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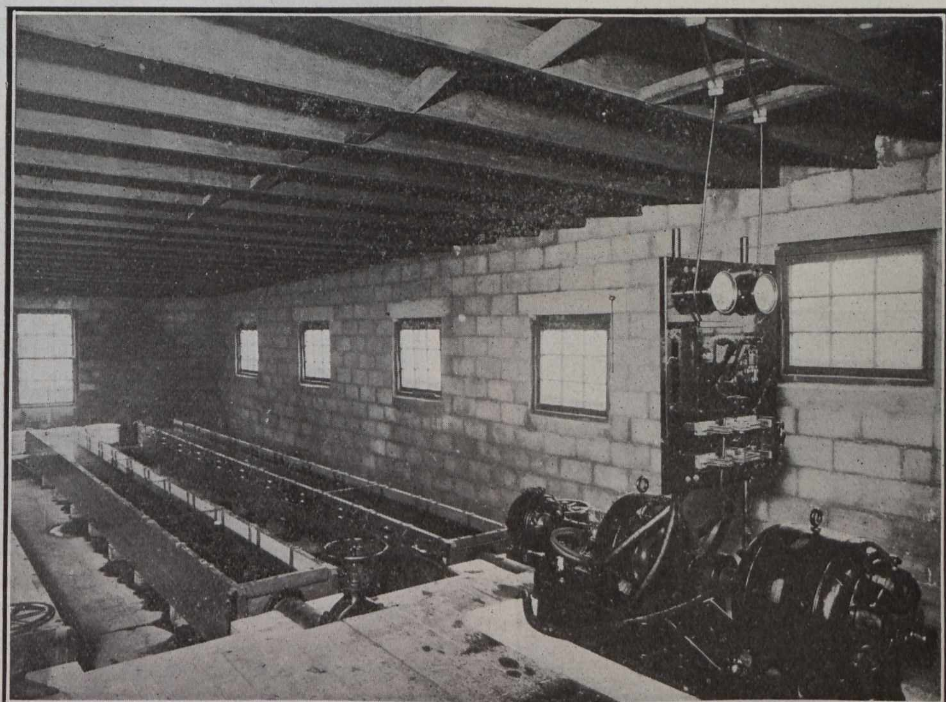
AN ELECTRICAL SEWAGE DISPOSAL PLANT.

By C. L. EDHOLM, Los Angeles, Cal.

In order to render odorless and innocuous the sewage of a city, a system has been perfected for treating it by the electrolytic process, at slight expense and with complete success. Two such plants are in operation in the West, and a third, of three times the capacity, is being constructed at a cost of $45,000, so that the device is no longer in the experimental stage. These plants may be seen in service at Santa Monica, near Los Angeles, California, and in Oklahoma City, and in the latter town a second plant was ordered after a thorough trial of the one now operating.

The purifying of water by electrolysis has been known for some time, but it was only in late years that experiments were successfully made with the view of destroying the disease germs in sewage and eliminating offensive odor by the use of electrodes.

The process may be described briefly as follows: The raw sewage is allowed to flow through wooden flumes having a length of thirty feet, width of 22 inches and depth of 18 inches. Ten sets of electrodes are placed in each flume, being composed of cast iron plates set half an inch apart and having the dimensions of nine inches by 24 inches, and a thickness of 3/16th of an inch. These electrodes receive a current of two to three volts and seven to eight hundred amperes, and as the sewage flows slowly through the flumes it is speedily purified. The odor is instantly "killed," so that there is no offence to the nostrils, even to one standing directly over the flumes. But this is not all, the liquid is clarified as well and practically all the germs are destroyed, preventing further putrefaction and making it possible to discharge the sewage into a river or upon land for irrigation purposes without danger to health. This is not a case of the germs being electrocuted, but is due to chemical changes brought about by the decomposition of the metal in the electrodes. Just how this is done has been determined by chemical analysis, but the results are plain to the most casual observer.

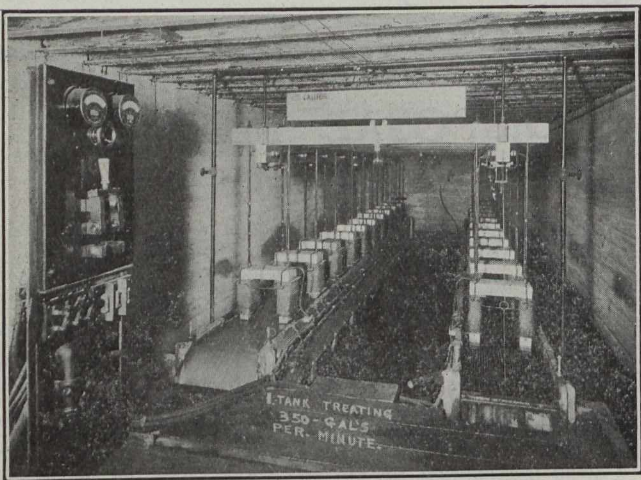


Interior of Oklahoma City Plant.

The electrical equipment of the Oklahoma City plant is described by Howard V. Hinkley, consulting and supervising engineer, as follows; "The drive consists of a 7½ h.p. alternating current motor using commercial current at 220 volts. This motor is direct connected, under the switchboard, to a 3 kw. multipolar direct current generator and exciter, all resting on a single bedplate 2 x 5 feet. The combination is designed and built for this special service and delivers to the copper cable conductors of 1,000,000 circular mills 800 to 900 amperes at a voltage of 1½ to 3, these being the limit between which the desired results are obtainable, varying somewhat with the character of the sewage. A double pole, double throw knife switch allows the reversal of the current at pleasure and a knife switch at the upper end of each flume cuts on or off the current for that flume. Owing to the high amperage as compared to the low voltage the switches and conductors are necessarily heavy. If only one flume is used the ammeter is set at 270 or 300."

The Santa Monica plant has in addition a centrifugal pump, which is operated by electricity, and used for raising the sewage from a reservoir to the level of the flumes, but this is caused by local topographical conditions, as elsewhere it might be convenient to construct the plant on a lower level than the basin.

The cost of current will vary in different cities, but the electrodes need but little (the bill for an entire year at Santa Monica was only $152.95) and the expense of repairs and replacement of plates is slight. One attendant can care

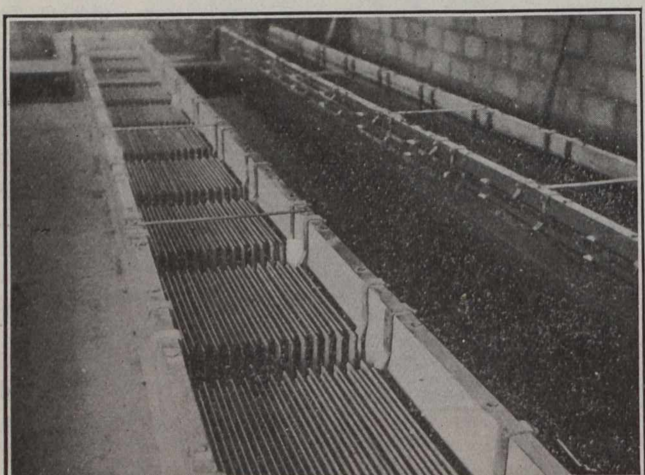


Santa Monica Plant, as Originally Built. The Magnets Over the Flumes Have Since Been Discarded and Another Flume Added.

for the plant, or even two or three if they were conveniently located for going back and forth between them, as they require hardly any work.

Cleaning of the plates is done by means of reversal of the current, while the use of a garden hose a few minutes each day cleans out the flumes and washes off the plates.

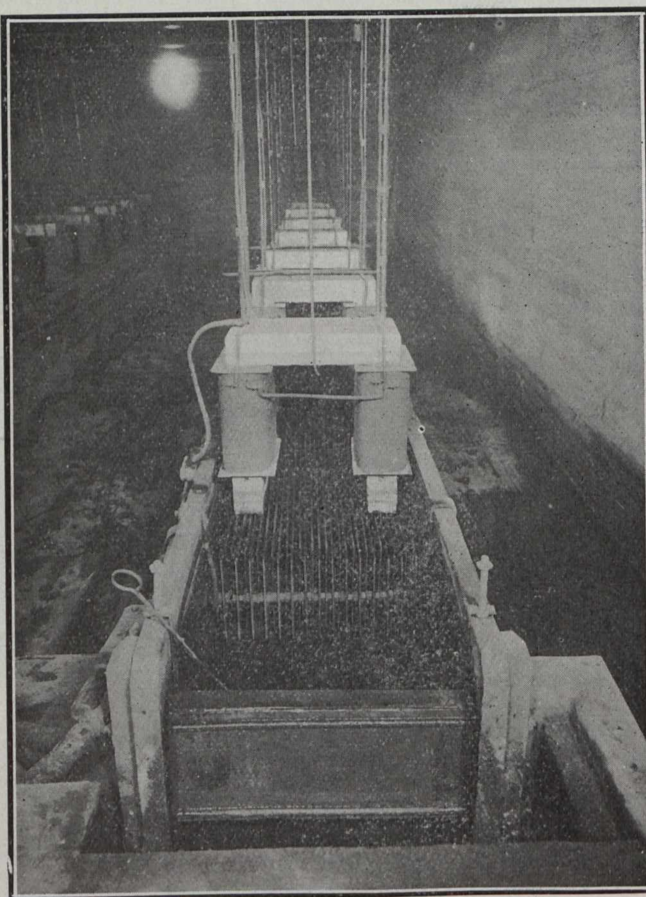
Very limited space is sufficient to house such a plant. In Oklahoma City a building 18 x 50 feet and 10½ feet high encloses a system of three flumes that handles three-quarters



Interior Oklahoma City Plant, Showing Electrodes in Empty Flume, and Flow in Another.

of a million gallons a day. In Santa Monica no ground surface is required, the plant being installed under Colorado Avenue at the head of the pleasure pier owned by the city. This pier is a popular resort in spite of the fact that the city's sewage is treated right below it and discharges into the sea at its outer end. Most people are unaware of such a plant being in the vicinity, indicating that it is in no sense a nuisance. To show what it accomplishes, it may be stated that for a few days the plant was closed and the raw sewage discharged into the ocean. Protests were heard at once from visitors and residents, but when it started again, all complaints ceased. In Oklahoma the conditions were quite different, as the outfall was in a dry gulch which was shunned and its vicinity rendered useless for any purpose. Now that the discharge has been electrolytically treated, the air is not contaminated. In fact such water could be used for irrigation and its great proportion of fertilizing content put to good use.

The two plants described can be reproduced for $15,000 each. Many costly features have been eliminated since the first one was installed. The heavy and expensive magnets, once considered necessary, have been discarded, and an elaborate system of cleaning the electrodes by high pressure steam was abandoned when it was found that the reversal of the current would give better results. The cost of the plates has been greatly reduced, by the substitution of cast iron for



Electrodes in Place, Santa Monica Plant. The Heavy Magnets Have Now Been Discarded, Reducing Expense.

the aluminum which was first tried. The aluminum plates gave good results, but they were very costly and decomposed so rapidly that their expense was prohibitive. The cast iron was substituted, and by sheathing the upper edge of the plates with copper, excessive decomposition was prevented.

Aside from its sanitary importance, this novel use of the electric current may add materially to the world's wealth in saving the millions of tons of valuable fertilizer that are now swept into the sea each year. Thoughtful men have deplored this waste, and many years ago Victor Hugo, in writing a description of the sewers of Paris, referred to such waste as an appalling crime. In some parts of Germany and in China, the soil is so depleted that raw sewage is used in spite of its danger and nuisance to renew the exhausted lands. By this modern method it may be treated and used on fields, enormously increasing their value and being in no wise offensive to the senses or a menace to health.

THE CONSTRUCTION OF DISTRIBUTION SYSTEMS FOR OUTLYING SYSTEMS AND SMALLER PLANTS.

By S. Bingham Hood.
Toronto Electric Light Company.

(Continued from last week.)

