the execution of contracts for sewer construction, should contain:

First—**A notice to Intending Bidders.**

Such a notice should state clearly:

(a) Time and place at which bids will be received.

(b) Location and extent of the work to be bid for.

(c) Time allowed for the execution of the contract.

(d) Amount of security required.

(e) Manner in which the bid shall be presented and its contents.

(f) Engineer's estimate of cost.

(g) General cautions in regard to preparation of bid and execution of work.

(h) Other information for the assistance of the contractor in the preparation of his bid.

*Abstract of a report to the American Society of Municipal Improvements.

Second—**Contract or Agreement Proper.**

The contract form should contain in addition to the language of the agreement, bonds, official signatures and acknowledgements of the same, and official designations of the fund from which the expense is to be met.

(a) A certified copy of the official action granting authority to execute such a contract.

(b) A description of the parties to the contract and the officials or employees under whose supervision it is to be executed.

(c) A statement covering in detail all the work to be done and the prices bid for same.

(d) A definition of the authority and duties of the engineer and assistants in control of the work as the representatives of the city or party of the first part.

(e) A definition of the rights of the contracting authority in determining the time of commencement, supervision of work, methods of precedure, force to be employed, etc.

(f) A definition of the contractors' obligations in executing the work in accordance with specification requirements and the directions of the supervising authority, and in maintaining the same, in the protection of property from damage, the payment for labor and materials, the completion within contract time, manner and time of payment, liquidated damages for delay beyond the contract time, etc.

(g) Method of procedure in modifying the contract.

(h) Clauses relating to liens, claims, damages, guarantees, assignments, etc.

(i) Enumeration of the provisions of laws and ordinances especially applicable to municipal contract work which must be observed.

(j) Other clauses of special or local application.

Third—**Specifications.**

Following a general description of the work embraced in the contract and the limits within which it is to be done, the limits within which the lines may be located, manner and times of fixing grades by the engineer, the manner in which measurements shall be made, etc., the specifications should include:

(A) A description in detail of all labor performed both preliminary and subsequent to the emplacement of the sewer structure, and the manner of its performance.

(a1) Excavation of Trenches.

1. Dimensions for various sizes of sewers and lengths to be opened at one time.

2. Shoring and bracing.

3. Pumping and baling.

4. Foundations, their preparation to receive the sewer.

5. Disposition of excavated material.

6. Provisions for the maintenance of street traffic while work is under way.

7. Removal of pavements and disposition of paving material.

8. Protection and support of other structures.

(a2) Refilling of Trenches.

1. Character of material to be used especially about sewer.

2. Manner of placing, ramming, flooding, etc.

3. Disposition of surplus, deficiency, how met.

(a3) Embankment.

1. Dimensions.

2 Character of materials, how placed and compacted.

3. Provisions for traffic through intersecting streets.

(a4) Replacing of Street Surfaces.

1. Unpaved streets. Surface to be restored; maintenance period.

2. Pavements, curbs and sidewalks out of guarantee; how restored; maintenance period.

3. Pavements, etc., under guarantee; how restored.

(B) A description in detail of all materials to be employed; their quality as shown by standard tests, and their proper manipulation to produce the finished structure.

(b1) Cement and Mortar.

1. Cement, quality, standard tests to be met.
Cement, how delivered and stored.
Cement, measurement of volume.

2. Mortar, measurement and proportions of ingredients.
Method of mixing.
Character of sand.
Amount of water.

(b2) Concrete.

1. Size and character of stone or gravel.
2. Size and uniformity of sand grains.
3. Proportions of ingredients to be used in mixture.
4. Methods of mixing, placing and surfacing.
5. Molds and forms.

(b3) Brick Masonry.

1. Quality and size of bricks to be used.

2. Manner in which they are to be laid and protected from injury. (Inverts, arches, haunch walls, manholes and catch basins, spurs and branches.)

(b4) Stone Masonry.

1. Quality and dimensions of stones. Rubble, ashlar and dry masonry, coping stones, basin heads, etc.

2. How laid to produce finished walls and structures.

(b5) Steel and Iron.

1. Rods for reinforcement, quality, dimensions and tests.

2. Structural shapes, quality, dimensions and tests.

3. Expanded metal, wire mesh, etc.

4. How placed in the finished structure.

5. Spikes used in platforms, grillages, cribs, etc., quality, dimensions, etc.

6. Cast iron.
Quality and tests.
Conformity to place.

(b6) Sewer Pipe.

Specification for pipe sewers and sewer pipe is to be in accordance with recommendations of Committee C4 of the American Society for Testing Materials, appointed to report upon "Standard Specifications and Tests for Clay and Cement Sewer Pipe." The work of that committee is not yet completed. Its last annual report, June, 1911, is referred to.

(b7) Pile and Timber Foundations.

1. Bearing Piles.
a. Kinds and quality of timber.
b. Dimensions.
c. How driven.
d. How measured and paid for.

2. Foundation timber.
a. Kinds and quality of timber.
b. Dimensions as shown on plan.
c. How laid and secured.

3. Sheathing and Bracing Timber.
Manner of Placing
a. To remain in the work.
Kind, quality, dimensions, etc.
b. To be withdrawn.
Kind, quality, dimensions, etc.

(b8) Sewer Connections.

1. Manner and time of connecting house drains.
2. Connections intersected to be re-connected.
3. Flow of old sewer—how cared for.
4. Method of making all connections.

(b9) House Connection Drains.

1. Spur pipe to receive house connection drains. Spacing and size. How laid.

2. Standpipes on deep sewers.

3. Cast-iron pipe for house connection drains, where necessary, how laid, quality, etc.

(b10) Manholes.

1. Concrete, brick.

How built, dimensions, etc.

2. Manhole heads and covers.

Standard plan.

Weights, dimensions, etc.

Quality of iron.

Inspection.

(b11) Sewer Basins or Inlets.

1. Standard plan.

2. Excavation, dimensions, how made.

3. Heads and gratings or pans.

4. Traps.

5. Culverts, dimensions, how laid and connected to same, etc.

6. Restoration of curb, sidewalk and pavement after construction.

FLOUR MILLING AND MILL ENGINEERING.

At a meeting of the American Society of Mechanical Engineers held in Philadelphia, March 30, 1912, a paper was presented by B. W. Dedrick, instructor of milling and mill engineering, Pennsylvania State College, State College, Pa., on Flour Milling and Mill Engineering. An abstract of the paper is given below:

The ancient builder of mills was called the millwright, and, even up to comparatively modern times, was the only person capable of designing, building, and placing machinery and planning buildings for their accommodation, not only of flour mills, but factories or whatever machinery was employed.

The modern flour mill building does not depart radically from other buildings designed for the reception and operation of heavy machinery, but the height of building and floors is given more consideration. Mill buildings are usually carried up three, four, five or more stories above the basement. It is necessary and better economy to have sufficient height in order to place certain machines one above the other, so as to take advantage of the force of gravity in the handling of stock. In designing mill buildings, the engineer must also take into consideration the great weight to be supported, not only of the heavy and numerous machines required and their driving connectors, spouts ad bins, but of the grain and flour that is kept within the building. Besides, in the modern mill nearly all machines used are rapidly revolving, and if improperly placed or balanced, are particularly hard on a building, causing a perceptible weaving motion or tremor. The floors have to be of proper height to give sufficient pitch or incline to spouts, for if the spout is too flat or of insufficient pitch, the flour or other material will not run down, but choke or clog. The flour mill building, especially on the grinding and bolting floors, should be well lighted by a sufficient number of windows in day time, and electric or other good light at night, for it is necessary frequently to inspect the flour and other stock, and a good steady and bright light is absolutely essential to detect the extremely close shades in the color of flour, and to compare it with the standard samples.

Practically the first step of the wheat in the mill is in the separators, of which there are usually two: the receiving, that rough cleans the grain as it comes into the mill, taking out straws, wheat heads, sticks, oats, seeds and other trash; and the mill separator, that handles the wheat, cleaned almost entirely of foreign matter, making a closer and finer separation of the wheat, taking out any remaining oats, white caps, joints and seeds left over by the receiving separator. The light and imperfect wheat is drawn out by air current. From the separators the thoroughly cleaned wheat goes to the scourer which has a cylinder or series of blades of beaters revolving very rapidly, from 500 to 700 revolutions. These beaters throw the grain against the "case" which may be simply of heavy woven wire, the mesh or openings being small enough to prevent even the smallest berry from passing through, but allowing pieces of bran, chit or seed to be forced through, to settle in the hopper below, or to be drawn into the fan.

The effect of the beaters throwing the wheat against the rough casing at varying angles is to scour off the beards, exteriors dirt and, in case of severe scouring, the outside cuticle or woody covering, all this being forced through the openings of the case, with the beaters acting as blowing fans. In both cases of the separator and scourer, the wheat is subjected to a current of air or suction at the receiving end and again on leaving the machine; this takes out the lighter wheat and remaining dust. On their passage to the fan, the heavier grains are arrested when they get into the tips where the expanding air loses some of its force, and cannot carry them farther, so they fall of their own weight into what is called "the screening tips." In some mills wheat that contains a great deal of cockle seed is passed through a cockle-cylinder which removes seed more perfectly. Mills that use wheat containing a good deal of smut or contaminated by smut, wash the wheat in machines for that purpose, after which it is dried and again scoured and tempered before going to the rolls.

A modern roll called a "double stand" consists of two pairs, one on each side. If each pair handles different material as they do in smaller mills, a partition below the rolls practically makes each a distinct pair.

The rolls are carried on bearings, which are rigid for one roll and movable or free for the other, allowing this roll to be adjusted closer to or further apart from the other roll according to the fineness desired to break or crush the stock passing between the rolls.

The arms of the movable roll are pivoted below on eccentric bearings, one on each side of the roll frame. The tramming or bringing the rolls into level is accomplished by means of turning this eccentric bolt, and then locked by a nut, but the arm is allowed to move or swing freely as in adjusting the rolls or spreading them apart, by the lever, when shutting down or when the roll runs empty. The arm at the top carries a recess which contains a heavy coil spring, which bears against the inner closed end, and against the wheel at the outer end. The rod passing through is the adjusting or lighter, corresponding to that of the millstone. At the outer end is the hand wheel used to compress the spring and thus stiffen or increase the tension. The inner hand wheel is the adjustor. By turning the wheel left or right, or forward on the threaded rod, it permits the rolls to close up; turning it in the opposite direction, spreads the rolls apart. Passing through the centre under the feeder housing is a small shaft to which is attached a lever. There are two pairs of eccentrics on each end, to which are attached the adjusting rods by their yokes. The movement of the lever in one direction throws both the movable rolls from their mates simultaneously at both ends, and vice versa brings them back to position.

Each pair of rolls has a fast and slow roll. In order to grind or crush with effect, there must be more or less of a rending or tearing action, and for this reason the rolls are given "differentials" in speed, the most common differentials used being 2½ to 1 for break rolls on wheat, to 1½ to 1¼ to 1 on the middling reduction rolls, which are smooth almost without exception, though very finely corrugated, or scratch rolls are sometimes used on the first clean middlings.

There are several types of bolters or sifters. The hexagon or six-sided reel is the oldest type of bolter still used, but its action in bolting is rather harsh. The round reel dresser is gentler in action, and like the hexagon, is slow in running, 30 revolutions being the mean. The centrifugal reel is used only on very soft, flaky material, for its disintegrating effect. The gyrating type of sifter is altogether considered to be the best and most gentle of all. The action of the gyrating sieves is to compel the stock to travel spirally on the surface of the flat sieve and on top of the silk, so as to bring the lighter, fluffier and impure parts on top of the travelling stream and hold them there until they tail off, the purer going through the cloth. Various means or devices are used to keep the meshes of the cloth open.

From there the wheat goes to purifiers. In the old flat grinding process all the flour possible was made at one and the first grinding. This system was very simple, consisting of a rolling screen, a smutter, a pair of burrs, one or two long reels, and a couple of elevators. Some middling or semolinas were made, but of such a character and containing so much fine bran or germs that when these middlings were reground on stone and bolted, it made an inferior flour as compared with the first, or superfine, produced in the grind of the wheat itself. The invention of a successful middlings purifier changed all that. From seeking to grind low, making no middlings, or as little as possible, it now became the object to grind higher, cut the bran as little, and make as much middlings as possible. The miller reduced the feed on the stone by half, bestowed more skill and patience in dressing the burr, giving smoother surfaces and grinding higher and cooler with a millstone; he thus produced middlings that after being purified and then ground separately on stones and bolted, made flour superior to the "first" or "clear" flour produced from the grinding of the wheat itself. This flour produced from the purified middlings was called "New Process" or "Patent" flour.

The different grades of middlings, after being purified, are crushed on the smooth rolls and then sent to the different sections of the sifter and sometimes to reels, as in the last roll reduction. With each reduction and subsequent separation of bolting, there is a certain amount of flour sifted out, and as a natural consequence there is an increased proportion of impurities to be handled on the next reduction and separation, so that the tendency is for the flour to be less white and clear, and partially to counteract this tendency it is necessary to have the cloths finer and finer. After certain reductions the tailings may be of such a nature as not to require further handling, and are sent direct to feed as finished, while those containing any floury parts are again reduced and sifted, the final results being flour, bran and shorts.

The paper contained also a detailed discussion of the capacity of machines and weights, and a description of the model mill to be built at Pennsylvania State College, State College, Pa., to give students the practical part of milling, and for experimental purposes in the way of testing the different kinds of wheat, to ascertain the bread making qualities of the flour; baking and chemical tests of flour and grain, and experimentation with various machines as to efficiency, power absorbed, etc.

BELTING INFORMATION.

The following, along with other valuable information, is taken from a catalogue and handbook published by the Fitz Water Wheel Co., manufacturers of the well-known I-X-L Overshoot Water Wheel, Hanover, Pa.:—

Rule for Calculating Length of Belting before Pulleys are Placed in Position.

Add together the diameter of the two pulleys and multiply the sum by 3.14159. To half of the result thus obtained add twice the distance from centre of one pulley (or shaft) to centre of the other pulley (or shaft).

Example.—Given the distance between centres of pulleys, 28 feet 8 inches; diameter of pulleys, 52 inches and 46 inches. What is length of belt?

52 + 46 = 98 × 3.14159 = 307.87 inches.
307.8 ÷ 2 = 153.98 inches ÷ 12 = 12.83 feet.
Centres 28 8-12 feet × 2 = 57.33 "

Answer 70⅙ feet.

Tightners.—The tightening pulley is applied to the belt to increase its adhesion to the pulley, and, as this is to fall first on the smaller pulley, it is usual to place it on the slack side of the belt near this pulley in order to increase the area of contact as well as adhesion. It also increases the friction of driving in proportion to the thrusting of the belt from the line of its natural curvature.

Horse-Power Transmitted by Leather Belts.

Speed in feet per minute.	Width of Belt in Inches. 2 H.P.	3 H.P.	4 H.P.	5 H.P.	6 H.P.	8 H.P.	10 H.P.	12 H.P.	14 H.P.	16 H.P.	18 H.P.	20 H.P.
400	1	1½	2	2½	3	4	5	6	7	8	9	10
600	1½	2¼	3	3¾	4½	6	7½	9	10½	12	13½	15
800	2	3	4	5	6	8	10	12	14	16	18	20
1,000	2½	3¼	5	6¼	7½	10	12½	15	17½	20	22½	25
1,200	3	4½	6	7½	9	12	15	18	21	24	27	30
1,500	3¾	5¾	7½	9½	11½	15	18¾	22½	26½	30	33¾	37½
1,800	4½	6¾	9	11¼	13½	18	22½	27	31½	36	40½	45
2,000	5	7½	10	12½	15	20	25	30	35	40	45	50
2,400	6	9	12	15	18	24	30	36	42	48	54	60
2,800	7	10½	14	17½	21	28	35	42	49	56	63	70
3,000	7½	11¼	15	18¾	22½	30	37½	45	52½	60	67½	75
3,500	8¾	13	17½	22	26	35	44	52½	61	70	79	88
4,000	10	15	20	25	30	40	50	60	70	80	90	100
4,500	11¼	17	22½	28	34	45	57	69	78	90	102	114
5,000	12½	19	25	31	37½	50	62½	75	87½	100	112	125

Metallurgical Comment

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

Correspondence and Discussion Invited

UTILIZATION OF SLAG HEAT.*

It has long been realized that in the operation of blast furnaces the usual practice of tapping the slag into ladles, and removing it in a molten state to the slag-tip, is extremely wasteful of heat. It has the further disadvantage of occupying all the available land in the vicinity of the furnaces and rendering it useless; whilst disposing of the slag in this manner becomes gradually more and more costly as the tips get higher and further away, and the surrounding land becomes more valuable for the housing of workmen, etc. This difficulty has been met to a small extent in some works by the introduction of slag-brick-making machinery, slag wool or silicate cotton plant, and crushing and granulating plant for cement or manure, but in all these processes the enormous quantity of heat contained in the slag is entirely wasted.

Various attempts have been made to utilize the heat of slag for raising steam, but owing to the rapidity with which slag scales over and ceases to part freely with its heat when exposed in trays passing through boiler flues, and the losses in transmission of heat through plates, only a very small portion of the total heat can be actually imparted to the water in an ordinary boiler. In other designs where it has been attempted to take the slag hot or molten into the water, the formation of acids, due to the presence of air, has rendered the steam unfit for use for the generation of power, owing to the destructive effect of the acid on the boiler-plates and machinery; while the admission of air to the boiler makes condensing impracticable.

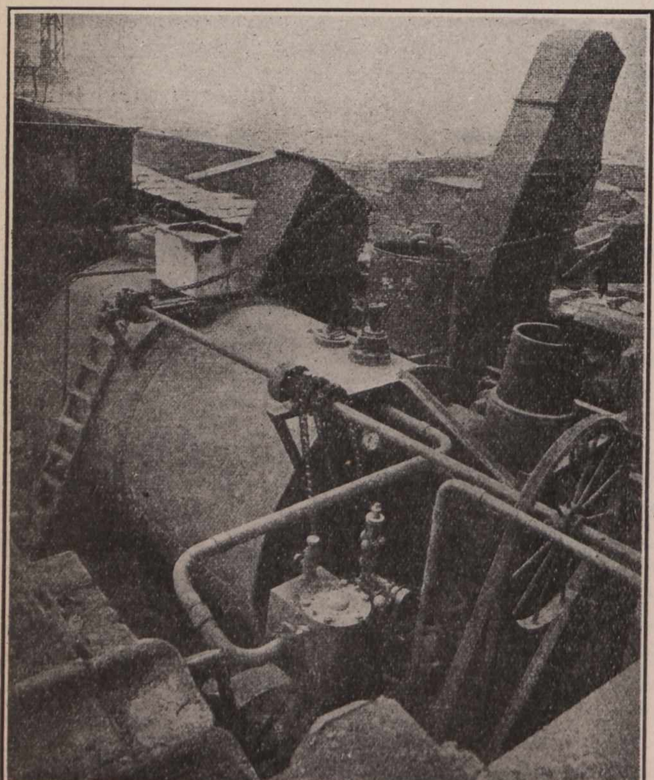


Fig. 1.—Experimental Plant for Utilization of Slag Heat.

In the plant described and illustrated below, practically the whole of the heat in the slag is effectively imparted to the water in the boiler, and the exclusion of air from the boiler is a feature which not only prevents the formation of acid, but also allows of the steam generated being economically used in a low-pressure turbine, as the highest degree of vacuum can be maintained at the condenser. The system is based on the Vautin patent, developed by Messrs. Slag Power, Limited, of 638 Salisbury House, London Wall, E.C. In dealing with slag from copper furnaces, the steam generated was found, on analysis, to be well suited for use in low-pressure steam turbines, and it was decided to ascertain whether the slag from blast furnaces could also be handled under the patent.

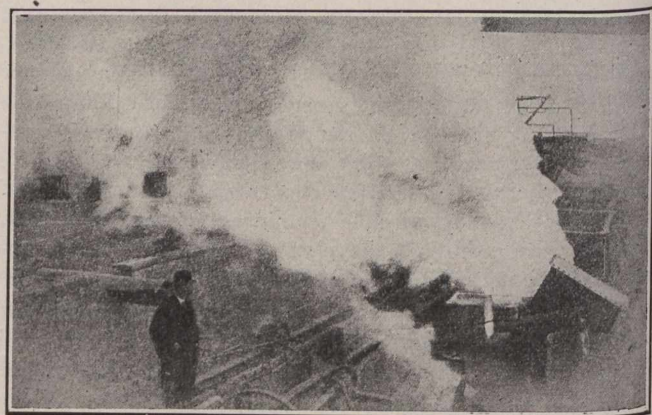


Fig. 2.—Plant in Operation.

Fig. 1 illustrates the temporary experimental plant installed for this purpose at the ironworks of Sir B. Samuelson & Company, Limited, of Middlesbrough, and modified as required, and Fig. 2 shows the same plant at work, blowing steam to atmosphere through a 13-inch gate valve fully open, the pressure in the boiler being about 1 lb. above atmospheric pressure.

Chemical analyses have shown that no trace of sulphuric acid, or, in fact, of any kind, can be detected in the steam when condensed; that the amount of sulphuretted hydrogen is not sufficient to be harmful to the blades of a turbine, if made of sound and suitable metal; that the steam, though almost instantaneously generated, is superheated about 70 deg. Fahr., and that the quantity of steam generated from a furnace producing 1,800 tons of slag per week could safely be relied upon to develop 500 kilowatts of electric current per hour, with an expenditure of 6 h.p. for operating the plant.

The following figures may be taken as fairly representative of the quantities of the principal ingredients in a large number of samples of the granulated slag and condensed steam analyzed from time to time.

Slag.—Silica, 28.5 per cent.; alumina, 19 per cent.; lime, 36.4 per cent;. sulphur, 1.12 per cent.; iron, from 0.7 to 2.5 per cent.

Steam (in grains per gallon).—Chlorine, 0.4; total sulphur, 10; sulphuretted hydrogen, 3; acid, 0.

The corrosion of the shell of the boiler, after alternately working and being exposed to atmospheric influences for several months, is quite normal and uniform, showing no sign of pitting. A quantity of clean mild-steel drillings was placed in a sample of the condensed steam, and at the end of a fortnight the water was drained off and found, on test, to contain no trace of iron.

*Iron and Coal Trades Review.