The best metal pin designed to pass through the arm is undoubtedly a design which has been placed on the market within the past year. This is of high carbon steel with bolt ½-inch in diameter. The shoulder is increased in diameter and drawn square, which not only stiffens the pin, but provides a wrench hold. The contact point with the arm is swaged out to form a good-sized shoulder, and the insulator thread is formed of a steel wire spiral which slips around in the insulator thread when expanding and contracting. This absolutely prevents insulator breakage and also that very annoying property of insulators to unscrew and become loose on the pin. These pins cost about three times that of a locust pin, but are an excellent investment, as, being hot galvanized, there is practically no limit to their life, and, while they may be bent, they will never break and drop the line. Another feature that makes them an economy is the small amount taken out of the arm for the pin hole. A wood pin leaves only 2 inches of wood out of a total of 3½ inches, while the steel pin leaves 3 inches, or 50 per cent. more, which not only adds to the strength of the arm, but also materially to its life. For heavier strains the same makers have recently brought out a clamp pin made of a bend of ¾-inch channel. A "U" bolt of flat steel is used to clamp this to the arm and insulator support is their usual steel spring thread. Such a method of fastening effectually does away with any possibility of the arm spliting and for heavy or important feeder lines makes an excellent job at very moderate increase in cost, the pin and clamp averaging complete about twenty cents.

For dead ending a line, particularly with large wire, the best pin made is an unsafe proposition and for such use some form of strain insulator with bolt right through the double arms should be used. The writer has not located up to date a device which can be purchased in the open market and which meets the requirements. We are using, however, a malleable iron clevis adapted to take a standard ⅝-inch bolt and using a porcelain spool insulator held in position by a ⅝-inch pin with cotters in each end (see Fig. 3). These can be made up cheaply in any shop and make a dead end that can't get away. We also use a ⅝-inch eye-nut where it is desired to head guy the arm, this placing no strain on the arms other than actually holding up the weight of the line.

The balance of pole hardware is now standardized, but, above all, should be hot galvanized only; plain iron for bolts or braces being both an expensive and dangerous proposition for use with treated poles, as they will not outlast the pole which should be the first part of the line to give out from age.

For taking off services and branch lines we are all familiar with the wooden side block and the reverse or buck arm. For junction poles at important corners the latter may be necessary, but for other places either is such an eye-sore that their use should be condemned in the strongest terms. For this purpose some form of metal spreader bracket should always be used. Various styles of malleable iron brackets have been on the market for years, but have defects which are too well known to need mention here. Fortunately it is now possible to obtain a full line of wrought steel brackets to meet every possible need. These are unbreakable, of light weight, and have a spring thread similar to the metal pins mentioned above. As the heaviest pattern of three-pin bracket costs only about one-half dollar, and a light two-pin about 20 cents, the cost is low enough to make their use general. For attaching to buildings the same line of brackets are available, together with a number of other styles adapted to building use only. With such fittings available there is no longer any excuse for unsightly and shipshod methods of taking off or attaching service leads.

A method of running secondary distributing mains which is finding favor within the past few years is that of dispensing with cross-arms altogether. The three wires of the system are carried in a vertical plane on brackets fastened directly to the pole (see Fig. 4). A three-pin metal bracket for this purpose will cost erected about 50 cents, which is less than the cost of a cross-arm. With this method of suspension the lines cannot swing together, and consequently, can be placed on very short spacing, decreasing the inductive drop on A. C. lines. A further advantage of this method is the ability to take off service lines directly from the line pins without crosses in the line. For dead ending

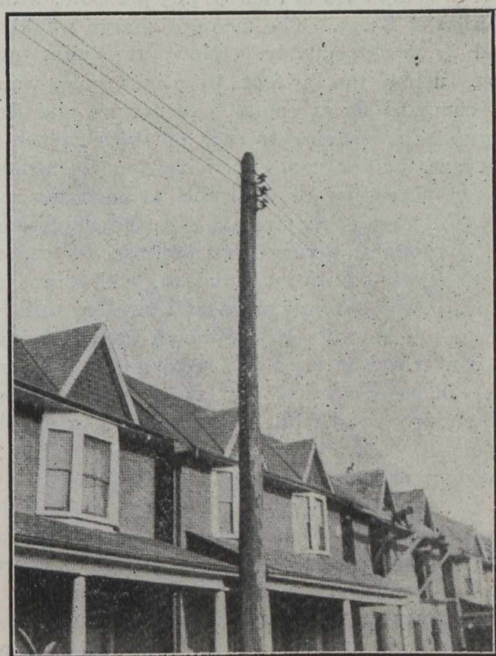


Fig. 4.—Vertical Secondary Distribution.

these lines a three-spool insulator bracket is used, secured to the pole with two ⅝-inch through bolts, forming an anchorage which will stay as long as the pole holds up. As we have a number of 500,000 C. M. mains carried on this type of bracket some idea of their strength can be realized. Reference to the illustrations will demonstrate the vast gain in appearance which can be made with this type of construction in comparison to the old cross-arm method.

Before going into the question of wires a few words on the subject of joint poles may be opportune. Aside from the beneficial effect of minimizing the number of poles on the highway, as regards public opinion, the joint use of poles offers great economy both as to first cost and upkeep expenses. The telephone or telegraph is found practically every place where electric light or power is required, and there is no valid reason why both classes of public service companies can not beneficially co-operate to utilize each other's investment to the maximum. Where both systems are on the same street, as they must be to supply service, there is always the chance of the two systems becoming crossed owing to falling wires. This is equally true irrespective as to whether they are on separate pole lines or on a joint pole. For ordinary distribution under suburban conditions of load density a pole heavy enough to properly carry either system will just as safely carry both. This is due to the strength of a pole considered simply as a prop being far greater than the maximum load it must bear. With the wires and services of two systems on the same pole the bracing effect would be materially greater than where each system has its own pole line. With up-to-date construction where the lighting secondaries are carried in a vertical plane on brackets and the telephone is either lead cable carried on a messenger wire, or drop wire carried in rings for short branches, the appearance of the line can scarcely be considered as an objection beyond that which is an unavoidable evil made necessary by advance in our civilization.

From the financial standpoint we will assume for argument that the one company selects as a standard a 30-foot by 6-inch treated pole costing $10.56 in position and having an annual charge against it of $1.49. The other company must cross and re-cross the first line and finds these conditions require a 35-foot pole with 7-inch top, costing $14.47, and having fixed charge of $1.84 per year. The total expense to both companies is then $25.03 per pole, with a total annual charge of $3.33. The average charge would then be $12.52 and $1.66 respectively. Now, the joint pole line proposition, using the 35-foot by 7-inch pole, would only cost each company $7.24 capital expenditure and $0.92 annual charge, a clear saving to each of about 42 per cent. in investment and 44 per cent. fixed charge. In actual practice it is not necessary or desirable to have any real joint ownership. All that is required is a working agreement between the companies, giving the methods of construction necessary to make a uniform standard, and some provision as to notification when one company desires to utilize a pole belonging to the other. Having such an agreement compensation can be based on a yearly rental. By referring to Table 1 it will be at once evident that, under ordinary conditions of suburban distribution a rental of one dollar per year per pole would average about right and require little or no bookkeeping to keep the accounts straight. It is fair to suppose that, where true co-operation exists, as it should, one company would use the other company's poles about equally, so that any excess or deficit in the rentals would be wiped out by the law of averages. Indeed, were it not for the standing given any joint pole agreement due to a definite compensation being established, there would be no real reason for establishing any charge whatever between the respective companies.

Having selected the various fittings which combine to form a uniform method of construction the actual running of the wire is a simple matter. Any economy to be gained here is largely that due to the selection of a distribution system adapted to the requirements of the load to be served. As to the kind of wire to use, copper is the only choice. Aluminium wire may offer economies for transmission work, but for ordinary distribution it is unsuitable owing to the large span dip necessary to avoid overreaching the tensile strength of this metal. This extra dip would usually mean a higher pole, the cost of which would offset the saving in metal. In addition, aluminium, owing to its light weight, and greater area for same conductivity, will swing and whip around in a wind to an extent that introduces all kinds of complications where space will not permit wide separation of the conductors.

For suburban distribution we need consider only A.C. systems. The frequency is based upon that of the generating plant from which primary energy is obtained. This is generally already fixed before local distribution is considered and may be anything from 25 to 60 cycle. For lighting 60 cycle has undoubtedly some advantages, but the idea that frequencies as low as 25 cycle are impractical for this purpose is entirely in error, provided your generators have a wave from approximating a smooth true sinu-soidal curve. Low wattage metallic filament lamps show a very bad flicker on frequencies below 30, but it is so easy to educate the public to the use of higher candle power units for the economical lighting of rooms, in preference to several small units, that this objection is not serious. In lighting large areas indoors, for amusement places principally, where large numbers of small units are used, the "25 cycle flicker" is very pronounced as soon as the illumination exceeds a certain critical point. In this case the flicker should be welcomed as a warning that the bounds of good illumination are being exceeded; the flicker being a sure sign, if noticeable, that the eye of the observer is under undue strain owing to excessive amount of light entering the retina; consequently it is unable to adjust itself to the variations in intensity between cycles. For arc lighting low frequencies are objectionable, but as the arc for interior illumination is now practically obsolete, having been replaced by tungsten clusters with greater all round reliability and efficiency, low frequencies do not introduce serious complications here either.

Taking all these points into consideration there is no reason for complicating the system by introducing frequency changers. If the frequency is not already selected, and rotary converters are not intended to be operated on the system to any great extent, then 60 cycle is probably the best standard to adopt. If the bulk of the output will be used for power purposes then a lower frequency may offer some advantages, and, for American practice, 25 cycle would be the standard. Unfortunately this particular frequency does offer some slight disadvantages from a lighting standpoint, as mentioned above. Experiments have shown, however, that just slightly above 25 cycle these defects disappear. With this in mind a running frequency of about 27½ is a marked improvement and can be obtained by simply running standard 25 cycle apparatus proportionately overspeed.

For the generating equipment there is no question but what multiphase current is necessary. This may be either two or three-phase with the latter far in the lead as regards efficiency of distribution. For this reason only the three-phase system will be considered. This system is commonly operated delta connected, but of late years the star connection is finding more and more favor where distribution networks cover large areas. In fact, the writer ventures a prediction that the next decade will see all our systems operated star connected with a solidly grounded neutral. If we stop to consider that, under operating conditions, our insulation strain is nearly always that between phase wire and ground, and not that between wires, it is at once clear that operating at only 58 per cent. of the voltage which our insulation is designed to stand is pretty poor economy. We can reconnect the same apparatus in star and operate the same line to transmit three times the power. In order to operate successfully in this manner it is imperative that the neutral points of the star be solidly grounded, not only at the ends, but at frequent intervals on the line. With this grounding there will always be more or less earth current which may cause interference with adjacent telephone or telegraph companies. To minimize this it is advisable to run a neutral conductor throughout the network, so that under only abnormal conditions will the earth be called upon to carry current. As ground lines have been demonstrated to be advantageous for lighting protection, and are quite generally in use on transmission systems, it is only necessary to substitute a wire capable of carrying the maximum neutral current in phase of the ground wire, the added expense being slight.

The question of grounding is one which has been under discussion for years past, but to-day is still being argued. The advisability of grounding below 250 volts is seldom questioned, the problem being simply that of getting a permanent ground. Here, however, the problem is supposed to be one of life hazard only, and the increased efficiency and reliability of a system when its position in relation to earth potential is definitely established appears to have been entirely overlooked. Any electric circuit, unless effectually grounded at some established potential point, is like a lost soul floating around in space. Its potential to earth may vary by thousands of volts, irrespective of its normal working voltage.

It has been a fixed law of the universe from the days of the creation that all things must start from the earth's surface, either up or down. The writer is firmly convinced that electric circuits are no exception to this law, and, unless we firmly anchor them to the earth, sooner or later something will happen with disastrous results. This subject is one which alone could be made to cover a paper as large as the Good Book we all try to follow, and, as the proof of the pudding is in the eating, those who have not tried grounding can get all the proof needed by adopting this method. By "grounding" we mean, however, SOLID GROUNDING, and not driven pipes, plates buried in coke, so-called grounding cones, limiting resistances and what not. A pipe forming a portion of a buried piping system is the only successful ground the writer has so far discovered. Our results following grounded operation lead us to believe that every electric circuit should be grounded, irrespective of the voltage at which it operates. In transmission circuits the objection to solid grounding has always been that a ground on any of the three-phase wires renders the system inoperative. This is undoubtedly true, but if the system has normally operated ungrounded, will not some unexpected weak point break down when subjected to full potential to ground? In this case, and it will be true in many cases, the system will fail to operate anyhow. It is very nice from an operating standpoint to hang on to our load to the limit. But, as engineers, it is good policy to continue in operation a system after it has developed what is known to be an abnormal and dangerous fault?