In the "Vautin" system of working, air is excluded entirely from the boiler by means of a slag trap at the inlet and a head of water at the outlet. The elevator casing is made small in area, and the cold feed water is admitted at this point, to minimize the loss by evaporation, and the elevator push-plates are perforated to allow water to drain back into the boiler. Usually the most convenient arrangement is to install a separate boiler close to each furnace at the end of the slag road, the molten slag being led by a trough into the trap, and as it flows from same it is granulated in the steam space by a flat jet of the hot boiler water, circulated by a small centrifugal pump.

The elevator for removing the granulated slag is a combination of the push-plate and tray types, the trays being above the slag as it is pushed along the bottom of the boiler, to prevent any light material floating again after having been skimmed from the surface of the water. The granulated slag is removed from the end of boiler furthest away from the inlet, where it is taken up to a suitable height for discharging into a small storage hopper or direct into trucks.

About three minutes after slag is admitted, a cold boiler is steaming at full capacity, and the steam is led by a baffle-plate past the incoming slag to take up superheat. The working pressure is 1 to 1½ lbs. per sq. in. above atmospheric pressure (say 16 lbs. absolute), and the traps and elevator casings are designed so that no air is admitted unless the pressure is allowed to drop below 13½ lbs. per sq. in. absolute. The steam from each boiler is piped to the steam main, which supplies a low-pressure condensing steam turbine driving an electric generator.

Each boiler is fitted with two slag traps (one of which is a stand-by), and either of them can be emptied and made air-tight in a few minutes. There is a large body of slag in a molten state under the inlet to the boiler to prevent chilling, but prickers are also provided in case "nosing" is necessary. The traps are fitted with tapping holes and hinged bottoms for removal of the "skull" formed after a stoppage, the bottom doors being counter-balanced so that one man can easily operate them. The plate forming the bridge of the trap is quickly renewable and is a small, simple and cheap casting. The slag inlet to the boiler, which protects the boiler-plate, is also small and cheap, and is reversible before renewal.

The boiler illustrated was cylindrical, 8 ft. in diameter by 12 ft. long, but a flat-bottomed boiler about 6 ft. 6 in. wide and 10 ft. high is preferred. The power required to operate the granulating pump and the elevator is only about 1 per cent. of the power generated.

RAIL OUTPUT IN AMERICA, 1911.

According to statistics collected by the American Iron and Steel Association, and published in their "Bulletin," the production of all kinds of rails in the United States in 1911 amounted to 2,822,790 tons, as against 3,636,031 tons in 1910, a decrease of 813,241 tons, or over 22.3 per cent. Rails rolled from purchased blooms, crop ends, and "seconds," and re-rolled and renewed steel rails are included. Included in the total for 1911 are 205,409 tons of girder and high T steel rails for electric and street railways. The maximum production of all kinds of rails was reached in 1906, when 3,977,887 tons were rolled.

Bessemer Steel Rails.—The production of Bessemer steel rails in 1911 amounted to 1,138,633 tons, as against 1,884,442 tons in 1910, a decrease of 745,809 tons, or over 39.5 per cent. Of the total in 1911, 1,053,420 tons were rolled by makers of domestic ingots and 85,213 tons by companies which did not operate Bessemer converters. Included in the total by makers of ingots are 19,379 tons of re-rolled rails.

Open-Hearth Steel Rails.—The production of open-hearth steel rails in 1911 was 1,676,923 tons, as against 1,751,359 tons in 1910, a decrease of 74,436 tons, or over 4.2 per cent. Almost all the open-hearth rails in 1911 were rolled from basic steel and all were rolled by producers of open-hearth ingots.

Miscellaneous Rails.—A total of 7,234 tons of miscellaneous rails was rolled in 1911, including 234 tons of iron rails, 462 tons of rails rolled from electric steel, and 6,538 tons of re-rolled steel rails which the makers were unable to classify as Bessemer or open-hearth rails. Of the total production of steel rails in 1911, 2,708,795 tons were rolled from ingots made by the makers and 113,761 tons were rolled from purchased ingots or blooms, crop ends, "seconds," or renewed or re-rolled rails.

Weight of Rails.—The following table gives the production of all kinds of rails in 1911, according to the weight of the rails per yard. Girder and high T rails for street and electric railways are included.

Kind of rails.	Under 45 pounds. Tons.	45 pounds and less than 85 Tons.	85 pounds and over Tons.	Total. Tons.
Bessemer rails ...	111,231	606,300	421,102	1,138,633
Open-hearth rails.	100,755	461,387	1,114,781	1,676,923
Miscellaneous	6,772	9	453	7,234
Total in 1911 ..	218,758	1,067,696	1,536,336	2,822,790
Total in 1910 ..	260,709	1,275,339	2,099,983	3,636,031
Total in 1909 ..	255,726	1,024,856	1,743,263	3,023,845
Total in 1908 ..	183,869	687,632	1,049,514	1,921,015
Total in 1907 ..	295,838	1,569,985	1,767,831	3,633,654

OIL-FIRED OPEN-HEARTH FURNACE.*

E. Richarme.

The principal dimensions of the oil-fired furnace at Tsaritsyne are: Length of hearth, 14 ft.; width at the level of the burners, 6¼ ft.; mean height, 3½ ft.; air flue, 44 by 6 in.; slope, 30 degrees; slope of burners, 14 degrees. The bed is formed of two layers of magnesite bricks (the upper one laid on edge) covered with a layer of granular magnesite mixed with 25 per cent. of slag. The end wall is of magnesite bricks, and the front wall of magnesite brick below, and silica brick above. The injectors through which the petroleum residuum used as fuel is forced into the furnace, are arranged one on each side, and are sloped at a low angle to prevent the direct impact of the jets on the surface of the metal bath. The arch is made of large silica blocks.

The furnace was started working in April, 1907, and in November, after running 1,129 charges, was stopped for cleaning out the slag boxes. The end walls and door arches were repaired at a cost of 756 roubles (about £80), but the arch of the furnace and the chequer-work of the air chambers were still in good condition; in fact, both these portions of the plant lasted out a run of 1,694 charges before part of the arch collapsed. Examination then showed extensive corrosion of the arch, and both ends were corroded at the springings of the arch, the flues being also

* Revue de Metallurgie.

more or less eaten away. In the air chambers the upper layers of silica bricks were discovered to be fused, and about half the cells in the next layer were choked up, the rest of the chamber being in fairly good condition. The total cost of repairing these defective parts of the furnace and air chambers amounted to 2,113 roubles (£220). Up to the time of these repairs the furnace had been run for 591 shifts, or 1,694 charges (each of an average of 264 poods, or 4¼ tons), the net production per 24 hours being 1,432 poods (14 tons). The consumption of charging material included: Hematite pig, 172,651 poods (2,785 tons); scrap, 270,126 poods (4,357 tons); 80 per cent. ferro-manganese, 1,783 poods (29 tons); 50 per cent. ferro-silicon, 1,115 poods (18 tons); or 445,675 poods (7,189 tons) in all. To this must be added: Ore, 10,172 poods (164 tons); flux, 26,177 poods (422 tons); magnesite and dolomite, 4,921 poods (80 tons); and fuel, 57,998 poods (935 tons). The total production amounted to: Ingots, 387,053 poods (6,245 tns); molten steel for castings, 36,212 poods (584 tons); and waste in runners, gates, etc., 5,079 poods (82 tons), a grand total of 428,344 poods (6,911 tons).

Since that time the furnace, which has a capacity of about 4 tons, has been run continuously, with a stoppage for repairs once a year after an average run of 1,700 charges, and a mean cost for repairs of 0.7 copeck per pood (11d. per ton) of output. The consumption of fuel is 130 per cent., and since the heating value of this fuel is 11,200 cal., as compared with 7,300 cal. in the case of coal with 11 per cent. of ash, the foregoing consumption corresponds to one of 200 per cent. of coal.

The jet of oil fuel is directed toward the bath of metal at an angle of 14 degrees to the horizontal; a simultaneous examination of flame and furnace arch through smoked glasses shows that the arch is dark in comparison with the flame, and that there is a dark zone between the two; a circumstance which explains the long working life of the arch and also the large number of charges which can be worked in 24 hours. This arrangement of the flame so as to heat by contact with the charge is contrary to the theoretical recommendations of certain metallurgists, namely, that the heat should be reverberated from the arch of the furnace. As a matter of fact, the flame must be kept as far as possible away from the arch and as close as possible to the materials to be heated, in order that the arch may be protected from corrosion and the heating be effected with rapidity and economy.

The seven 20-ton furnaces worked on the same system at Tsaritsyne also act satisfactorily. The charges have the following composition per 1,000 parts of steel produced: Hematite pig 670; scrap iron 360; steel scrap 20; ferro-manganese (80 per cent.) 4, Krivoi-Rog ore 60; rolling-mill cinder 40. The consumption of petroleum for heating and smelting is 150 parts, corresponding to 230 per cent. of coal containing 11 per cent. of ash. All the materials of the charge are put in cold. These 20-ton furnaces run for 1,094 charges before any extensive repairs are needed. The diurnal output is over 60 tons each; that is to say, three charges per 24 hours, on the average of the year's run, with an occasional output of 80 tons, or four charges, per 24 hours.

REPRINT OF PROPERTIES OF METAL.

On page 606, May 2nd issue of *The Canadian Engineer* was printed a table of "Properties of Metals." As this will probably be of considerable use to draughtsmen and designers, we have reprinted the table on heavy mounted paper. Copies may be obtained free by addressing the Book Department, The Canadian Engineer.

GAS CIRCULATION IN ELECTRICAL REDUCTION FURNACES.*

By Jos. W. Richards.

Mr. J. A. Leffler's splendid report on the working of the Trollhättan furnace in the electrical reduction or iron ores, presented at the annual meeting of the Jernkontoret at Stockholm, Sweden, May 31, 1911, occupying over 200 pages of that Society's transactions, brings out more information as to the electrical reduction of iron ores than has ever before been available. The report has been discussed at length before this Society by Mr. T. D. Robertson (Volume XX, page 375), and also by Mr. Otto Frick, in Metallurgical and Chemical Engineering (December, 1911, page 631). A discussion of the results and of the devices employed brings into prominence the question of circulating the gases in such an electric shaft furnace, a device which has been employed by the Aktiebolaget Elektrometall for the last three years. The writer has some reflections to offer upon this subject, which may be preceded by a short discussion of the reasons for the adoption of this circulation.

Reasons for Circulating the Cases.—In the early working of the Domnarfvet furnace, the weakest point was the overheating of the roof of the crucible. To preserve this roof, Messrs. Groenwall, Lindblad and Stalhane conceived the idea of bringing from the top of the furnace some of the waste gases, and injecting them, comparatively cool, into the space beneath the arched roof of the crucible and charge beneath, so as to cool the under surface of the arch and thus preserve it from destruction. Later, some of this cool gas was also employed to pass through the bronze castings, forming jackets through which the electrodes passed, thus cooling them thoroughly and sending into the furnace the heat absorbed from them, instead of losing said heat in cooling water.