With the three-phase four-wire system, having solidly grounded neutral, there is one advantage which particularly applies to suburban distribution where the lighting load forms a large proportion of the whole. This is the ability to operate two of the phases after the third has developed a fault which renders it inoperative. The load of faulty phase can be transferred to one of the good ones and the lighting and single phase motor load carried until permanent repairs are made.

For suburban and semi-urban distribution it does not follow that because our generating system is three-phase the entire distribution must be the same. For lighting circuits the simplest and best secondary distribution is the single-phase three-wire system. In order to permit of inter-connection of these secondaries into a network covering a considerable area a single-phase primary is desirable. With this in mind it is now almost uniform practice to distribute lighting by single-phase sub-feeders, either balancing on different phases at the main bus or at selected points on a three-phase feeder line. For power distribution it used to be considered necessary to have multi-phase currents, but recent developments have overcome this for motors of small size, say up to 15 horse-power. For these the modern single-phase motor fulfils all requirements and greatly simplifies the distribution and metering problem. Motors on suburban lines seldom exceed five horse-power and up to this size they can usually be operated off the lighting network, unless frequent starting and stopping is necessary and their use extends regularly over into the lighting peak. In this case, and in motors of larger size, individual transformers are desirable. Where these are necessary they should have their neutral point connected to the lighting neutral, which, of course, is solidly grounded. If this point is overlooked we do not properly protect our power customers against high tension crosses or leakage.

As to the point where it pays to distribute three-phase from the sub-station or generating station in preference to single-phase, neglecting demands which may arise for large motors. This is where the investment for copper, in position, for the three-phase (four-wire) feeder equals that for a single-phase line. As No. 4 wire is the smallest which should be used for distribution and give the requisite margin of mechanical safety, it will be found that a No. 0 single-phase line is the largest that should be run. In fact, if No. 0 is requires then preference should be given to the four No. 4 wires operating three-phase grounded star.

Fig. 5.—Four-Wire Common Neutral System.

After having overreached the economical bounds of single-phase feeder distribution and having adopted three-phase, the question comes up as to at what limit the latter becomes uneconomical when operated at the utilization voltage, or the voltage at which the distribution transformers are operated. This limit has been increased three-fold by the adoption of the four-wire system, and it is now possible to transmit at the working voltage a considerable amount of power over a considerable distance. A No. 2/0 circuit will deliver about 300 kw. a distance of ten miles without exceeding economical limits of line loss under ordinary suburban load conditions and average initial power costs. This is sufficient to feed a pretty well developed suburban town.

A rough rule which has been used for some years is to allow 1,000 volts per mile. This is simply a rule of thumb, and is disproved right in the above case where this rule, if applied, would demand a transmission voltage of 10,000 in place of 4,000 as shown.

In the transmission of moderate amounts of power the craze for high voltage transmission lines can very easily get the best of one's common sense if we are not careful. The general rule in this regard is that the annual cost of energy lost in the line equals the annual cost for depreciation and interest on the line when maximum economy has been reached. In those cases where the selected voltage requires either step up or step down transformers, or both, the cost of these, together with their switching arrangements, must be included in the line investment. In many cases the cost of these, if put into additional copper, would carry the same amount of power with equal economy and cut out just that many links in the chain of trouble.

In designing any line the prospective future growth of the territory must be considered, and if this is promising and will eventually overreach the economical limits for 4,000 volts, then the line should be designed for high tension operation. In doing this it is as well to go the limit, which for this class of work is about 25,000 volts. The extra cost for wider spacing and larger insulators is so small that the extra investment is certainly warranted if future prospects look anywhere good. Such a line can be operated at 4,000 volts until such time as it becomes loaded. Step up or down transformers can then be installed and the change over made. There is no good reason for operating higher than reasonable requirements demand, and, consequently, the transformers should be purchased with double primary coils and operated at half voltage until the full pressure is required.

Fig. 6.—Single Primary Fuse Block.

For distribution over a large area from a central generating station the writer particularly favors a method which is only made possible with the adoption of a solid grounded neutral three-phase four-wire system. This is the use of auto-transformers in preference to the regular double coil type. It will be shown later on how these work out for general distribution, and their use in transmission will now be explained. With the grounded neutral system and using step down transmission, we would have in the complete system, under ordinary practice, no less than three neutrals; the secondary, the primary, and the transmission. Each one of these being solidly grounded is to all intent and purpose one wire as far as potential is concerned. The natural thing to do is to combine them mechanically as well as electrically. The neutral current distribution is somewhat complex and while capacity must be provided to carry the greatest unbalanced load in practice the currents are very small. In using a common neutral for all systems a single wire of the same cross section as the larger of the three separate neutrals will fulfil all requirements. The current distribution in such a common neutral is somewhat peculiar in that the drop on either circuit appears to be only that due to its own current and not that of the combined currents flowing. The heating effect may be that due to the combined currents or may be much less, as, under certain conditions, the neutral current from one system will flow in the opposite direction to that in the other and consequently tend to neutralize it. This is one of the great economies made possible by a solidly grounded neutral.

As regards the auto-transformers, as used for transmission. Take a single coil transformer having its winding split up into four equal sections, each having a voltage of 2,300. As a regular transformer assume this to have a capacity of 100. Connecting these coils two in parallel and the two sets in series we get an auto-transformer of 1:1 ratio. One end of the coil goes to neutral, the middle to the distribution phase wire, and the other end to the transmission phase wire. Here we transmit approximately 8,000 volts on the delta and step down to 4,000 volts for distribution, the star voltages being respectively 4,600 and 2,300. The capacity of this auto would then be 200 and the investment for transformers but one-half that for the straight transformer connection as now used generally.

By connecting two of the sections in series and these in turn in series with the other two coils in parallel we get a ratio of 2:1 and transmit at approximately 12,000 volts delta with a capacity of 150, the transformer investment being but two-thirds that of the old method. A transformer of this kind would be insulated for 7,000 volts between coils and core and proportionately between coils; but at no time would but a small portion of the winding be operated under this pressure, which would drop uniformly, throughout the winding, from maximum to zero.

The same principle can be carried out up to the highest limits of transmission voltages, but, of course, the economy in transformer investment becomes less as the ratio between distribution voltage and transmission voltage becomes greater. In very high voltages a further saving in transformer costs may be effected in that the maximum insulation need be only that for the star voltage and this insulation can then be shaded down from this to a very small amount at the earthed star connection, only one high tension bushing being required, as it will never be necessary to reverse the windings in order to get the star voltage distribution to come right.

Another point of economy in the grounded neutral is that where a portion or all of the circuit is carried through lead covered cables. With a neutral not solidly grounded a four-core cable is necessary. With the solid ground it is not even necessary to pull in a bare conductor in the ducts as we already have a lead sheath capable of carrying, in a 3-core, 250,000 C. M. cable, about 100 amperes without heating enough to interfere with capacity of the cable. By bonding all sheaths together a combined capacity far in excess of any normal requirement is obtained.

In operating this grounded common return system the first requirement after erecting the pole line is, of course, the running of this common return wire. For all ordinary cases of local distribution a wire of the equivalent of No. 4 copper is ample in size. From an operating standpoint it should be insulated with regular weatherproof insulation and supported on glass insulators if wooden poles are used and high tension wires are on same poles. This is not to insulate the return wire, which electrically can just as well be bare, but to prevent linemen working on the poles and handling high potentials coming in contact with the grounded conductor. An insulated wire is also of some benefit if a high potential wire falls over it, that is provided the other wire is also insulated and potential to ground does not greatly exceed 2,300 volts. In other words, for potentials up to 4,000 volts delta use insulation on all lines, and above this point omit insulation on the high potential and do not depend on it as a protection against crosses between the high potentials and the adjacent low potential circuits. Insulation which is not a protection is a death trap, and its omission is both a safeguard and an economy. This common return main must, as already stated, be permanently and effectually grounded. This condition can only be obtained by attaching to an underground piping system at a number of points. Fortunately, but few towns of even small size are to-day without their local water supply systems, and even the farmers quite generally have their own piping systems leading from a well to the various buildings. This makes it comparatively easy to get good ground connections.

In introducing services good practice demands some form of sealed service box in order to prevent theft of current and prevent the consumer inserting service fuses dangerously large for his installation. This makes it imperative to enter the building through conduit, and the natural place to enter in this manner is the basement or ground floor. The fire underwriters require these conduits to be grounded to a piping system, and, by so doing, have made it very easy for us to get our common neutral grounded at every conduit service at a cost of but a few cents each. The process consists simply of placing a jumper between the conduit ground wire and the service wire which connects to our common return on the pole. This may be done at the service cutout and requires but a few inches of wire and a few moments of time. The various distribution neutrals should be cross connected as often as possible in order to form a series of neutral rings throughout the system. This makes it impossible to open the neutral or leave it unprotected by grounds, and, incidentally, permits of economic utilization of a cross section greatly in excess of that on any one street.

Transformers connected to this common return system are of the usual standard type, stepping down from 2,200 to 110/220 volts. The primary supply requires, however, but a single wire, which can advantageously be attached to an insulator on steel pin placed directly in top of pole. This type of pole construction, using a three-wire secondary main supported on steel vertical bracket, makes an unusually neat, as well as economical, design (Fig. 5). In making extensions the three-pin secondary bracket is installed throughout the run and the common neutral placed on centre pin. The outer wires of secondary are then extended both ways from the transformer as required, and, when they meet, are interconnected. This makes possible a secondary distribution interconnected throughout even in new districts, the rule to apply being to extend secondary beyond the primary or in preference to installing additional transformers up to the point where the annual charges for outer wires of secondary system would equal the fixed charges of an individual transformer, giving careful consideration to the point that copper wire has a well fixed scrap value on which to base depreciation, whereas a transformer may last two years and may last twenty.

In connecting the transformer for standard ratio of 10 and 20 to 1 but one primary lead is used, being protected by a single pole fuse block (Fig. 6). The other end of primary coil is connected inside the case to the neutral secondary lead. This connection may, of course, be made outside, but it is neater and better if made inside. This same transformer may be connected to either boost or crush 5 per cent. by simply tapping the other end of primary to one or the other outer leads of the secondary instead of the neutral. This gives, when connected to boost, an increased capacity of 5 per cent. The ratios thus possible to obtain without primary tappings are 19:1, 20:1 and 21:1. For transformers regularly supplied with 5 and 10 per cent. taps additional ratios of 17:1 and 18:1 may be obtained. This makes an ideal system for suburban distribution, as the transformers in various towns may be so connected that their ratios bear an approximate relation to their distance from the main generating station and fair peak load regulation should be possible without individual feeder regulators, bus regulation being used entirely. For first-class distribution, however, the automatic induction regulator for each feeder is the only solution. These are fairly expensive, but their cost is well warranted by the results obtained, particularly in the case of a feeder supplying several small towns or separate load centres. For a single feeder this condition requires very heavy wire between the load centres in order that the difference in primary pressure may be very low. This frequently makes it necessary, where local regulation is not used, to run separate feeders to each centre. With an automatic regulator installed at each load centre absolutely uniform pressure may be obtained in every town, even if several are supplied from same feeder. The local substation need be but a small building and requires very little attention, a visit once per week to clean and inspect the regulator contacts being all that is required. This plan of supplying each load centre from a small substation is of further advantage in that automatic protective devices may be conveniently installed here to cut off this particular section in case of trouble. The regulator is supplied by its own potential and current transformers, and a single phase 5 ampere integrating secondary wattmeter may be installed on the same transformers, thereby measuring at very small expense all the current delivered to this particular section. This is of particular benefit to both the distribution and commercial departments, as it enables them to check up the line losses and also the revenue obtained from any one load centre or district.