Incidentally to the use of cool waste gases, it was found that when these gases were thus returned into the crucible of the furnace, in amount equal or superior to the volume of gases being generated by the reduction of the ore, this additional volume of gas carried out of the crucible into the shaft of the furnace above a considerable amount of heat, thus prolonging upwards the hot zone of the furnace, and increasing considerably the amount of reduction of the ore by CO gas in the shaft of the furnace. Indeed, without this circulation of gases the amount of gases produced by the reduction alone in the crucible was insufficient to heat the shaft of the furnace to any considerable distance, thus rendering the shaft useless as a place of reduction of the ore by ascending gases. The circulation was then pushed to an extreme, such that two-thirds to three-fourths of all the gases passing out at the top of the furnace was returned to the crucible, and thus virtually the same gas passed two or three times through the charge; the effect of this increased circulation was a pronounced economy and advantage, viz., increased heating of the shaft by the carrying upwards into it of surplus heat from the crucible, that is, a better distribution of the crucible heat upwards into the shaft of the furnace, and finally a better ratio of CO_2 to CO in the furnace shaft gases, showing that much reduction of ore has been accomplished by CO gas in the upper part of the furnace, and thus the ultimate goal of better utilization of carbon in the furnace was attained.

The writer is convinced, however, that these advantages are offset by serious disadvantages. The most obvious dis-

*Presented at the recent meeting of the Am. Electro-Chem. Soc.

advantage is that the moisture of the charges and the CO_2 of the flux and the CO_2 gas naturally produced in the furnace are returned in large part to the crucible, and there act upon the unconsumed carbon, by the reactions.

$$CO_2 + C = 2CO$$
$$H_2O + C = H_2 + CO$$

This very materially cools the smelting zone of the furnace, its most vital working part. The constructors and operators of these furnaces have recently introduced dust-catchers to intercept fine dust carried out at the top of the furnace by the gases, and also scrubbers, where the circulating gas is cooled, washed, and made to deposit this excess of water before passing into the crucible of the furnace. This device certainly removes the dust and most of the water of the gases, but cannot remove the CO_2 which it is the aim of the circulating process to increase to as high a percentage as possible and thus economize the carbon of the furnace. It stands to reason, therefore, that the better the circulating system works in facilitating reduction in the furnace, that is, in producing more CO_2 in the gases, the more prejudicial will be the introducing of the gases into the crucible of the furnace produced by the chemical reduction of this CO_2 to CO. Besides, the circulating system is cumbersome and expensive, and soon reaches the maximum of useful effect; in the writer's opinion it is an imperfect solution of the difficulties of the furnace. Considering merely the reduction of the ore by CO gas in the shaft of the furnace, it is a question of temperature and time, and to a lesser extent of the amount of CO gas passing. The reduction in the crucible undoubtedly produces CO gas, which, rising upwards slowly through the charge, will have the very best opportunity of producing the maximum amount of CO_2 if it slowly filters upwards through the shaft and there has ore at a low red heat to act upon. If it were possible to keep the column of ore in the shaft of the furnace at a low red heat it is certain that the CO gas would perform the maximum amount of reduction possible, and pass out one-half or two-thirds converted into CO_2, thus consuming the theoretical minimum amount of carbon for reduction in the furnace. The critical point of this analysis is that the ore in the shaft and furnace cannot be maintained at a red heat by the ascending of the gas naturally produced by reduction of the ore; it is insufficient in amount. It follows that the reduction is facilitated either by maintaining the ore red hot by other means, or by circulating the gases two or three times through the ore, thus keeping the materials in the shaft at the reducing temperature. The latter scheme has been the only one adopted, and has been effective, but the extent of its advantages is largely self-limiting, as has been already explained. It is quite evident that when the amount of gas passing through the furnace is increased two or three times, its velocity is increased two or three times, and therefore it is in contact with the ore only one-half to one-third as long. Theoretically this would mean that there would be no increased reduction by CO, except because of the higher temperature produced in the shaft by the increased volume of circulating gas increasing the velocity of the reduction reaction. The consideration of these circumstances leads to the following proposition.

Modified Working.—The writer thinks that the circulation of the gases should be entirely dispensed with, thus simplifying very greatly the operation of the furnace and regularity of its running. If this were done, means should be provided to preserve the arch of the crucible other than by injection of cool gas beneath it. I believe that the present experience of furnace men in preserving arches, ports and bridges of open-hearth furnaces by means of water-cooled plates embedded in the brick-work can be made to conserve the form of the arch of the crucible satisfactorily, thus dispensing with the necessity of introducing cool gas for this purpose. Then, having gotten away from the circulation of the gas, and the furnace again started in its original path, we can reduce the ore in the crucible by carbon and allow only the CO gas there produced to filter slowly through the charge in the shaft of the furnace.

In order that the ore in the shaft of the furnace may be reduced by gas it will be necessary to adopt other means of keeping the charge in the shaft of the furnace at a temperature above, say, 400° Centigrade. This can be done by means of auxiliary electric energy, and also conceivably by jacketing the shaft and burning the waste furnace gas around it.

I therefore suggest that the material in the shaft of the furnace be heated by the waste gases of the furnace burnt in flues around it, or by electric current passed through it from surface electrodes embedded in the walls of the shaft, at a point near the middle of the shaft, sufficient current being passed through the charge to heat it by its own resistance to a red heat. This will give the up-rising CO gas the maximum opportunity of reducing Fe_2O_3 and attaining equilibrium. In this way I believe that the following reaction can be attained,

$$5Fe_2O_3 + 9C = 6CO_2 + 3CO + 10Fe$$

representing the maximum formation of CO_2 by reduction in a slow current of CO. The above reaction requires only 200 parts of carbon per 1,000 or iron reduced, which is much better than can possibly be attained by the present circulating system.

As above given, the reaction is based upon dispensing with the CO_2 of the limestone; that is, the limestone should be calcined outside of the furnace (which could also be done by waste gas of the furnace itself). This saves carbon by avoiding the evolution of CO_2 from carbonates in the lower part of the furnace, below the zone of reduction by CO gas, but where CO_2 is reduced to CO by solid carbon.

Conclusions.—(1) The arch of the crucible of the furnace should be protected by water-cooled plates, as is common in open-hearth furnaces.

(2) The artificial circulation of the gas in the furnace should be dispensed with.

(3) The limestone flux should be calcined before putting into the furnace.

(4) The shaft of the furnace should be provided with auxiliary heating to maintain its contents at or above 400° Centigrade, to permit of reduction of Fe_2O_3 by the slow current of CO gas.

(5) Under these conditions an amount of carbon equal to one-fifth of the weight of iron produced should be sufficient, producing gas containing two volumes of CO_2 to one of CO.

(6) Eliminating the expense of circulating and purifying the gas, and reducing the amount of fuel required for reduction, would both simplify and cheapen the operation of the furnace.

CORRECTION.

In the April 25th issue of *The Canadian Engineer*, on page 510, an article by Mr. Ed. S. Bryant on "Foresting" was credited to the Boston Society of Civil Engineers. This article was read before the New England Waterworks' Association.

A NEW HYDRAULIC TURBINE.

A description of the hydraulic turbines of the Société anonyme des Ateliers de Construction de Th. Bell et Cie de Kriens (Lucerne, Switzerland), is given in L'Industria. An abstract of the article appears in the April Journal of the American Society of Mechanical Engineers. The turbine is of the Francis type. The regulator is shown in Fig. 1. The oil under pressure is driven from the reservoir B by a pump, driven by the pulley S, to the valve gear V, which communicates with the cylinder chambers C_1 and C_2 by the ducts K_1 and K_2, and with the reservoir B by the duct K_3. The valve gear is regulated by the spring governor R in such a way that the pressure acting on one side of the piston

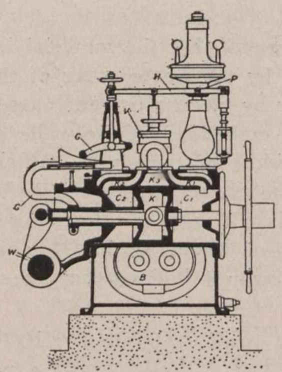


Fig. 1.—Oil Regulator in the Bell Water Turbine.

K varies according to the conditions of work of the turbine, and produces displacements of the piston which are transmitted to the governor spindle. To decrease the stroke of the piston, and to prevent excessive opening and closing of the turbine, the gear rod G is provided to bring the valve into its middle position, so that when the number of revolutions of the turbine is constant, the pump works as if there were no pressure, and it had only to make the oil circulate, thus making the consumption of power very slight.

PERSONALS.

Mr. Murray D. Kennedy has been appointed manager of the Beacon Mines at Elk Lake, Ont.

Mr. Robert Potter, B.Sc., of Fernie, B.C., has been appointed to the position of city engineer of Regina, Sask.

Mr. L. A. Thornton has been appointed to the office of a city commissioner for the municipality of Regina, Sask.

Mr. Arthur B. Lee has received the appointment of secretary-treasurer of the Woodstock Water and Light Commission.

Mr. F. M. Radford, of Sidney, has been appointed assistant to the Commissioner of the Geodetic Surveys of Canada.

Mr. E. F. Bradley, of the Canadian General Electric Company, has been appointed sales-manager of the Canada Wire & Cable Co., Ltd.

Mr. Edward Henry Keating, consulting engineer, and a former city engineer of Toronto, has been elected to the Council of Institution of Civil Engineers of Great Britain.

Mr. Mellis Ferguson, of Stratford, has been appointed city engineer of Guelph, at a salary of $2,000 a year. Mr. Ferguson has been town engineer of Stratford for the past few years.

Mr. H. A. Brazier has been appointed to the position of assistant city engineer for the municipality of London, Ont. Mr. Brazier has been for some time employed in the engineering department of the city of Toronto.

Mr. Carl I. Printz has opened offices in Toronto as a Consulting, designing and inspection engineer. His office address will be 127 Delaware Avenue, He will take over the Ontario business of Messrs. Escher, Wyss & Company.

Mr. R. L. Werry has been appointed secretary-treasurer of the Montreal Builder's Exchange. Up to the present Mr. Werry has been engaged in newspaper work and has had especial opportunities of keeping in touch with interests that will be found of value in his new position.

Mr. R. H. Parsons has been appointed superintendent of the municipal power plant at Edmonton, Alta. Mr. Parsons recently completed a hurried trip across the Atlantic in order that the position should not remain unoccupied long, owing to the resignation of Mr. Huffman.

Mr. Geo. G. MacLennan, S.P.S., '10, has been appointed resident engineer for Messrs. Mitchell & Mitchell, consulting engineers, Toronto, on power development at Minnedosa, Man. Mr. MacLennan has just completed his post-graduate course at the University of Toronto.

Mr. H. T. Routley, O.L.S., D.L.S., of the firm of Routley, Summers & Malcolmson, Haileybury, Ont., was recently elected to the presidency at the Board of Trade at that town. Mr. Routley is engineer for the township of Coleman, which is the richest township in the Dominion.

OBITUARIES.

The list of men, prominent in the public life of Canada, who have been recently called by the hand of death has been added to by the sudden death of **James Pitt Mabee,** late chief commissioner of the Board of Railway Commissioners for the Dominion of Canada.

His death resulted from an attack of appendicitis, and occurred in St. Michael's Hospital, Toronto, on Monday, May 6th, last.