In selecting the size of pole transformers and the type of secondary distribution, local conditions must be studied carefully. Unless the load is very badly scattered, relatively large transformer units feeding a large interconnected secondary network makes the most economical as well as most reliable system. Transformers may be confined to three sizes, 5, 10, and 15 kw., the latter used for large concentrated loads and for feeding the networks. The small size will be found useful in feeding isolated loads and to help out the tail ends of a network while the business is growing, being changed when load conditions warrant for the larger size. The intermediate size will be found useful in networks of moderate size, as not less than three transformers should ever be interconnected, and small villages will frequently not warrant the installation of three 15 kw's.

The outer secondary leads of all transformers should be protected with low tension fuses, the neutrals, of course, being connected solid. In networks a fuse may also be inserted in the mains half way between transformers; in fact, this is necessary unless the primary feeding the network can be disconnected in case of trouble. Unless this is done the transformers banked can not be re-fused if they blow out under load. In large networks the better practice is to connect solid and depend on the heavy current available to burn off faults, etc. Just a word of caution, however, in regard to these secondary fuses. They are exposed to the weather and an ordinary lead and copper tip fuse will disintegrate. Use cast brass or copper contact posts and wing nuts and copper fuses. A plain copper wire supported on about four-inch centres makes an ideal fuse for exposure to the weather. No. 18 B. & S. gauge will carry about 100 amperes, No. 16 150 amperes, and No. 14 about 200. An ideal distribution is shown by Fig. 2.

In high-class suburban districts occasional demands arise for underground distribution. This can be cheaply and reliably handled by simply laying the cables solid in the earth, covering them if desired with a treated plank to prevent mechanical damage. The common neutral may be a bare copper wire or plain weatherproof insulation. This type of construction for secondary distribution does not greatly exceed the cost of a first-class overhead line when upkeep and replacement costs are considered, and, being laid usually under unpaved streets or grass plots, can be opened up for repairs or extensions at minimum cost. Service taps are taken off through a small cast metal box enclosing the joint and afterwards filled with compound. The actual tap is usually made through a single strand of copper wire which will fuse under short circuit conditions and disconnect the defective service. If single branches are made the box should be of non-magnetic metal, to avoid inductive effects. If made of cast iron the box must enclose all wires of the main, and these must enter through a non-magnetic bushing. Lead makes the best metal for this purpose. On extensive underground networks junction points should be sectionalized in a pillar box placed near the curb at intersections. These would have somewhat the appearance of the ordinary stone carriage steps which used to be so common and do not constitute an eyesore to the general public.

It must be self-evident that a system on the foregoing lines can be installed with less upkeep cost than former methods, and, having fewer parts to cause trouble, must perforce be more reliable. As to just what savings are possible can only be determined by figuring actual cases; this saving is, however, very considerable, as has been proven by actual operation of such a system.

CANTILEVER FORMS FOR CONCRETE RETAINING WALLS*.

By Thomas J. Kelly.†

The accompanying sketch shows the cantilever system of concrete forming that is being used on lock walls at Mayos Bar, Coosa River, Ga. The first section is a stationary form, which is braced from the ground, the concrete being put in in lifts of 6 ft. each. In the second and succeeding lifts, bolts ¾ in. x 30 in., with nuts on each end, are put in the concrete 10 in. above the bottom and 10 in. below the top of the lift, and 4 ft. apart, leaving enough of the bolts outside of the concrete to go through the lagging, uprights and wales.

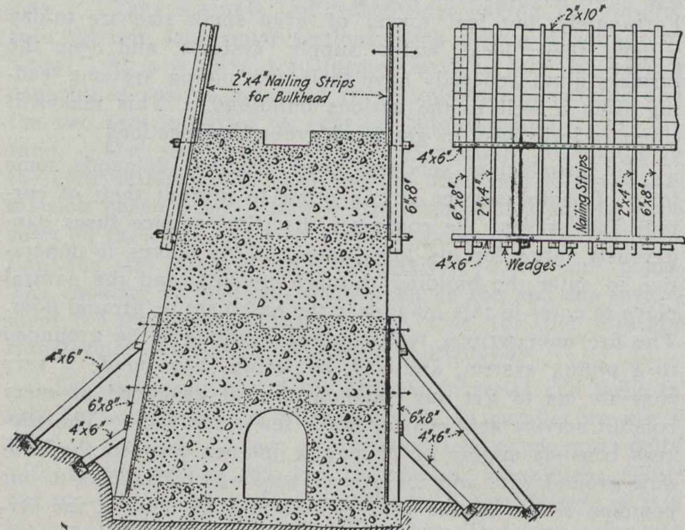
When the concrete has sufficiently set, the lower form is removed and holes bored in the walls to correspond with each bolt. The wales are then put on the bolts and uprights are put in between the wales and concrete, first putting one piece of lagging on top of the upper bolts, next to the face of the concrete; wedges are then driven near bottom end of the uprights, between the face of the concrete and the uprights, these wedges being used to line the forms and keep them rigidly in place.

The bolts should be left outside the forming, as shown in the upper left-hand of the cut, until just before the concrete reaches this point; they should then be greased with "cable dope" and shoved in to the proper position.

Sometime during the next day the bolts should be given a few turns with a wrench, so they will be loose in the concrete and can be removed at any time, and the holes plugged with neat cement. Nailing strips, 2 x 4 in., are used to tack the lagging together, and a strip of the same size is also used to secure the bulkhead, or end forming, in place.

After the form has been used for the first time, the lagging can be taken up bodily with the derrick, and lifted to the next position, being allowed to rest on the top bolts while the wales are being bolted on; then the lower row of bolts can be removed and used repeatedly, with only the loss of one nut each time, which loss is inexpensive.

In the writer's opinion, this is the most economical system of forming in use to-day, both as to cost of material and cost of erection, for the lumber and other material can



Details of Cantilever Forms for Concrete Walls.

be used over and over repeatedly.

This system can be used to advantage on all classes of heavy masonry, such as lock and dam work, bridge piers and retaining walls; especially so where cyclopean masonry is used, as there are no rods or braces to obstruct the laying of large stones or in handling concrete buckets, and these forms can be used at a height of 100 ft., or more, as easily as at a height of 20 ft.

* From Professional Memoirs, Corps of Engineers, United States Army and Engineering Department at Large, May-June, 1912, No. 15. Vol. 4.

† Overseer, Mayos Bar, Coosa River, Ga.

TESTS OF TILE AND CONCRETE WALL-SECTIONS.

The National Fireproofing Co. has recently had made for it a series of tests on sections of tile wall, varying from 4 to 10 in. thick and from 8 to 37 in. long, all about 12 ft. high. The tests were made by a well-known firm of engineers. In each test the crushing load, and the lateral deflection and vertical compression under various loads were recorded. Wall sections of concrete, reinforced concrete, and brick, and interlocking tile, were included in the series, with the walls of plain tile laid both horizontal and vertical.

The results of the tests are summarized in the table below. In arranging this table we have computed the failure

TESTS OF TILE, BRICK AND CONCRETE WALL-SECTIONS

Tests of Walls About 12 Ft. High				Comparison Tests of Single Tile	
Material	Age days	Horizontal dimensions, inches	Failure load, lb. per sq. in. of gross cross-section	Bottom area, and position	Failure load, lb. per sp.in. gross sec.
Brick wall	47	8 x33¾	248		
Concrete wall	49	8 x36	1610		
Reinforced concrete walls	55	8 x36	2060, 1st loading; 1920, 2d loading — no signs of failure		
Interlocking tile wall; side	13	8½x37	288	8x12, side	600
Monarch tile pier (laid up of 4x8x8 tile on end)	25	8½x 8½	2685	4x8, end	8350
Monarch, 4" wall	25	4 x33¾	2560*		
Monarch 8" wall	47	8¼x37	1260	8x12, end, av. of three	2700
Monarch 8" wall	35	8¼x37	1130		
Monarch 8" wall	26	8¼x36½	1680		
Natco 8" wall	28	7¾x35	570	8x12, end, av. of two	3050
Natco 8" wall	33	8 x36½	1220		
Natco 8" wall: side	28	7¾x36¾	280	8x12, side	350
Natco 10" wall; side	33	9¾x36¾	415	10x12, side	395

*Buckled

load in pounds per square inch of gross cross-section of wall, this being the quantity usually taken into consideration in designing.

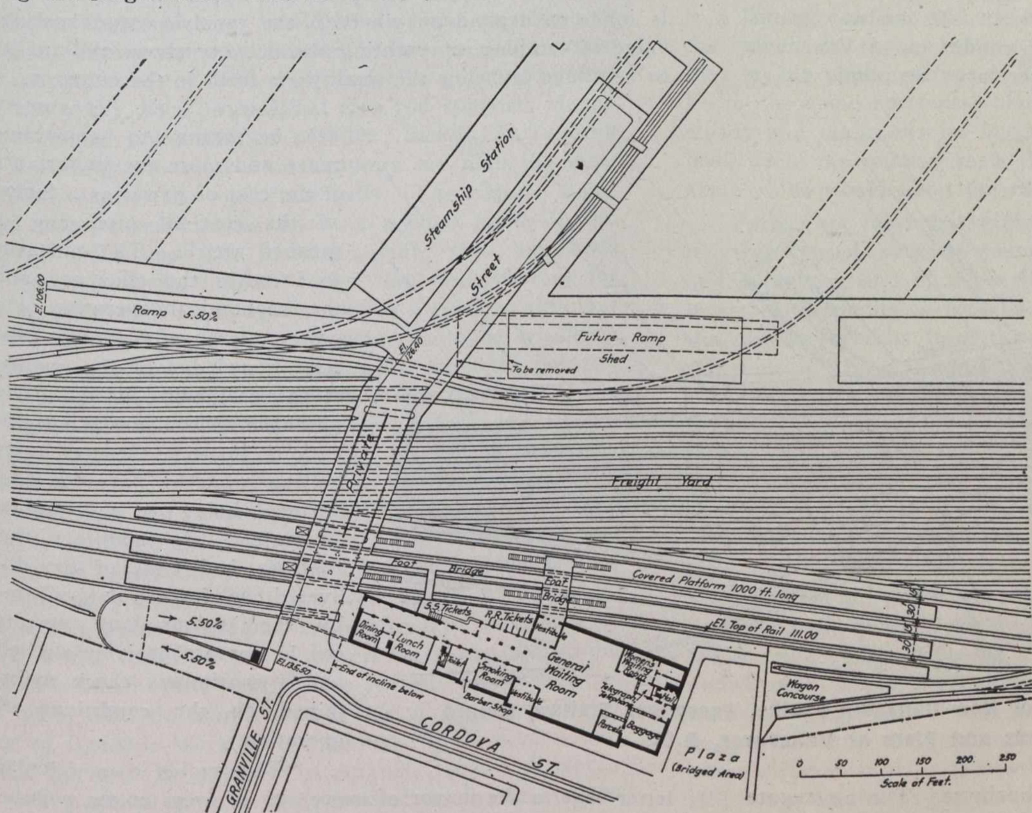
Tests of single tile were made, one for each tile wall section. We give the results for comparison with the strengths developed by the walls. The great variations of ratio between wall strength and tile strength are to be noted.

PASSENGER TERMINAL AND OFFICE FACILITIES, CANADIAN PACIFIC RAILWAY, VANCOUVER, B.C.

Plans have been prepared and work is now under way on certain improvements in connection with the Canadian Pacific Railway Company's passenger terminal at Vancouver, B. C.

The present passenger station of the Canadian Pacific Railway at Vancouver is located at the foot of Granville Street, near the shore line of Burrard Inlet. The station was built about fourteen years ago, and except for minor alterations, is unchanged from its original plans. The general waiting room and ticket offices are at the street level, and the baggage room on the track level which is about thirty feet below the street.

Along the water-front across the local freight yard tracks are located the steamship wharves. There are two large sheds on a jetty pier of recent construction used by the Trans-Pacific Steamship Lines; also five sheds adjoining the longitudinal wharves used by the Seattle, Victoria Alaska and other steamship lines of the Canadian Pacific Railway.



Plan of the passenger Station of Canadian Pacific Railway at Vancouver, B.C.

Between the wharf sheds and the passenger tracks adjoining the passenger station certain of the freight tracks serve the several sheds, and other tracks are used for drilling and storage. The yard tracks extend along the harbor front about one and a half miles.

By reason of its favorable location and the transportation facilities afforded by the enterprise of the Canadian Pacific Railway, Vancouver has grown from a trading camp to a well established city with over 125,000 inhabitants in about twenty-five years time. All business lines are represented in the commercial field centering at the city. Situated at the terminal of the first, and still the only, Canadian Transcontinental railway line on a fine natural harbor and with other favorable surroundings, its growth has been based on advantages which insure continued growth and permanency and there is every indication that its population will be not less than 300,000 at the end of the next decade.

The past growth has rendered inadequate the present facilities for handling the terminal business of the railway company and the general plan shown herewith has been adopted to relieve the present congestion, as well as to provide for reasonable growth in the near future.

The general scheme embraces a passenger station and office building suitably located on available land immediately east of the present passenger station. There will be four passenger tracks with provision for more when required, separated by wide platforms, between the station and the present freight yard. The passenger tracks are to be raised about five feet above the present track level to reduce the difference in level between the street and the tracks to about twenty-five feet.

In order to avoid an inconvenient grade crossing and delays to traffic between the city and steamship wharf a bridge on the line of Granville Street extended, is to pass over the passenger and freight tracks to the steamship pier and connect directly with passenger accommodations on the pier. An incline is also to be built leading from the west side of this bridge to the wharf giving access to the lower deck of the pier and freight sheds and the water-front.

Another viaduct over the tracks is to be built on the line of Burrard Street extended northerly with an incline giving access to the present Trans-Pacific pier and other portions of the water-front.

The main entrance of the passenger station will be on Cordova Street with the main waiting room located centrally in the station on the street level. Ticket offices serving the several classes of railway and steamship passengers are located at one end of the waiting room, and the baggage checking room, lunch and dining room, parcel room, women's waiting room, men's smoking room, news booth, information booth and other facilities are all placed immediately adjoining the main waiting room.

On the lower floors of the station are located the baggage rooms, express company's space, immigrant rooms, supply rooms, and other station facilities not directly used by passengers. Stairways and lifts connect the two levels of the station and also afford communication with the office floors above. A separate foot bridge is carried over the passenger tracks directly connected with the waiting room at one end and with stairways leading to the track level, giving access to platforms without crossing tracks at grade.

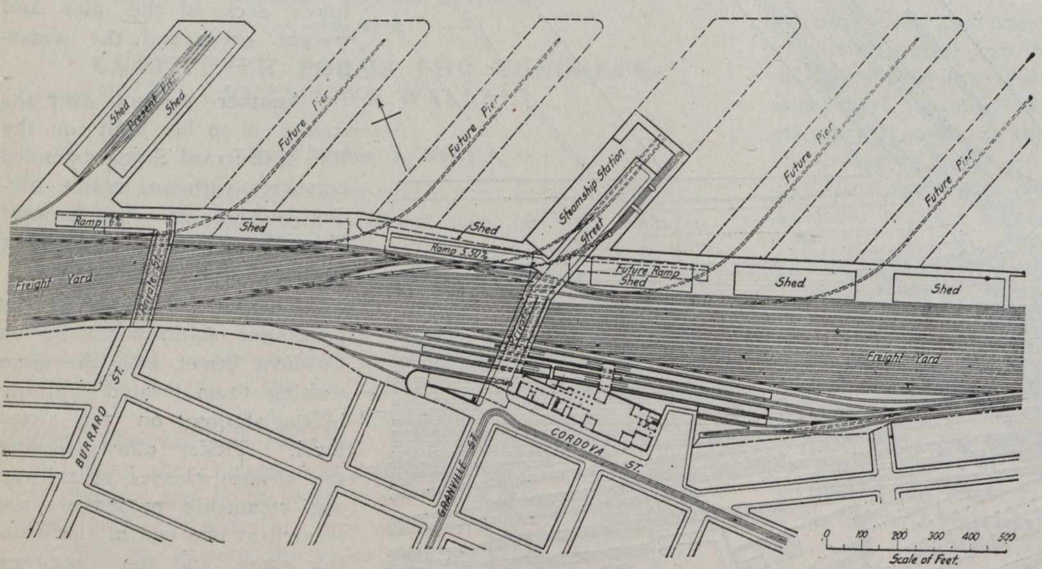
The track platforms are 1,000 feet in length, and are to be covered with shelter sheds of the umbrella type. The platform adjoining the station will be used only for baggage express and supplies.

Above the public rooms of the station building the space will be devoted to the general offices of the railway company. The interor arrangement of the office space will be adapted for a unit system of sub-division; that is, each panel will have heating and lighting facilities so that partitions may be placed or removed at will in order to provide for changes in arrangement of office accommodations which may be desired from time to time.

The proposed steamship station on the pier is a two level building, the upper floor being devoted to the passenger business and offices and the lower floor to freight, baggage and express. There will be double level gangways on the west side of the pier, which will be used for the Victoria and Seattle service, the lower gangway being used for freight and the upper for pasengers; these gangways to be supported on floating pontoons to maintain the landing at constant level with respect to the boats.

On the passenger or upper level of the pier are provided waiting rooms, ticket offices, baggage checking room, customs office and other conveniences. Separate rooms are provided for outgoing and incoming passengers. Two tracks will be placed on the surface of the pier within the shed, and one track on the outside of the building for the direct handling of freight between cars and steamers.

The essence of the general design has been to secure easy lines of communication between the railway trains, steamers and the city. The traffic conditions at Vancouver are unusual as compared with other large terminals on account of the absence of suburban business. The aggregate number of trains is not large but they are long and frequently are run in several sections and contain a number of classes of traffic.



General Plan Showing Layout of New Canadian Pacific. Passenger Station, freight Yards and Piers at Vancouver, B.C.

The designs for the terminal have been prepared by Messrs. Westinghouse Church Kerr and Company, Montreal, Calgary and Vancouver, in co-operation with the officials of the Canadian Pacific Railway and the construction of the station and facilities is now being carried out by the same organization.

The capacity of contact beds diminishes in proportion to the length of time the beds are in service. In a paper before the British Institution of Municipal and County Engineers, Mr. F. C. Cook gives some figures regarding the reduction in capacity of contact beds of the sewage disposal works at Nuneaton. In 1904, two years after they had been placed in service, the secondary beds had a capacity of 87.16 per cent. of their original capacity; in 1905, 72.17 per cent.; in 1906, 57.35 per cent.; in 1907, 45.96 per cent., and in 1908, 34.77 per cent.

THE BUYING OF COAL.

Manufacturers and others who use coal in considerable quantity will be interested in Bulletin 41, of the United States Bureau of Mines, on the subject, Government Coal Purchases under Specifications. This bulletin, which has just come from the public printer, was prepared by George S. Pope, engineer in charge of fuel inspection for the government, and contains chapter on the fuel inspection laboratory of the bureau by Joseph D. Davis, chemist in charge. The bulletin is the fourth of a series showing the results of the purchase of coal by the government.

Mr. Pope, in his introductory says: "The purchase of coal on the dealer's statement as to quality, or on the reputation of the mine or district producing the coal is gradually being discontinued. . At present most coal-purchasing contracts make definite provision regarding the desired heating value of a coal and the composition as shown by analysis. The heating value is usually expressed in British thermal units and the composition specified is that shown by proximate analysis. The price to be paid for delivered coal is made to depend on whether the analyses and heating-value of samples representing the delivery shows the quality to be above or below the quality set forth in the contract.

"Large coal consumers are beginning to appreciate more and more the importance of the cost of power as a factor in the cost of producing a finished article. The endeavor to increase the efficiency and the economical operation of a power plant calls for an intimate knowledge of the quality of the coal being used. The purchase of coal under specifications insures the purchaser getting what he pays for and the coal being of the quality guaranteed. In addition. the analyses and tests of the delivered coal furnish data whereby the power-plant results can be comprehensively studied and a continuous check maintained on the conditions of operation.

"The replies to a circular letter sent to the mayor of every city of over 100,000 population in the United States brought out the fact that about 55 per cent. of the cities replying purchase coal under specifications, many of which are similar to those used by the government. A great many industrial concerns are likewise purchasing coal under specifications. The numerous requests received by the Bureau of Mines for authentic information concerning purchase of coal under specifications, or according to its heating value, attest the growing interest in the subject.

"The purchase of coal on a specification basis is an important step toward the conservation of the mineral resources of the nation, for it results in the increased use of the lower grades of coal. The poorer grades find a market by competing with the better grades, not as to the price per ton, but as to the cost of an equal number of heat units.

"The purpose of this paper is to explain in general terms the methods that the government has found most satisfactory for the purchase of a large part of its coal supply, including the consideration of bids, the awarding of contracts, and the analyzing of samples on which the price corrections are based.

"In this report, for the information of prospective bidders or government contracts, a list of the coal contracts in force during the fiscal year ended June 30, 1911, is furnished. General averages of the analyses during the fiscal year 1908 to 1910, inclusive, are tabulated for the various sizes of anthracite and also for the several kinds of bituminous coal purchased for government use, and the results for the fiscal year ended June 30, 1910, are shown in detail by months. It is hoped that this information will be of value to both coal dealers and coal consumers."

Copies of this bulletin may be obtained by addressing the Director of the Bureau of Mines, Washington, D.C.

PRECISE LEVELLING IN CANADA.

By F. R. Reid, D.L.S.

(Continued from last week.)

Another source of error would be a systematic rising or settling of the rod supports, this would have a similar effect to the movement of the level, and cannot be guarded against in the same way, so it is essential that rod supports should be as solid and immovable as possible; luckily, in running along a railway the most solid supports are also the most convenient, namely the top of the rails. The rodman holds the rod with its semicircular knob on a cross made on top of the rail about one foot from the joint; this has been found by all levellers, I think, to be more satisfactory for a turning point than anything else; upon a track in ordinary condition the passage of a train appears to have no effect, the rail may rise and fall an inch or more under the passage of the wheels, but careful comparison of the elevation of the point with some solid point to one side, before and after a train has passed, shows that the rail returns to precisely the same elevaton. Of course when the track has been freshly ballasted and is consequently likely to settle under a train, a turning point is taken to one side when a train is known to be approaching. When following a highway, as when running branch lines into a town, suitable steel pins, driven solidly into the ground, are used. The verticality of the rod whilst readings are in progress, is maintained by means of a small spirit level. With regard to rod supports I will quote from the 1907 report of Mr. J. F. Hayford, Inspector of Geodetic Work of the United States Coast and Geodetic Survey. He says:—"In August, 1903, the experiment was made of using a point marked on the top of the rail of the railroad track as the rod support. The most prominent effect was to change the rate of accumulation of discrepancy between the forward and backward lines. This is a clear confirmation of the theory that the accumulated discrepancy is due mainly to a systematic rising or settling of the rod supports. This theory is based upon the frequently observed fact that when a change is made in the method of rod support or in the habits of the rodman, a change is liable to take place in the rate of accumulation of discrepancy between the forward and backward lines.

"The evidence showed clearly that the use of the rail for the rod support increased both the speed and accuracy of the levelling, and the practice has been adopted in all Coast & Geodetic Survey levelling since that time.

"Two uncertainties in connection with the method of rod support will occur to anyone who considers it carefully, namely, the uncertainty as to whether the rodman holds the foot of the rod for both foresight and backsight on precisely the same spot on the slightly rounding and sometimes inclined surface of the top of the rail, and the uncertainty as to the recovery by the rail of its former elevation after a train has passed over it.

"The first of these uncertainties is very small provided the rodman is careful. No difficulty was found in marking the exact spot on the rail which was used in such a way, with chalk or steel, so that the mark was recoverable, even after a train had passed over it.

"Direct observations have indicated that, as a rule, the rail rises to sensibly its former elevation quickly after a train passes. Doubtless there are exceptional cases. The best proof available that such cases are comparatively rare for the conditions under which the rail was used as a rod support, and that the systematic permanent settling of the rail caused by the passage of a train is exceedingly small, is furnished by the comparison given in Appendix 6—Report for 1904—of the accuracy of the levelling by each party before and after beginning the use of the rail as a rod support, and this has been confirmed by the good results obtained on later lines."