The late Judge Mabee was born in 1859 at Port Rowan in Norfolk county, Ont. He was educated at the Port Rowan High School, and, graduating at the age of eighteen, went into the study of law. He was called to the Bar when but twenty-three years of age, and for five years practised in Listowel. From Listowel the young man moved to Stratford, where he practised for eighteen years. It was from here he began to assume the duties which doubtless hastened his end, and Chairman Mabee proved himself to be capable of the big work before him. To be chairman of a body that has jurisdiction over some twenty-five thousand miles of railway reaching over half a continent was a work which had no parallel in any other country. In this capacity he had to exercise all the powers of analysis that made him a big lawyer and a strong judge; all the patience and tenacity that make a master mind in dealing with evidence. And Chairman Mabee became the biggest unelected public man in Canada.

The deceased leaves a son, Lionel, with the National Trust Company, Toronto, and a daughter, Mabel, at home. Mr. O. H. Mabee, of the Manufacturers' Life Insurance Company, is a brother of the deceased.

The Canadian Pacific Railway have recently lost a valued and trusted official in the person of **Mr. James Oborne.** His death occurred in Vancouver, B.C., on Tuesday, April 30th, from erysipelas. Mr. Oborne was for some time superintendent of this railway at Toronto, but had been recently appointed General Superintendent of the Pacific Division. He was born in Montreal fifty-five years ago and entered the offices of the mechanical superintendent of the Grand Trunk Railway when about fourteen years old. In 1883 he joined the staff of the Canadian Pacific Railway as chief mechanical clerk. In 1886 Mr. Thomas G. Shaughnessy, then general manager, appointed James Oborne his chief clerk. He held his position for sixteen months. In September, 1887, he was made car accountant, and in 1890 superintendent of car service. In 1892 Mr. Oborne was appointed general fuel agent. Four years later he was made assistant to the vice-president, and his tenure of office continued for three years. Following this office, Mr. Oborne got his first appointment as a division superintendent. He was sent to Winnipeg to supervise the affairs of the division, which then extended from Port Arthur to Laggan, B.C. In 1901 he was transferred to the superintendency of the Atlantic division, with headquarters at St. John, N.B. After two years he was appointed general superintendent of the eastern division, with headquarters at Montreal. Then, in December, 1906, Mr. Oborne was appointed general superintendent of the Ontario division, with headquarters in this city. He held this position until two months ago, when he exchanged the Ontario superintendency for that of the Pacific Coast.

COMING MEETINGS.

AMERICAN RAILWAY ASSOCIATION.—May 15th. Semi-Annual meeting at New York City. Sec'y, W. F. Allen, 75 Church St., New York.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.—May 22nd-25th. Annual Convention at Chicago, Ill. Secy., D. B. Sebastian, La Salle St. station, Chicago.

FOURTH NATIONAL CONFERENCE ON CITY PLANNING.—May 27th-29th. Meeting, Public Library, Boston, Mass. Sec'y, Flavel Shurtleff, 19 Congress Street, Boston, Mass.

AMERICAN WATER WORKS ASSOCIATION.—June 3rd 8th. Annual Convention at Louisville, Ky. Secy., J. M. Diven, 271 River St., Troy, N.Y.

CANADIAN ELECTRICAL ASSOCIATION.—June 19th-21st. Annual meeting at Ottawa, Ont. Sec'y, T. S. Young, 220 King St. West, Toronto, Ont.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—June 26th-28th. Annual meeting at Boston, Mass. Sec'y, H. H. Norris, Cornell University, Ithica, N.Y.

ONTARIO MUNICIPAL ASSOCIATION.—Annual convention will be held in the City Hall, Toronto, on June 18th and 19th, 1912. Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ont.

CANADIAN PUBLIC HEALTH ASSOCIATION.—Second Annual Meeting to be held in Toronto, Sept. 16, 17 and 18.

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, W. Alan, Kennedy; 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, Chas. Hopewell, Mayor, Ottawa; 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, W. Sanford Evans, Mayor of Winnipeg; Hon. Secretary-Treasurer, W. D. Lighthall, K.C., Ex-Mayor of Westmount.

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

UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. 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, Reeve Forke, Pipestone, Man.; Secy-Treasurer, Reeve Cardale, Oak River, Man.

CANADIAN TECHNICAL SOCIETIES

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

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

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

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

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, N. W. Ryerson Niagara Falls; Secretary, T. S. Young, Canadian Electrical News, Toronto.

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

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

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

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, D. McDonald, Manager, Montreal Street Railway; Secretary, Acton Burrows, 70 Bond Street, Toronto.

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

CENTRAL RAILWAY AND ENGINEERING CLUB.—Toronto. President G. Baldwin; Secretary, C. L. Worth, 409 Union Station. Meets third Tuesday each month except June, July 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 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, Wm Pierce, Calgary; Secretary-Treasurer, John T. Hall, Brandon, Man.

WESTERN CANADA RAILWAY CLUB.—President, R. R. Nield; Secretary, W. H. Rosevear, 115 Phœnix Block, Winnipeg, Man. Second Monday, except June, July and August, at Winnipeg.

CONSTRUCTION NEWS SECTION

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand and projected, contracts awarded, changes in staffs, etc. Printed forms for the purpose will be furnished upon application.

PLANS AND SPECIFICATIONS ON FILE.

The following Plans (P.) and Specifications (S.) are on file for reference only unless otherwise noted at the office of The Canadian Engineer, 62 Church Street, Toronto:—

Bids close		Noted in issue of
5-10	One diesel oil engine, Vernon, B.C. .....(S.)	4-25
5-15	Reinforced arch bridge, Guelph, Ont...(P. & S.)	5-2
5-29	—Water works, sewerage and electric light systems, Melfort, Sask. ....(P. & S.)	5-2

(Melfort plans and specifications are also on file at The Canadian Engineer Offices, 820 Union Bank Building, Winnipeg, and B33, Board of Trade Building, Montreal).

TENDERS PENDING.

In Addition to Those in this Issue.

Further information may be had from the issues of The Canadian Engineer referred to.

Place of Work.	Tenders Close.	Issue of.	Page.
Arkona, Ont., church	May 10.	May 2.	59
Australia, steel rails and fish plates	May 29.	May 2.	60
Calgary, Alta., timber structures	May 15.	Apr. 18.	76
Cobourg, Ont., sewage disposal works	May 14.	May 2.	74
Exeter, Ont., sewer pipe	May 10.	Apr. 25.	72
Fort William, Ont., garbage incinerator	May 15.	Apr. 18.	74
Fredericton, N.B., culvert	May 20.	May 2.	60
Guelph, Ont., Masonic temple..	May 8.	May 2.	59
Guelph, Ont., bridge	May 15.	May 2.	72
Hamilton, Ont., public comfort station	May 9.	May 2.	59
Hamilton, Ont., castings, meters, etc.	May 30.	May 2.	72
Lebret, Sask., school house...	May 31.	Apr. 25.	61
Moose Jaw, Sask., paving	May 15.	Apr. 25.	72
Melfort, Sask., waterworks, sewerage, etc.	May 29.	May 2.	72
North Battleford, Sask., boiler, steam engine, etc.	May 15.	May 2.	60
Ottawa, Ont., dredging	May 13.	May 2.	60
Ottawa, Ont., dredging	May 15.	May 2.	60
Owen Sound, Ont., concrete dam.	May 13.	May 2.	60
Ottawa, Ont., pumping machinery	May 14.	Apr. 25.	70
Ottawa, Ont., dredging	May 13.	Apr. 25.	62
Ottawa, Ont., steel tug	Apr. 22.	Apr. 11.	60
Ottawa Ont., designs for monument	Oct. 1.	Apr. 18.	60
Ottawa, Ont., fishing protection vessel	June 17.	Apr. 18.	74
Port of Quebec, Que., proposals for drydock	July 2.	Apr. 18.	60
Point Grey, B.C., plans for university	July 31.	Feb. 7.	60
Quebec, Que., leasing of waterpowers	June 26.	May 2.	72
Regina, Sask., electric supplies, Sec. 6 to 9	May 15.	Apr. 11.	72
Saskatoon, Sask., garbage incinerator	June 25.	May 2.	74
Saskatoon, Sask., superstructure 23rd Street subway	May 17.	Apr. 18.	76
Sault Ste. Marie, Ont., widening lower entrance channelway	May 10.	Apr. 18.	60
Vancouver, B.C., water pipe and gate valves	May 15.	Apr. 25.	62
Varna, Ont., drainage work ..	May 15.	Apr. 25.	62
Vernon, B.C., diesel oil engine.	May 10.	Apr. 25.	72
Wallaceburg, Ont., public building	May 13.	May 2.	60
Winnipeg, Man., electric locomotive, etc.	May 15.	May 2.	60

TENDERS.

Aylmer, Ont.—Tenders for the several trades in connection with the erection of a Carnegie Free Library at Aylmer, will be received up to May 15th, 1912. Plans, etc., at the office of the architect, W. A. Mahoney, Telephone Building, Guelph, or at the Molsons Bank, Aylmer. D. N. McGregor, Secretary, Aylmer Library Board.

Edmonds, B.C.—Tenders for the construction of a concrete covered reservoir on the Royal Oak Road, in D. L. 158, will be received up to Monday, May 20th, 1912, at the office of W. Griffiths, Comptroller, Edmonds. Particulars may be obtained at the office of the engineers, Cleveland & Cameron, 506 Winch Bldg., Vancouver.

Lunenburg, N.S.—Tenders will be received by Geo. H. Love, Town Clerk, Lunenburg, up to June 1st, 1912, for the construction of a system of sewerage for the town, in accordance with the terms of a report, plans, and specifications furnished to the town by Snow & Barbour, Civil Engineers, and now on file at the Town Office.

Minnedosa, Man.—Tenders for the construction of the spillway, intake, penstocks and power-house foundations of the Minnedosa Power Company, will be received up to May 10th, 1912, at the office of H. F. Maulson, Secretary of the Minnedosa Power Company, Minnedosa, Man. Plans and specifications may be seen at the office of W. Sanford Evans & Company, Grain Exchange Building, Winnipeg, and at the office of F. G. Taylor, barrister, Portage la Prairie, and at the offices of the company at Minnedosa.

Montreal, Que.—Tenders will be received up to noon of Monday, May 20th, 1912, for the demolition of old buildings and the erection of the Montreal City Hall Annex, in Gosford, Champ de Mars and St. Louis Streets. Plans, etc., may be seen at the office of Messrs. Marchand & Haskell, architects, No. 164 St. James St., city. L. N. Senecal, secretary, Board of Commissioners' Office, City Hall, Montreal.

Moose Jaw, Sask.—Tenders will be received until May 15th, for all the works required and necessary in connection with the erection and completion of a brick and stone church building for St. Andrew's congregation at Moose Jaw, Sask. Plans, etc., at the office of T. J. McCammon, Secretary Board of Managers, 57 River Street West, Moose Jaw, or to J. H. G. Russell, architect, Winnipeg.

Ottawa, Ont.—The Department of Public Works will receive tenders up to 4 p.m., on Thursday, May 23, 1912, for the construction of a wharf at Upper Maugerville, Sunbury County, N.B. Plans and specifications with J. K. Scammell, Esq., District Engineer, St. John, N.B.; the Postmaster at Upper Maugerville, Sunbury County, N.B.; and the Department of Public Works, Ottawa.

Ottawa, Ont.—Tenders will be received until May 13th, 1912, for dredging required at Maquapit Lake, N.B. Full particulars at the office of R. C. Desrochers, Secretary, Department of Public Works, Ottawa.