When a reading is to be made upon a permanent bench mark a chisel about one foot long and 1 inch wide, levelled to a flat edge at one end, is inserted in the cross mark in the end of the copper bolt, with the sharp edge at the top, that is, the upper surface of the chisel and the cross mark lie in the same horizontal plane; one man holds the chisel steady and maintains its horizontality by means of a hand level while the rodman rests the rod upon the top of it the same as he would upon the rail.

Foresights and backsights of approximately equal length are used, so as to counteract the effects of refraction and curvature, and of a possible lack of adjustment of the level; this equality is secured by having the rodman count the number of rails from the last turning point to the instrument and from the instrument to the next turning point, the instructions are that backsights and foresights should differ by not more than 30 feet.

At this point it will be necessary to say something about the programme of observation followed in the field. The observer sets up the instrument, levels it—as nearly as may be—by means of the three levelling screws, then points it on one or other of the rods and moves the object glass slid in or out till prefect definition of the rod is obtained, he then turns the drum of the micrometer screw, which is under the eye end of the telescope to the left or right, as may be necessary, to bring the bubble exactly to the centre of its run, watching it carefully all the while with his left eye. He then makes the three rod readings corresponding to the three cross wires as rapidly as possible, consistent with accuracy, still being careful to see that the bubble maintains its exact centre position; these readings are recorded by the recorder and the thread interval between the first and second and between the second and third obtained by subtraction; if these do not correspond within a certain limit—fixed for the particular instrument at the beginning of the season by careful observation under the best conditions— the readings are repeated until they do correspond; the mean of the three readings is used to ascertain the differences of level; the use of three readings usually shows up any mistake in reading feet or tenths which might be made in a single reading. The thread intervals obtained as above evidently will correspond to the length of sight, or in other words, the stadia method of obtaining distances is used; in a column headed "Sum of Intervals" these thread intervals are summed continuously from a bench mark, on the left hand page for the backsights and on the right hand for the foresights, this furnishes a ready means of equalizing the sights, if from any cause, they should become uneven, by setting the level behind or ahead— as the case may be—of the centre point between the rods; thus at the end of a section the total backsights and foresights may be made as nearly equal as desired.

When running up steep grades, the point read on the forward rod is much nearer the ground than that on the rear rod, consequently the effect of refraction, or boiling of the atmosphere, is to distort the foresight more than the backsight; by taking very short sights and thus keeping the line of sight away from the ground as much as possible, the effect is minimized but not by any means eliminated. The only way of doing the latter would be to wait for cool cloudy weather when there is no perceptible refraction. If one makes the forward levelling in such weather and the backward in a bright hot sun or vice versa the discrepancy is usually very noticeable; if both measures were made under the unfavorable conditions the results would show a good accordance, but both would be in error; however, the error would be compensated for on the next down grade provided the conditions were the same, so in the aggregate effect upon a line, I think this class of errors should not be classed as cumulative, the more so as in observing during a large number of days one will probably encounter good weather and bad weather combinations indiscriminately upon forward and backward running and upon up and down grades. My own experience has been that the grades have little effect as to causing the total discrepancy to accumulate. Atmospheric refraction affects the readings on the levelling rods most noticeably in two ways:—Firstly, when the ground is being rapidly heated by the rays of the rising sun, the lowest stratum of air becomes in its turn heated by the ground and begins to flow upward; this has the effect of making the readings appear to rise and fall vertically, and even to remain for a minute or so in quite abnormal positions; such conditions are unsuitable for observations. Secondly, when the air is bubbling the graduations on the rods appear to dance or vibrate; they are then difficult to subdivide, but no systematic error is to be feared.

The length of sight taken depends upon the atmospheric conditions; under the influence of a bright sun, without any breeze, especially when following a cold night, the boiling of the atmosphere is so severe that the divisions on the rod often cannot be subdivided with the proper degree of accuracy at a greater distance than 200 feet. Under average conditions, sights vary from 300 to 360 feet; on a very favorable day these may be lengthened to 500 or 550 feet or even more; with one of our instruments having a particularly good object glass, sights of over 700 feet have been obtained. The observer is left to use his judgment as to the length of sight he shall use; if he attempts to read farther than he should, the thread intervals will become irregular and time will be lost in taking readings over; in any case the gain in speed in taking sights of over 450 feet or thereabouts is not very marked owing to the time lost in waiting for the rodman to catch up.

The above remarks apply, naturally, to a level or almost level track; on a 2 per cent. grade, sights of 200 feet could not safely be exceeded in the best of weather.

Owing to these varying conditions it is very hard to say what constitutes an average full day's work; probably it varies, for an experienced leveller between 7 and 8 miles, levelled, that is, in one direction only. In the course of a month, a few days and parts of days are lost from high winds and rain, and relevelling and other causes of delay reduce the total mileage, so that about 65 miles of completed line (levelled both forward and backward) is considered good progress.* These are supposed to be average conditions and are greatly exceeded sometimes under exceptionally good conditions, as over 12 miles have been done in a single day, and in one month, 87 miles of levelling were completed.

The amount of relevelling required should not amount to more than 10 or 15 per cent. provided weather conditions are at all favorable.

This class of work is so dependent for speed and precision upon the weather that it is found necessary to discontinue it in the autumn when the weather gets cold and wind storms become prevalent; the usual season for work is from some time in April till the end of October or the early part of November.

When carrying the line of levels along the railways the elevation of the top of the rail is taken opposite each station house and at the diamond crossings of all intersecting railways; these are tabulated in the office in a separate form of record from the bench marks and are useful as giving permanent records of the work in addition to those furnished by the bench marks; they are also very useful to the companies as they furnish a means of comparing their profiles with our levels without the necessity of making any actual connections on the ground as is usually necessary in the case of bench marks.

The elevations furnished in this way are not in any degree precise, and are only calculated to the nearest tenth of a foot, but they furnish a very practical record, nevertheless, and are in demand by engineers and others.

Adjustment of Instruments.—The collimation adjustment of the precise level is made in a manner very similar to that employed for the Dumpy level. Two solid points suitable for turning points are selected at, say, 360 feet apart and the level set up and carefully levelled at a point half way between them. The readings on the rods are made, and by subtracting them the true difference in elevation is known, regardless of whether the instrument is in adjustment or not. It is then set up with the ocular directly over one of the points on which the rod was held and the distance from the point to the centre of the aperture of the ocular is measured with a steel tape. By adding to or subtracting from this the difference of elevation of the two points, the result will be the true reading upon the rod held on the other point. Upon making this reading, should it not be within 0.01 foot of the true reading, the micrometer drum is to be turned till the centre wire intersects the proper point upon the rod as indicated by the true reading, then, by turning the adjusting nut at one end of the level vial the bubble is brought again to the centre of its run and this adjustment is complete.

The line of collimation is made to revolve in a plane at right angles to the vertical axis of the instrument as follows: the bubble is brought to the centre of its run, the telescope is turned 180 degrees in azimuth, half the error—if any—is corrected by the micrometer screw and half by the foot screws. For convenience the telescope may be placed so that the ocular is over one of the foot screws. The position of the zero of the micrometer drum—after this adjustment is made—should be noted and used when setting up the instrument at a station; the drum may be placed at this reading before using the foot screws for "levelling up." In this way this adjustment of the level will be kept constant.

So well do the precise levels hold their adjustments that it is not often necessary to adjust them more than once in several weeks, though the adjustment is tried at intervals to see that it is all right. As the backsights and foresights are kept of equal length and no intermediate sights

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*Say 19 full working days; 7½ miles levelled per day gives 143 miles; 10 per cent. of this is relevelling; then amount actually accomplished = 130 miles = 65 miles double levelling.

are ever taken, it is not a very serious matter if the level should be slightly out of adjustment in collimation. However, it is well to have it in adjustment if only for convenience.

Adjustments of Nets of Levelling.—When circuits of levelling are closed and when connecting links are run, it is obvious that new elevations will be obtained for bench marks at junction points, unless all work were performed with absolute accuracy, a condition which is, of course, never attained in practice. The question then arises "How much change will be necessitated in the published elevations of bench marks on the original lines of levelling?" I will again quote from the 1907 report of Mr. J. F. Hayford. He says:—"It is a great convenience to have fixed assigned elevations for bench marks—standard elevations, so to speak—to which all other elevations in surrounding regions shall be referred and to make no changes in these values unless necessary. Every change in the assigned elevations of the principal bench marks is liable to cause inconvenience to engineers outside the survey, as well as to the survey, by making extensive changes necessary in computations based upon these assigned elevations. On the other hand, however desirable it may be to have fixed values for the elevations of the principal bench marks, and so to make no changes in those which have already been given to the public in print, it is not desirable to keep a value for an elevation unchanged, when later levelling gives a value differing from it greatly which is determined with a higher degree of accuracy. Therefore, it is never possible to adopt a final standard value for the elevation of any bench mark unless it is positively known that no more precise levelling connected with the net will be done, or else that, if done, it will not be utilized to improve the existing assigned elevation, for all new levelling, besides giving elevations for points not previously determined, affects, by its connections, many elevations in the net as already adjusted, the effect being necessarily greater in the vicinity of the new levelling than in regions more remote. But if all new levelling is to be utilized to the fullest extent in securing elevations of the highest degree of accuracy in every part of the net, then whenever new levelling forming links in the net is secured, the whole net must be readjusted and the old adjusted elevation must be completely superseded by the new.

"Neither of the radical plans indicated above—either to hold all old elevations without change and merely to fit new levelling to the old, or to supersede all old elevations by new ones seems desirable. But a conservative procedure, intermediate between the two is possible.

"If after a complete re-adjustment of the level net the change in the published elevation of any junction point required by the new adjustment is very small, or in other words, elevations from the old and new adjustments agree closely, it seems best to hold the elevations already published. Especially does it seem certain that whenever the change called for by the new adjustment is much smaller than the uncertainties in the new adjusted elevations, no change would be made. So, also, when for any link in the net the new adjustment gives a difference of elevation far within the limits of uncertainty of the new adjusted difference, it seems that th old difference of elevation should be held without change, even though a constant correction to the elevations along the line is found to be necessary."

In India, where a system of levelling has been carried on since 1858, a complete report has lately been published by the Great Triangulation Survey in which a thorough adjustment of all precise levelling up to 1909 is made, by the method of least squares; before this publication, arbitrary methods of adjustments were adopted, in most cases by giving infinite weight to the older lines and then fitting the new levelling into the old. Such discrepancies arose, however, that a complete readjustment, by a scientific method was found to be necessary. I will quote from this volume as follows:—

"It is necessary to point out that in the future we shall have to relapse again into arbitrary methods that we are denouncing and abandoning. In this volume the circuit errors will be adjusted and the heights of all bench marks erected between 1858 and 1900 will be fixed. Any level lines subsequently observed will have to be fitted to the adjusted level net. The lines forming the level net will thus be accorded a greater weight than those observed subsequently to the reduction of the level net; from a scientific point of view this is not quite satisfactory, seeing that the future lines of levelling which should be more accurate than the old, will be subordinated. But we are in the same dilemma as our predecessors and we cannot postpone publication of results, or wait for a finality which is unattainable. Topographers and engineers, who make use of our bench marks, only ask us to eliminate contradictions and to provide them with accordant values of height, such as they can regard as final; they deprecate frequent modifications and disturbances of values.

"This volume will therefore furnish values of heights sufficiently reliable to serve all purposes for at least half a century. In 1958 it will be open to our successors to reconsider the question and to readjust the level net of India. By that time there should be a second level net superimposed on the first; the second will consist of all lines observed between 1908 and 1958, and will be attached to new open coast tidal stations which have not as yet been connected with the levelling net work. The second level net (1908-1958), will be a more scientific work than the present one (1858-1908). It will then be interesting to see what differences in value will occur in the heights of those bench marks that are common to both nets."

In the adjustment of this Indian level net the weights assigned to the different lines were made proportional to the reciprocals of the length of the lines. There were 86 lines of levels forming 29 circuits, which were tied to mean sea level at 9 points; these 9 tidal points were given infinite weight in the adjustment, and the elevations of all the junction points in the net were computed by the method of least squares. The correct elevation of the junction points and of the terminals of lines being given, the corrections to the observed heights of intermediate bench marks on the main lines were interpolated betwen the terminal points. In the interpolation on any particular line the corrections were assumed to vary at a uniform rate along the line. For any branch line that terminated without a second connection with a main line or with sea level, a constant correction was applied throughout, equal to the correction applied to the height of its junction point with the main line.

The problem of making adjustments has not come up as yet with us in Canada, for, as was mentioned earlier in this paper, only two circuits of our own levelling have been closed—in Western Ontario—and they were only completed at the end of last season. It is satisfactory to note that there are no large errors of closure to be disposed of there.

Mean Sea Level.—As all elevations are derived from mean sea level it is important that this should be accurately determined and that the points selected should be such that the sea level at them will not be affected by local influences. In this connection let me quote again from the report of the

Great Triangulation Survey of India:—"The mean level of the sea is the zero or datum surface from which the elevations of the bench marks of India have been measured. In 1909 a selection had to be made of the tidal observatories, which were to form the basis of the levelling net, and which were to furnish data for the determination of mean sea level. There were three alternative courses open, namely:—

1. One reliable tidal observatory could have been chosen, and the height of the whole level net could have been based upon the mean sea level at this point; or

2. The values of mean sea level, derived from all tidal observatories connected with the level net, could have been introduced into the levelling adjustment; or

3. The results obtained from selected tidal observatories could be retained and those from other observatories rejected.

The first alternative was not considered satisfactory. The mean sea level at any point may be permanently influenced by winds and currents; and the tidal observations may be affected by instrumental errors. At no station does the annual determination of mean-sea-level reproduce the values obtained in former years. As these uncertainties exist, it seemed inadvisable to base the whole net upon the measurements at one port.

"The second alternative plan by which all tidal observations were to be included, was investigated and rejected. The levelling operations have shown that the mean-sea-level in certain confined places, such as the Gulf of Cutch and the mouth of the Hooghly, is abnormal, and permanently deformed. At these points the mean water level differs from the mean surface of the open sea by amounts greater than the probable errors of levelling, and it was considered incorrect to force the levelling into accord with the tidal determinations.

"So long as the error of a determination of mean-sea-level is clearly larger than the error accumulated in the levelling, the rejection of the tidal result may be considered advisable. But in the case of some tidal observatories the evidence is very doubtful. The selection or rejection of tidal stations then becomes a difficult question, and one that can only be settled arbitrarily. It must be remembered that the tidal stations are required to form the foundations of the levelling net, that they are expected in fact to give to the levelling in their respective localities more reliable values of height than the levelling can bring from any distant tidal observatory. It is futile then to endeavor to test their reliability by means of levelling results, which they themselves are intended to control. We must either accept one or the other as the more correct; we cannot utilize each in turn as the test of the other.

"If the observed difference of elevation between the mean-sea-level at different ports, connected by levelling, is considerably greater than the error to which levelling is ordinarily liable, it may be assumed that the two sea levels do not belong to the same level surface. But no definite conclusion can be drawn, when the observed difference of elevation is very small; in such a case the two sea levels have not been proved to belong to one level surface. The accordance of results may be fortuitous and due to the error of the levelling having the same sign and effect as the actual difference of sea levels, or to the levelling errors having a tendency to cancel the errors of tidal measurements.

"The selection of tidal observatories on which to base the levelling net, has been therefore governed by general principles, and not by any observed accordance of results. It has been decided, firstly, to select open-coast stations, at which successive annual determinations of mean-sea-level have proved accordant, and secondly, to reject tidal observatories situated in channels, gulfs, creeks, or rivers, and those at which annual determinations of mean-sea-level appeared discordant.

"The variations of mean-sea-level—When we refer to variations of mean-sea-level we mean always variations relative to the level of the land surface. The movements of the earth's crust are of two descriptions—the gradual and the sudden; there are, firstly, the slow imperceptible elevations and subsidences of possible immense areas, and, secondly, the sudden change caused by earthquakes.

"The Branch line of levels from Saharanpur to Mussooree is the only line in India that has, so far as we know, been disturbed by an earthquake. We have moreover no evidence that any of our bench marks have been disturbed by slow gradual movements of the earth's crust;........... ...... we have the annual determination of sea-level made at nine different tidal observatories, and we have been unable to detect in them any tendency to constant change in one direction. The mean-sea-level has been shown, it is true, to vary annually, but it seems to oscillate from year to year about one mean position."

These conclusions will have to be taken into consideration when determining upon a mean-sea-level datum for the Geodetic Survey of Canada, if it is decided to abandon that of New York, which we take up at Rouse Point.

Progress—and Publication of Results.—Levelling operations are at present being carried on vigorously by this Department; during the last two seasons three completely equipped parties have been in the field, in 1910, 812 miles of completed levelling was accomplished and during 1911, 893 miles. The total amount to date is 2,627 miles, that is to say, this distance has been run forward and the same distance backward, no account being taken of the additional relevelling done.

748 bench marks (all of the copper bolt variety described above) have been established since the beginning of the work, this number does not include any that are known to have been since destroyed, but only those actually in existence and connected to the lines of levels.

The question of publishing the results of the work for the benefit of the public was not taken up till about the beginning of last year, as it was desired to have the work on a sound basis and to have some connections with other datums before doing so. The Chief Astronomer's report for 1910, now in course of preparation, contains the complete descriptions and elevations of bench marks and rail levels at stations from 840 miles in Ontario, Quebec and New Brunswick and the 1911 report will probably contain additional results to the amount of 850 miles or thereabouts.

STANDARDIZATION OF FITTINGS AND VALVES.

At a meeting of the committee of manufacturers on standardization of fittings and valves, held at No. 30 Church Street, New York, N.Y., July 10th, 1912, the "Manufacturers" 1912 schedule of flanged fittings and flanges was adopted to take effect October 1st, 1912. There was practically no opposition among the manufacturers present to the adoption of this schedule, but one vote being recorded against it. Copies of this schedule will be printed and distributed to the manufacturers and the trade generally as soon as possible. New list prices for brass and iron body swing check valves, standard and extra heavy, were adopted at this meeting, to take effect October 1st, 1912, copies of which will be printed and distributed to the trade as promptly as possible.

THE CHARACTERISTICS OF COPPER AND ALUMINUM OVERHEAD LINE CONDUCTORS.

By E. V. Pannell.

The assertion has been made that in the sequence of processes involved in the production, distribution and utilization of electric power the weakest link is in the transmission line; the same being far more liable to electrical or mechanical failure than any of the generating, transforming, or converting apparatus. Whether this statement be justifiable or no, it is certain that until recently considerably less attention and care have been devoted to the line than to the electro-dynamical plant, and only of late has the former received its due share of attention. In this country, of course, long-distance overhead transmission is only in its embryonic stage, and little in the way of operating data is available. When, however, the time is ripe, we shall undoubtedly profit by the experiences of transmission engineers in Europe and America who have accomplished the pioneer work in this field. Such engineers have by no means neglected to study the relative utility of various conducting materials, and it is far from being the claim of the author to have opened up a new subject. The object of this article is, however, to set forth a few rules by the use of which a comparison of line conductors may be readily made, and to attempt a few deductions from the same as far as apply to our British conditions.

In the field at the present day there may be said to be two active competitors as conducting materials, viz., copper and aluminum. In preference to the latter metal in its pure state, alloys have often been experimented with. Bearing in mind that the tensile strength of aluminum may be increased upwards of 60 per cent. by judicious alloying without a very great decrease in conductivity, this would seem to be justified. It is, however, found in practice that no such alloy is as resistant to corrosive effects as pure aluminum, and this disadvantage is sufficient to discount the use of alloys for bare overhead conductors. For abnormally long spans, stranded cables of steel have frequently been used both in Europe and America, but the drawbacks to their general use are quite apparent. To take advantage of the high tensile strength by spacing the supporting structures farther apart would result in so great an expenditure on the latter as entirely to off-set any saving on the conductors.

The comparative physical properties of copper and aluminum have been detailed at length on several occasions, and need not be dwelt on here. Such properties are relevant to this investigation are set out in Table I. below. It should be noted that the physical constants are such as to apply to stranded cables in both cases, as all schemes transmitting appreciable quantities of energy now use stranded conductors. This is more than usually true in this country, where it is doubtful if legislation will permit of the use of such high line voltages as render the use of a small solid conductor preferable to the equivalent stranded cable. Before leaving the question of fundamental properties, it should be mentioned that now that such large quantities of high-grade aluminum are being produced for electrical work, the conductivity and tensile strength can be confidently guaranteed. Conductivity and freedom from corrosion are equally dependent on the purity of the metal, and improvements in production have rendered it possible to place upon the market aluminum of well over 99 per cent. purity.

Table I.—Properties of Copper and Aluminum Stranded Overhead Conductors.

	Copper.	Aluminum.
Relative conductivity %	100	60
Specific gravity	8·95	2·71
Relative weights for equal conductance	100	50
Relative cross-section	100	166
Tensile strength, lb. per sq. in.	60,000	30,000
Factor of safety	5	5
Maximum working stress	12,000	6,000
Modulus of elasticity	12,000,000	9,000,000
Specific extension λ	·00000008	·00000011
Coefficient of expansion α	·0000093	·0000130
$\beta = \alpha/\lambda$	116	118
Extension in feet for full working stress, 100 ft. span.	·096	·066
Do. 200-ft. span	·192	·132
Do. 400-ft. span	·384	·264

The enormous outlay called for by the line conductors of a transmission scheme renders the economic question a vital one, and before a comparison such as this is justifiable the competing metal must show an advantage over copper in respect of capital invested. In this connection the diagram shown in Fig. 1 gives a graphical means of estimating the difference of cost between the two metals, yielding the result in terms of pounds sterling by which aluminum is cheaper than copper per ton of the latter. The prices considered are the basis ones for wire in each case. A small circle has been inscribed to represent the approximate prices ruling at the time of preparation of this article (January, 1912), the figures being:—

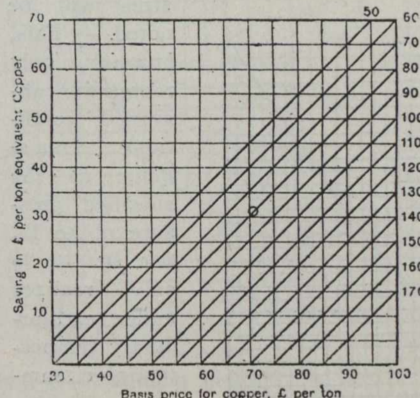


Fig. 1.—Diagram for Estimating the Saving Effected by the Use of Aluminum.

Copper (per ton)	£71 0 0
Aluminum (half ton)	40 0 0
Saving in favor of aluminum	£31 0 0

The computation, of course, takes into account the fact of aluminum being for a given conductance exactly half the weight of copper. The extra charges for drawing and stranding are a function of the length of the cable, hence on a mileage basis are approximately equal for both metals. The saving as calculated on the above basis is, therefore, unaffected except where multi-stranded cables of small diameter wire are employed.

Turning to the technical problems involved, a starting point is fixed by the Board of Trade recommendations for overhead line construction. Briefly stated, these call for a stress in the conductor not exceeding one-fifth of the ultimate tensile, assuming a temperature of 22 deg. Fahr. and a horizontal wind pressure of 30 lb. per sq. ft. (corresponding to 18 lb. per sq. ft. on the projected surface of the wire). These values together with certain of the physical constants already set forth can by suitable manipulation be substituted in the standard equation for deflection and stress, where—

Deflection at mid-span $\delta = w\,l^2/8\,a\,s$,

and in which w = loading per foot run, lb.; l = span in feet; a = cross-section of conductor, sq. in.; s = maximum working stress, lb. per sq. in. The deduction of this equation from the catenary need not be entered into here.

The loading on the wire (w) is the resultant of its weight w and the wind pressure p—

$$W = \sqrt{w^2 + p^2}—$$

and the inclination of the plane in which the conductor will hang is given by—

$$\text{Angle with vertical } \theta = \tan^{-1} p/w,$$

the two forces p and w acting at right angles. In estimating these and other functions it has been found convenient to use a basis as the outside diameter of the cable. A relation between this quantity and the sectional area has been plotted in Fig. 2, and the approximation is very close indeed.