Ottawa, Ont.—Tenders for the construction of a breakwater at Trout Cove, Digby County, N.S., will be received by the Secretary, Department of Public Works, Ottawa, until May 23rd, 1912. Plans, specifications, etc., can be seen at

this department and at the offices of C. E. W. Dodwell, Esq., District Engineer, Halifax, N.S.; E. T. P. Shewen, Esq., District Engineer, St. John, N.B.; and on application to the Postmasters at Yarmouth, N.S., and at Centreville, (Trout Cove), N.S.

Ottawa, Ont.—The time for receiving tenders for widening the Lower Entrance Channel-way, Sault Ste. Marie Canal, advertised to be in on Friday, May 10th, 1912, is extended to 16 o'clock on Monday, May 20th. L. K. Jones, Secretary, Department of Railways and Canals, Ottawa.

Ottawa, Ont.—Tenders will be received by P. E. Ryan, secretary, the Commissioners of the Transcontinental Railway, Ottawa, up to noon of May 31st, 1912, for 200-ton mechanical coaling plants with sand houses and track approaches; also, 1,000-ton coaling station with the inclined trestle approach. Plans and specifications may be seen at the office of Mr. W. J. Press, Mechanical Engineer, Ottawa. (See advt. in Canadian Engineer).

Ottawa, Ont.—Tenders will be received up to noon of May 31st, 1912, for the erection of station and other buildings required along the line of the Transcontinental Railway. Plans and specifications may be seen at the office of Mr. Gordon Grant, Chief Engineer, Ottawa. (See advt. in Canadian Engineer).

Ottawa, Ont.—R. C. Desrochers, Secretary, Department of Public Works, Ottawa, will receive tenders until May 13th, 1912, for dredging required at the following places in the Province of Ontario,—Goderich, Napanee, Picton, Telegraph and Nigger Islands. (See advt. in Canadian Engineer).

Ottawa, Ont.—Tenders will be received at the Department of Public Works, Ottawa, until Wednesday, May 15th, 1912, for the hull repairs and renewals on the C.G.S. "Tyrian." Specifications, etc., may be obtained at the office of the Department, and at the office of C. E. W. Dodwell, Esq., District Engineer, Halifax, N.S.

Ottawa, Ont.—Separate sealed tenders will be received at the office of L. K. Jones, Secretary, Department of Railways and Canals, until May 16th, 1912, for the construction (1) of a brick and stone passenger station at Chatham, N.B., and (2) of a standard (wooden) passenger station and dwelling at Nelson, N.B. Plans, etc., at the office of the Chief Engineer of the Department of Railways and Canals, Ottawa; at the office of the Chief Engineers of the Intercolonial Railway, Moncton, N.B., and also at the station master's offices at Chatham and Nelson for the respective buildings at those places.

Ottawa, Ont.—The Department of Public Works, Ottawa, will receive tenders until Monday, May 20th, 1912, for dredging required at Sault Ste. Marie, Ont. Specifications, etc., at the office of the Department of Public Works.

Province of Saskatchewan.—Tenders for the erection of the following bridges in this province will be called for in a few days from the offices of the Board of Highway Commissioners:—

North-west of Asquith, over Eagle Creek, span 100 feet.
South of Estevan, over Souris River, span 100 ft.
East of Davidson, over Arm River, span 100 ft.
West of Battleford, over Battle River, span 250 feet.
North of Melfort, over Melfort Creek, span 60 ft.
South of Maple Creek, over Maple Creek, span 60 ft.
South of Drinkwater, over Moose Jaw Creek, span 150 ft.
North of Veregin, over Assiniboine River, span 125 ft.
West of Gorlitz, over Whitesand River, span 80 ft.
West of Lumsden, over Wascana Creek, span 80 ft.
West of Sturgis, over Assiniboine River, span 80 ft.
South of Webb, over Swift Current Creek, span 120 ft.

Sault Ste. Marie, Ont.—Tenders for supplying and laying about 21,000 lineal feet of tile sewer pipe with appurtenances, will be received until May 27th, 1912. C. J. Pim, City Clerk; W. W. Van Every, City Engineer. (See advt. in Canadian Engineer).

Sault Ste. Marie, Ont.—Tenders will be received until May 27th, 1912, for the construction of about 169,000 square feet of cement concrete sidewalks and about 21,000 lineal feet of concrete curbing. C. J. Pim, City Clerk; W. W. Van Every, City Engineer. (See advt. in Canadian Engineer).

Toronto, Ont.—Tenders will be received up to noon of May 17th, 1912, for sewer work on Walpole St., McKinley St., Tyrrell St., Davenport Rd., and Oxford St., plans and specifications of which may be seen at City Engineer's office, City Hall. Mayor Geary, Chairman, Board of Control, Toronto.

Toronto, Ont.—Tenders will be received at the office of Frank Barber, Civil Engineer, 57 Adelaide St. E., Toronto, at which place plans and specifications may be seen, for the construction of concrete abutments for a steel bridge 40 ft. clear span, and also for a reinforced concrete truss bridge, 60 ft. clear span and abutments. (See advt. in Canadian Engineer).

Vancouver, B.C.—Tenders for the grading and bridging of the first 10 miles of the Comox extension of the E. & N. Railway, from McBride Junction to Courtenay, will be received, addressed to H. J. Cambie, Chief Engineer, Vancouver, up to May 15th, 1912. Plans, etc., can be seen at the office of R. A. Bainbridge, Divisional Engineer of the E. & N. Railway, Store Street, Victoria. R. Marpole, Vice-President.

Vancouver, B.C.—Tenders will be received up to noon of May 31st, 1912, for the grading, bridging, etc., of the following sections of the Howe Sound & Northern Railway: (a) From end of present constructed line to mile 12.0. (b) From mile 12 to mile 24.1. (c) Branch from mile 2.3 of main line along east branch of Squamish River, 2.7 miles. Plans and specifications may be seen at the office of the Engineers, Messrs. Cleveland & Cameron, 506 Winch Building, Vancouver. Howe Sound & Northern Railway Company, 506 Carter-Cotton Building, Vancouver.

Victoria, B.C.—Tenders for the erection and completion of a four-room school building to be erected on the corner of Cecilia Road and Oliver Avenue, will be received at the office of the Board of School Trustees on or before Wednesday, May 15th, 1912. Drawings, and specifications may be seen at the office of C. Elwood Watkins, architect, Victoria.

Winnipeg, Man.—Tenders will be received by the Chairman, Board of Control, up to noon, May 16th, 1912, for the whole or any portion of the work of repairing the Salter Street overhead bridge. Specifications, etc., at the office of the City Engineer, 233 James Avenue. M. Peterson, secretary, Board of Control Office, Winnipeg.

Winnipeg, Man.—Tenders will be received addressed to H. N. Ruttan, Consulting Engineer, Fort Garry Court, Winnipeg, until May 15th, 1912, for the construction of four miles of pipe sewer in Tuxedo Park, Municipality of Assiniboia.

N. H. Ruttan will also receive tenders until May 15th, 1912. for: 1,400 feet eight-inch, 3,600 ft. nine-inch, and 14,000 ft. of twelve-inch sewer pipe for Tuxedo Park Sewer System. Specifications may be seen at the Consulting Engineer's office.

CONTRACTS AWARDED.

Berlin, Ont.—The municipal councillors have accepted the tender of Messrs. Escher Wyss and Company, for the supply of two turbine pumps with a capacity of 500,000 gallons per day. The Canadian Westinghouse Company will supply the 75 horse-power induction motors for the operation of the above.

Calgary, Alta.—Harold Harvie, Calgary representative of the Canadian Mineral Rubber Company, received word from H. Rowstron, manager of the company, that they have just been awarded a contract for 100,000 yards of asphaltic concrete by the city of Vancouver.

Edmonton, Alta.—Messrs. W. Manders & Co., of Winnipeg, have been awarded the contract for 4½ miles of paving, 20 ft. wide, to cost $160,000.

Grandview, Ont.—Messrs. Schultz Bros., of Brantford, Ont., have secured the contract for the erection of a schoolhouse at Grandview, to cost $33,900.

Hamilton, Ont.—The city council have awarded the following contracts:—That of J. W. Danforth and Company, of Buffalo, for laying the waterworks conduit from the beach pump house to the filtering basins, and the laying of the intake pipe in the lake, for the bulk sum of $61,500. That of Drummond, McCall Company, for one 36-inch gate valve, $500, and four 30-inch at $300 each, for the beach pump house. The Canadian Foundry Company two valves, $725. The Darling Pump Manufacturing Company, two valves, $347. The Coffin Valve Company, for four swing valves, $950.50.

Hamilton, Ont.—Contract has been awarded to the Canada Wire & Iron Goods Co., 182 King William Street, Hamilton for heavy screens for the reformatory at Guelph, Ontario.

High River, Alta.—Contracts for the different branches of the work and the furnishing of materials for the installation of a system of waterworks and sewerage, estimated to cost $125,000, have been awarded as follows:

Contract A—All labor and certain materials necessary for laying water mains and sewers. Tenders: J. A. Broley and Co., Fernie, $27,755.60; Geo. W. Kemper, Minot, N.D., $42,951.25. Awarded to Broley and Co.

Contract C—Furnishing all materials for and erecting steel water tower, capacity 160,000 gallons. Tenders: William Hamilton Co., Peterboro, $8,060; John Inglis Co., Toronto, $8,150; Canadian Fairbanks-Morse Co., $8,436; Canada Foundry Co., $8,990; Chicago Bridge and Iron Works, $8,300. Awarded to John Inglis Co., Toronto.

Contract D—Furnishing cast iron water pipe, 422 tons, and special castings, 10 tons. Tenders: Stewart and Lloyds, Scotland Steel pipe, $17,166; Canada Foundry Co., $19,992.40; Gartshore, Thompson Co. of Hamilton, $20,725.60; Canadian Iron Works, Philadelphia, $25,638.40; Stavely Coal and Iron Co., England, $21,232.26; Canada Iron Corporation, Fort William, $21,006. Awarded to Canada Foundry Co.

Contract E—Furnishing fire hydrants, sprinkling cranes, gate valves and valve boxes. Tenders: Florence Iron Co., $3,706.25; Drummond and McCall, Montreal, $4,552.15; Roe Stevens and Co., $4,228.58; McAvity and Sons, Winnipeg, $3,469.35; Calgary Iron Works, $4,068.55; Canada Foundry Co., $4,384.70; Kerr Engine Co., Walkerville, $4,518.70. Awarded to McAvity and Sons, subject to approval of their style of hydrant by the engineers.

Contract O—All labor necessary for laying main sewer outfall. Tenders: J. A. Broley and Co., $2,940; Geo. W. Kemper, $3,780. Awarded to Broley and Co.

Contract S—Furnishing and delivering sewer pipe connections. Tenders: Red Wing Sewer Pipe Co., glaze tile, $7,092.90; Alberta Sewer Pipe Co., cement pipe, $5,956.50; American Sewer Pipe Co., glazed tile, $6,984.90. Awarded to American Sewer Pipe Co.

Contract W—Furnishing wooden stave pipe, 4,200 feet, and special castings. Tenders: Canadian Pipe Co., Vancouver, $2,309.50; Pacific Coast Pipe Co., Vancouver, $2,187.00. Awarded to Pacific Coast Pipe Co.

Kerrisdale, Point Grey, B.C.—The contract for the laying of sewers to serve the Kerrisdale and Magee districts in connection with the general sewerage scheme has been awarded to George H. Webster, and is estimated to cost in the neighborhood of $153,000. The outfall is down the Kaye Road into the Fraser River.

Penticton, B.C.—Messrs. G. A. Carlson and Company, railway contractors of Spokane, Wash., have secured the contract for 35 miles of road on the Kettle Valley line west of Penticton. Their contract will begin above Trout Creek and run to Osprey Lake, half-way to Princeton.

St. Catharines, Ont.—The Lincoln Construction Company have been awarded the contract for the laying of a duplicate water main under the Welland Canal at a cost of $1,495. The work includes piling and bank protection and according to the wording of the contract must be completed by May 22nd next.

Vancouver, B.C.—Messrs. H. L. Stevens and Company, of this city, have the contract for the erection of the new Molsons Bank of Canada, the building to be of brick and concrete block, 25 by 122 feet. Estimated cost, $80,500.

Victoria, B.C.—The Sydney Brick & Tile Company have secured the contract for the supply of 1,300,000 brick for sewer construction. Their prices were the lowest. Other bidders were Baker Brick & Tile Company, and Victoria Brick & Tile Company, each of which put in tenders of $15 per thousand, and that of Messrs Evans, Coleman & Evans at figures ranging from $14 to $17 per thousand.

Victoria, B.C.—The Seagrave Company, of Brantford, have received the contract calling for the supply of motor apparatus for the Fire Department. This order includes one combination hose and chemical apparatus, one double sixty gallon gas chemical wagon and one chassis for each of the fire engines and city service trucks now at fire headquarters. The total cost for this work is $29,075.

Westmount, Que.—The contracts for sewers on Western Avenue, Mountain Avenue and the Boulevard have been awarded to Messrs. R. G. Smith & Co. Estimated cost, $25,596.

Windsor, Ont.—Waterworks extension: Contractor, Messrs. W. J. Dupuis & Co., Detroit, Mich., and John Inglis and Company, Toronto; cost, $32,400.

Winnipeg, Man.—Preliminary contracts have been let for the construction of the big dry dock and shipbuilding plant at Prince Rupert. Contracts for the building of the piers, landing stage, building platform and launching ways have been given to the British-American Construction Company and representatives of that firm are now at the G.T.P. terminus making arrangements for commencing the work.

RAILWAYS—STEAM AND ELECTRIC.

County of Lanark, Ont.—Messrs. Larkin & Sangster, St. Catharines, are making preparations to begin work on the nine hundred foot tunnel on the new C.P.R. line near Glantay, in this county. The tunnel, which begins beyond Christy Lake, will take a year to construct, gangs working night and day on shifts of ten hours each. The contractors are putting in an air compressor plant that will work ten drills at one time.

Halifax, N.S.—The receipts for the week ending April 30th, 1912, of the Halifax Electric Tramway Company amounted to $5,211.43, an increase of $177.32 over the same period in 1911.

Montreal, P.Q.—Grand Trunk Railway traffic earnings for the period ending April 30th totalled $1,318,817, as compared with $1,125,144 for the last similar period, an increase of $193,673.

Montreal East, P.Q.—The municipality of Montreal East has established a line of autobuses to operate between this municipality and Place d'Armes, in Montreal, a distance of about eight miles. The first machine in operation, which started last week, is of the Berliot type, of twenty-four horsepower, and capable of seating comfortably twenty-eight passengers. The tariff has not been definitely fixed yet, but the rate will probably be ten cents.

Montreal, P.Q.—The new city by-law governing the operation of autobus lines within the city limits has been drafted and will be introduced in council within the next few days. One of the features of the new by-law is that any company operating a motor service must provide a seat for each passenger carried. The capacity of each autobus will be established by officials of the city and this limit must not be exceeded by the company operating the line.

Northern Canada.—A report states that the Government steamer Minto will convey an expedition to the Hudson Bay for the purpose of reporting on the respective merits of Port Nelson and Fort Churchill as the terminus of the Hudson Bay Railway.

Northern Ontario.—A report from Northern Ontario states that twelve miles of the right-of-way of the T. & N. O. Railway has been cleared, and over three hundred men are at work on the construction. Ballasting has commenced on the uncompleted portion of the Porcupine branch, and the depot at Timmins is now being erected. Chairman Englehart is hopeful that work on the new line will be sufficiently advanced to open for traffic by December 1. The outlook for the season's business is bright. A number of settlers are going into the country at points from Liskeard to Cochrane.

Province of British Columbia.—During a sitting of the Dominion Railway Board an edict was issued that provides that all locomotives operating in this province after December, 1914, must consume oil for steam generation. This followed an active movement on the part of the provincial authorities to prevent forest and grass fires during the dry season.

Quebec, P.Q.—It is reported that the Transcontinental Railway, after leaving the Quebec bridge, will descend by the river side for some distance, and will then enter the height of land somewhere about Wolfe's Cove. The location of the exit is not yet settled apparently, but the indications are that it will come out of the hill on a curve about half a mile outside of the city. The estimated cost of the tunnel is from $800,000 to $1,000,000, but if, as is expected, the excavation is seamy and it is necessary to line the tunnel, it may be much more.

St. Thomas, Ont.—Representatives of St. Thomas, Aylmer, Yarmouth and Malahide have practically agreed to guarantee the bonds of the London & Lake Erie Railroad for an extension of the line from St. Thomas to Aylmer.

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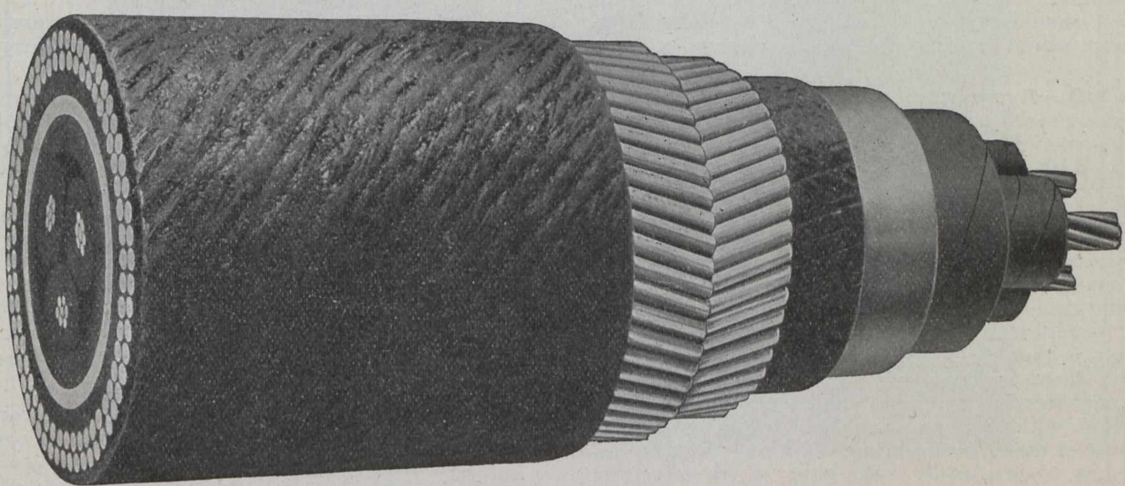

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HEAD OFFICE - MONTREAL

Toronto, Ont.—The municipal engineer has recommended that the Board of Control purchase three busses for use between Rosedale and the business centre. The cost of these would be $10,000 each.

Western Canada.—A report that has enjoyed extensive circulation in the West states that large interests are engaged in the matter of electric railway amalgamation and that should the plans mature the principal cities in the Canadian Prairie West will be linked together by electric lines operating under hydro-electric power. It is reported that the management of the Alberta Interurban Railway and the Manitoba Rural Railways Companies are interested in the matter.

LIGHT, HEAT AND POWER.

Hazelton, B.C.—The municipal council are giving serious attention to the latent powers of the falls on the Skena River near this town. It is claimed that 25,000 horse-power could be generated without any serious engineering work being involved, and that should this be accomplished, a large manufacturing district would spring up in the vicinity of this municipality.

Montreal, P.Q.—A report prepared for the municipal Board of Control shows that the cost of civic lighting will cost about $250,000. The estimate is made up as follows: Street lighting, $217,345; special lighting, $1,752; lighting parks and squares in summer, $2,178; lighting municipal buildings, $17,130; relocating lamps, $2,000; salaries of staff, $7,000. Realizing how large the sum is the controllers have studied the subject of municipal electric power. In another year's time the corporation will have completed the enlargement of the aqueduct. As this waterway is to be about three times its present width and nearly three times its present depth the result is that the water supply of the city will be much more than necessary for many years to come. Knowing this the chief engineer has prepared statements showing that it will be possible, with this extra supply of water, to develop power to do most of the street lighting. Not only is it the intention of the city to practically take care of all its street lighting, but the public buildings owned by the corporation will be cared for as well.

Saskatoon, Sask.—The municipal electrical department has shown a surplus despite the fact that reductions of 25 per cent. in power rates and 22 per cent. in lighting rate were introduced in the method of current sales. After allowing for the interest on debentures to the extent of almost $6,000, a depreciation of over $3,000 and a sinking fund of $2,328, a net profit of $2,451 is shown in a statement for the first quarter of the year which has just been made public. Saskatoon is the only city in Western Canada where electrical meters are free to the consumer.

Victoria, B.C.—The municipal council are making arrangements for the installation of a large electric sign to carry the words "Welcome to Victoria, the Gateway of the Pacific." It is to be placed on an eminence and is to be of such size that it will be visable for many miles at sea; thus serving the double purpose of a beacon light and a municipal advertisement.

GARBAGE, SEWAGE AND WATER.

Brandon, Man.—The ratepayers recently voted in favor of authorizing the issue of debentures amounting to $100,000 to be used for waterworks improvement. R. E. Speakman, City Engineer.

District of Muskoka, Ont.—With a view of preventing the pollution of lakes and streams the Provincial Board of Health is issuing dodgers warning the residents of that district against putting any garbage, animal or vegetable matter in the lakes and streams. A fine of $100 is imposed for a violation of this law.

Moose Jaw, Sask.—The ratepayers voted in favor of spending the sum of $60,000 on a new high pressure system in connection with the municipal water works system.

Port Arthur and Fort William, Ont.—The municipal council are having the waterworks system inspected by Mr. T. Aird Murray, of Toronto. It is probable that extensive changes will be made in the near future in this branch of the civic administration.

Sarnia, Ont.—Recent experiments conducted by City Engineer McLean to obtain information regarding the quality of water resulting from soakage through 30 feet of sand into test wells, resulted favorably. He plans to install a turbo-generator of 500-k.w., at the present water works, and from this operate pumps attached to about twenty additional wells.

BUILDINGS AND INDUSTRIAL WORKS.

Brandon, Man.—The ratepayers recently voted in favor of spending the sum of $33,000 to erect a new fire hall. R. E. Speakman, City Engineer.

Calgary, Alta.—Plans for the expenditure of $975,000 on new schools and school sites, $800,000 of it for the erection of schools, and $175,000 for the purchase of new sites to be held for future contingencies, were drawn up at a special meeting of the Calgary school board recently. Subject to the approval of the ratepayers, debentures are to be issued for $75,000 for 40 years at 4½ per cent.

Calgary, Alta.—Mr. G. D. Venine is preparing to erect an office and store building of brick and fireproof materials to cost $20,000.

Edmonton, Alta.—Plans have been prepared for the erection of a new Anglican Church to cost about $100,000. The new building, as planned, will be 150 feet long by 75 feet wide. The ground floor, raised five feet above grade and approached by three flights of steps from a wide vestibule will comprise the nave and side aisles, seating about 900, chancel with choir accommodation of 65, two transepts and large sanctuary and sacristy. Messrs. Barnes and Gibbs are the designers.

Fredericton, N.B.—The University Senate have announced their intention of erecting a substantial new grand stand at the atheletic grounds. It is to be constructed as soon as possible.

Hamilton, Ont.—Mr. H. H. New is preparing plans for the erection of a new children's hospital to cost $32,000.

Lethbridge, Alta.—The Free Masons of this city have made arrangements for the erection of a new hall to cost about $40,000.

Montreal, P.Q.—Plans have been prepared for a city hall annex and have been approved by the municipal council. The new structure will have a fine appearance and will do away with much congestion at the City Hall. In it will be situated the Recorder's Court, police headquarters, and health department. The annex will be four stories in height with granite foundations and a superstructure of sandstone. Tenders will be called at once for the erection of the building.

Moose Jaw, Sask.—The Saskatchewan Bridge and Iron Company have awarded the contract for the erection of their new machine shed on Fairford Street west to the Western Building Company. The new shed will be of iron-clad and steel construction 50 by 150 feet. The cost will be about $125,000.

Montreal, P.Q.—Mr. J. W. Birchenough will erect a $60,000 building on the corner of Bleury Street and Alexander Street.

Nelson, B.C.—Mr. E. Ross Mackenzie is interested in a project to erect a new opera house of brick, four stories in height to cost about $65,000. There will be seating capacity for about 900 persons.

Ottawa, Ont.—The Federal Government are considering the erection of dry-docks at the following points in Canada: St. John, N.B.; Quebec, P.Q.; Montreal, P.Q.; Toronto, Ont.; Sydney, N.S., and Prince Rupert, B.C. The docks at Collingwood, Ont., and Halifax, N.S., are to be extended.

Pincher Creek, Alta.—Plans that have been prepared for the erection of a new town hall for this municipality show a handsome building of brick, two storeys in height, with a large central tower above the main doorway.

Princeton, B.C.—Mr. Peter Swanson is having plans prepared for a hotel to cost $50,000.

Quebec, P.Q.—A report states that the Federal Government are considering the matter of reconstructing a portion of the breakwater at this point. This work will cost, according to the estimate, about $500,000.

Regina, Sask.—Plans have been prepared by Mr. F. N. Darrach for a new church building to be erected for the congregation of Westminster Presbyterian Church. They show a building with an arch at the entrance which will be support-

ed by four pillars set about halfway up the flight of steps, the doors being set well in from the pillars. The gable over the arch is high, and has a large window. The Sunday school adjoins the church. The cost of the work will be about $70,000.

Saskatoon, Sask.—A new company taking the name of the Concrete and Supply Company, has been formed with Mr. C. D. Fisher as president. The new company will manufacture cement, brick, Roman stone, and other ornamental stone. The plant is to be erected on the corner of Avenue L and 17th Street.

Saskatoon, Sask.—A report states that a Winnipeg firm contemplates erecting a seven-story building to be used for apartments and stores.

Saskatoon, Sask.—Dr. J. H. C. Willoughby and Mr. A. J. E. Sumner are preparing to erect a four story departmental store which is to be occupied upon completion by F R. McMillan & Co.

Sydney, C.B., N.S.—The firm of Mackay and Maxwell are having plans prepared for the erection of a new automobile garage to cost about $10,000. A recharging tank with appliances for recharging the new prestolight and searchlight tanks will be installed. An air pump attachment for tire pumping will be introduced also.

St. John, N.B.—Negotiations are under way for the transfer of limestone properties and the erection of a cement plant. The municipal council have agreed to sell the property for $26,200, on condition that the purchasers erect the plant and a report states that the deal only awaits ratification by the council.

St. Catharines, Ont.—A report states that the management of the Warren Axe and Tool Company, of Warren, Pa., U.S.A., propose the erection of a plant in this city. The ratepayers will vote on the question of the usual subsidy on May 9th.

St. Catharines, Ont.—A report from this city states that the management of the Reo Motor Car Company are contemplating the erection of a new factory in the vicinity of Berryman Avenue. About 80,000 additional square feet of floor space are required by the company as soon as possible.

Toronto, Ont.—The Toronto and Niagara Power Company intend to build a structural steel plant at the northeast corner of Shaw and Dupont Streets. The plant will cost $40,000.

Toronto, Ont.—The National Iron Works will commence work on an addition to their concrete dock.

Vancouver, B.C.—A report states that the management of the Canadian Home Investment Company have recently purchased a site in this city and contemplate the erection of a ten-story building to cost $1,000,000.

Vancouver, B.C.—The Northwest Commercial Travellers' Association have made preliminary arrangements for the erection of an office building in this city. The cost is estimated at $160,000.

Victoria, B.C.—Plans are being prepared by Thomas Hooper, Royal Bank Building, for a Women's Home to cost $19,000.

Windsor, Ont.—The National Auto Body Company, has been organized with a capital of $150,000. The company will manufacture auto bodies of wood, steel and aluminum, and will also build, trim and paint both open and closed bodies. A site covering three acres has already been purchased in the factory district and tenders calling for the construction of a number one plant have been advertised.

BRIDGES, ROADS AND PAVEMENTS.

County of Haltan, Ont.—The members of the county council are about to spend the sum of $?00,000 on road improvements covering over one hundred miles.

North Vancouver, B.C.—The estimated cost of constructing a bridge across the Second Narrows has been increased from $120,000 to $150,000.

Township of Morris, Ont.—The councillors of this township have found it necessary to issue debentures for the sum of $23,000, in order to replace the bridges which were swept away by the recent flood.

South Porcupine, Ont.—A large trestle bridge (200 foot) was destroyed by fire recently. It was on the line of the T & N.O. Railway seven miles south of Dane.

Toronto, Ont.—The civic engineering department has recommended the construction of an asphalt pavement on Bloor Street to cost $51,813. This will be from Bathurst St. to Dufferin St. The Works Committee are considering the question of widening the pavement on Spadina Avenue from 52 feet to 91 feet, at a cost of $35,231. This is from Queen St. to Baldwin.

FIRES.

Stratford, Ont.—The factory of Messrs. Totton Co.'s Willow Cheese manufacturers, was damaged by fire.

Treherne, Man.—Damage to the extent of $70,000 was caused by fire to the business section of this town. Among the damaged buildings the name of J. Adair & Son's implement warehouse appears.

Victoria, B.C.—The plant of the Canadian Puget Sound Lumber Mills was recently badly damaged by fire. This plant is at Rock Bay on Victoria Harbor.

CURRENT NEWS.

Brantford, Ont.—The ratepayers will vote on a by-law calling for the expenditure of $13,000 for improvements to the dyke system.

Collingwood, Ont.—The Collingwood Shipbuilding Company will construct a large freight ship for the Chicago and St. Lawrence Navigation Company of Toronto. It is to be ready for the opening of navigation in 1913 and will be the largest freighter operating on the lakes having a cargo capacity of 12,0000 tons. The dimensions are: Length over all, 550 feet; width between perpendiculars, 58 feet; moulded depth, 31 feet. The vessel will be built on the arch web system of framing, and will be fitted with side tanks and water bottom for her entire length. There will be 32 hatches with steel telescoping covers. The propelling machinery will be a vertical triple expansion engine, the cylinders being 24 in., 40 in., and 66 in. in diameter, with a 42-inch stroke. The steam will be supplied by three cylindrical boilers, each 13 feet in diameter, with a working pressure of 85 lbs., and they will be fitted with Howden's system of forced draught. The ship and machinery throughout will be built to the highest classification of the Great Lakes register. The vessel will cost complete about $375,000. Mr. W. D. Matthews is the president of the Chicago and St. Lawrence Navigation Company.

Hamilton, Ont.—The municipal council are seriously considering the question of purchasing auto trucks for hauling on civic works. The secretary of the Board of Control has been requested to secure prices and operation costs. Mr. A. F. MacCallum is the city engineer.

Nelson, B.C.—The management of the Nelson Gas & Coke Company have made overtures to the municipal council for the sale of their plant. They ask $75,000 for the business.

Ottawa, Ont.—The Civil Service Commissioners have announced that applications will be received for the position of architectural draughtsman in the chief architect's division, (Initial salary $1,300 per annum), and two draughtsmen in the same department with a salary of $800. Applications must be filed in the office of the Civil Service Commission, not later than the 20th day of May next.

Quebec, P.Q.—The Harbor Board of this municipality have arranged a plan of improvement which will cost about $1,000,000. A car ferry and a large grain elevator are on the list of improvements.

PERSONALS.

Mr. Arthur J. Demster, of Toronto, has been awarded the Science Research Scholarship by the senate of the University of Toronto.

Mr. Richard W. Allen, of the well-known firm of W. H. Allen, Sons & Co., Ltd., Bedford, England, was a visitor to Toronto this week.

Mr. L. K. Jones has been appointed to the position of Assistant Deputy-Minister of the Department of Railways and Canals for the Federal Government.

PATENTS.

The following is a list of patents recently granted to inventors in Canda. This list is furnished by Messrs. Fetherstonhaugh & Company, Royal Bank Building, King Street East, Toronto:—

W. Chater, pneumatic cushions for boot soles; J. E. Morrison and C. G. Palmer, coats; J. Bedlake, gang planks; W. A. Crickton, sheaf elevators; M. J. Haney, concrete block structures; J. R. Hendrickson, aeroplanes; C. E. Marsh, boiler compounds; J. A. Martin, devices for locking the controlling levers of automobiles; T. G. Mason, electrically controlled elevators; J. Moodie, metal railroad ties; E. Oliver, water wheels; C. A. Robinson, hat pin protectors; C. Taylor, windows.

TRADE ENQUIRIES.

The following were among the inquiries relating to Canadian trade received at the office of the High Commissioner for Canada, 17 Victoria Street, London, S.W., during the week ending April 22nd, 1912:—

A London firm manufacturing automatic packing machinery would like to hear from Canadian firms likely to be interested.

Inquiry is made for the names of Canadian manufacturers of leather cloth.

A West of England firm make inquiry for the names of Canadian manufacturers of wood turnings, such as dowels, spindles, legs for chair work and wooden wheels for toys.

A London firm manufacturing typewriter and duplicator supplies of all kinds desire to do business in Canada.

A manufacturing company at Regina, Sask., who use quantities of foreign woods of various kinds, desire to get into touch with United Kingdom exporters able to supply.

From the branch for City Trade Inquiries, 75 Basinghall Street, E.C.

An English manufacturing company would be glad to get into touch with Canadian firms in a position to take up the representation of a well-known plate powder.

A north of England company manufacturing specialties for use in the gas lighting industry are anxious to get into touch with Canadian manufacturers of gas stoves and incandescent gas lamps, particularly of high pressure type.