The loading (w) is shown by the curves in Fig. 3, which are plotted from the figures set out in Table II., and in which both of the components and the resultant have been plotted as a function of the cable diameter. The enormous preponderence of wind over weight loading in the smaller sizes will be noted. This, however, only represents abnormal conditions, inasmuch as the specified pressure of 30 lb. per sq. ft. is only realized under extraordinary tempestuous circumstances.

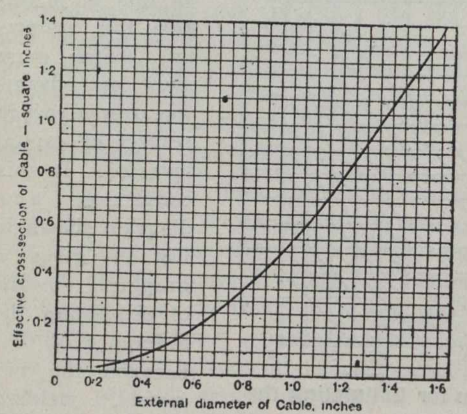


Fig. 2.—Diameter of Stranded Conductors.

As already stated, the formula above given represents the conditions obtaining at minimum temperature, 22 deg. Fahr. With increase of temperature the factor of linear expansion will come into play and the deflection will increase. It is highly important to know the value of the maximum deflection under conditions of high summer

Table II.—Particulars of Stranded Overhead Conductors.

Dia. of cable, in.	Effective cross-section sq in.	Weight per ft., lb.	Wind pressure per ft., lb.	Resultant force per ft., lb.
		Copper.		
0.40	0.10	0.40	0.60	0.72
0.60	0.22	0.81	0.90	1.21
0.80	0.38	1.43	1.20	1.80
1.00	0.60	2.24	1.50	2.70
1.20	0.84	3.34	1.80	3.90
1.40	1.15	4.65	2.10	6.00
		Aluminum.		
0.40	0.10	0.12	0.60	0.62
0.60	0.22	0.26	0.90	1.00
0.80	0.38	0.44	1.20	1.30
1.00	0.60	0.69	1.50	1.65
1.20	0.84	1.01	1.80	2.05
1.40	1.15	1.40	2.10	2.50

temperature, in order that the minimum distance of the line above ground-level may be observed and the height of the poles chosen in accordance with the same.

Considering therefore the effect of a rise in temperature $= t^\circ$ F., if α = expansion coefficient and L = total length of conductor, the expansion for a rise of $t^\circ = l\alpha t$, and total length, $L = l + l\alpha t$.

Now, from the properties of the catenary—

$$L = l + 8\delta^2/3l \text{ and } L_1 = l + 8\delta_1^2/3l$$

$$(L_1 - L) = 8(\delta_1^2 - \delta^2)/3l$$

but $L_1 - L$ = extension for temperature rise $t^\circ = l\alpha t$, hence—

$$l\alpha t = 8(\delta_1^2 - \delta^2)/3l \text{ and } t = 8(\delta_1^2 - \delta^2)/3l^2\alpha.$$

It has been thought desirable to manipulate the temperature—deflection equation in the above form in order that a correction for the elastic stretch of the wire may be more

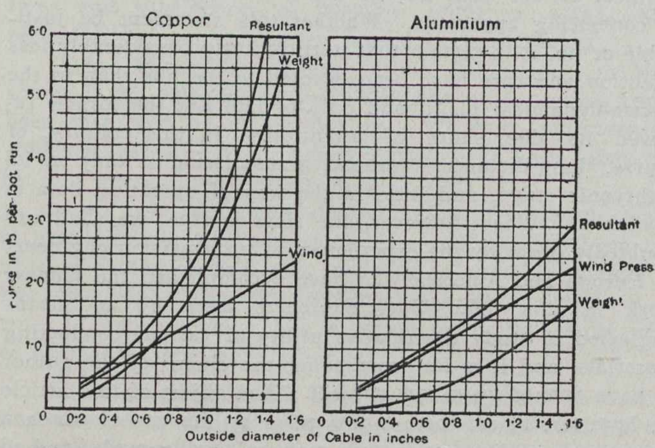


Fig. 3.—Loading Due to Weight and Wind-Pressure on Overhead Conductors.

readily made. It will readily be seen that as the cable expands with increased temperature the stress is relieved. This reduction of stress, however, gives a diminution of strain, and the conductor will, therefore, extend, due to temperature rise, by an amount which is less than that calculated by the shortening due to reduction of stress. From the other

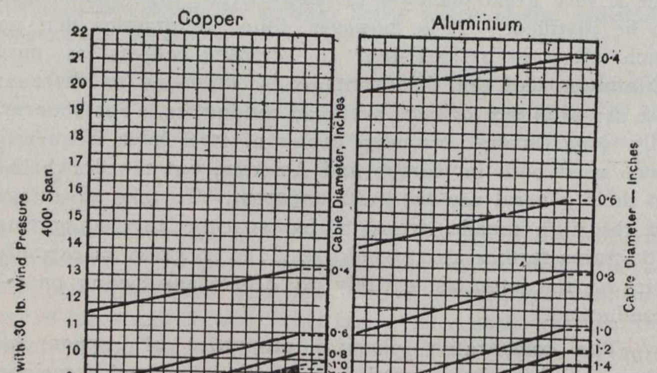


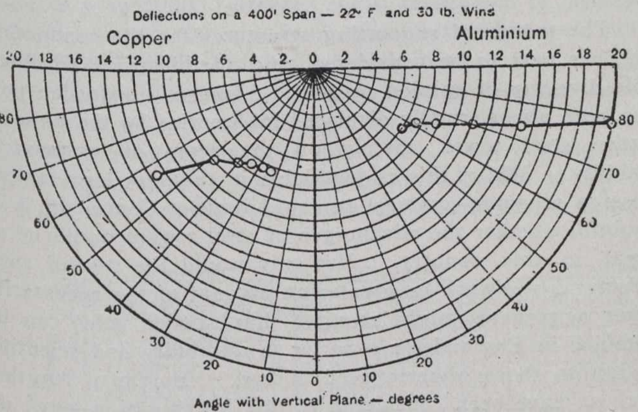
Fig. 4.—Deflections on Overhead Conductors Under Varying Conditions of Temperature.

standpoint it will be seen that the temperature rise for a given deflection will be greater than that worked out from the above formula. The correction may, therefore, most conveniently take the form of an increment to the calculated temperature rise. The correction used is a modification of that suggested by Mr. Shields in the discussion on a paper by Burne on "Overhead Constructions" (Journal I.E.E., Vol. XXXI., p. 432), which was read before this Institution some ten years ago.

This correction may be made as follows:—α = per cent. extension per ° F. λ = per cent. extension per lb. per sq. in. stress. $\beta = \alpha/\lambda$.

Now, for a change in deflection $= \delta_1 - \delta$, there is a change in stress $= S_1 - S$, and $S_1 = S\,\delta/\delta_1$; hence the increment for correcting the above temperature $= (S_1 - S)/\beta$, and this should be added to the right-hand side of the equation.

On this basis the curves in Fig. 4 have been plotted and the results tabulated. It will be noted that maximum wind pressure is assumed throughout, hence the deflection is not only considerably above the normal value, but the conductor will be swung out of the perpendicular by a considerable angle. As already shown, the value of this angle is $\tan^{-1} p/w$. It is, therefore, unaffected by temperature, and only depends upon the wind pressure and the weight of wire.



Diameters of Wire (Copper left to right, Aluminium right to left): 0·4, 0·6, 0·8, 1·0, 1·2, 1·4 inches.

Fig. 5.—Polar Diagram Showing the Angle by Which Conductors are Blown Out of the Vertical.

Fig. 5 shows this feature graphically, the values of deflection for a 400-ft. span, at 22° F., and the maximum wind pressure, being plotted in polars.

From curves in Figs. 4 and 5 will be seen, as might be expected, the relatively greater deflections on aluminum conductors, and the greater effect of a given wind pressure. It should be noted, however, that this is largely due to the abnormal value assumed for the latter quantity. Moreover, as will be seen later, a deflection double that of a copper conductor need only call for a pole 10 per cent. higher. The fact that the greater factor in the loading on aluminum cables is this assumed wind pressure, is an advantage on the side of conductors of this material. Under normal circumstances, with moderate winds, the weight of the cable is the more potent factor of the loading, and this value being 50 per cent. lower for the aluminum cables, it follows that the average stress in such will be lower in value. This is by no means an unimportant point, as the lower the average stress on any section, the less is the liability to fatigue.

In predetermining the forces acting on the conductors at the lower temperature limit of 22 deg. Fahr. it is necessary to take into account the wind pressure. In calculating the maximum deflection due to the highest summer temperature, however, wind pressure must be eliminated. Apart from the physical impossibility of a hurricane blowing at 100 deg. Fahr., it is necessary to calculate the maximum deflection in a vertical direction in order to estimate the necessary height of the pole or other supporting structure; in other words, the deflection in still air is what is required. Some manipulation is necessary to allow for this change in the conditions, and the author has found it convenient to use a graphic method for effecting this.

The conditions obtaining at 22 deg. Fahr., as has been seen, are expressed by—

$$\delta = w\,l^2/8\,a\,S.$$

It will be noticed that all save δ and S are constant; hence— $\delta = K/S$, and $\delta\,S = K$.

If, now, the wind pressure disappears, the state of affairs is given by—

$$\delta_1 = w\,l^2/S\,a\,S_1,\ \text{i.e.},\ \delta = K_1/S_1.$$

Ample information is available for the estimating of K and K_1; the latter being obtained, a locus is fixed for $\delta_1 = K_1/S_1$. This curve plotted for a 200-ft. span in aluminum is shown in Fg. 6, whilst at the top of the diagram is the elastic extension curve plotted downwards to represent a contraction. This is obtained simply by multiplying the stress by the elastic constant and by the length of span. The variation of deflection with extension of the cable is calculated from the equation already given—

$$L = l + 8\,\delta^2/3\,l$$

hence a series of deflection curves can be plotted from the values in the elastic extension curve. The points where these lines intersect the $\delta_1\,S_1$ hyperbola show the positions where the catenary and elastic laws coincide and give the actual deflections which the conductor will take up, with the corresponding stresses.

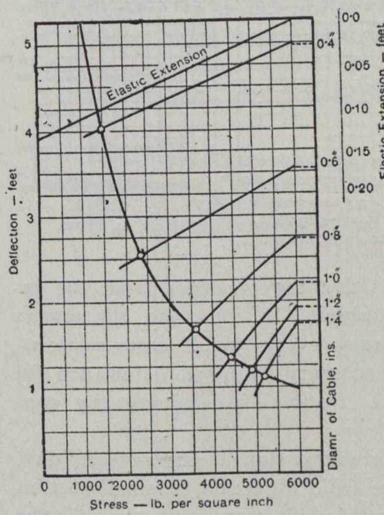


Fig. 6—Graphical Method for Determining the Reduced Deflection, with a Reduction of Stress. Aluminum Cables, 200-ft. Span.

A computation such as this, although somewhat laborious, is the only means of predetermining the actual conditions obtaining when an elastic conductor is used for aerial work. The accuracy of the method depends wholly upon the values chosen for elasticity, and there is room for a considerable amount of experimental work in this connection. Very little reliable information is available respecting the physical properties of stranded cables, and with the broadening of the field of electric power transmission such data must be extended.

The respective deflections on the copper and aluminum cables with and without wind-pressure are shown in Fig. 7. These curves, together with the figures in Table III., summarize all the foregoing calculations, and it will be seen that they are plotted to a base representing equivalent sectional area which, of course, is a function of current-carrying capacity. Thus the two materials are here brought into line on the fairest possible basis for comparison. Analysis of these results is very instructive—it being seen that the maximum amount by which the deflection on an aluminum line exceeds that for copper is about 35 per cent. With smaller sizes of cable than 0.1 sq. in. of course this ratio will increase, but this illustrates the fallacy of the statement frequently made to the effect that aluminum is only suitable for small and unimportant transmission schemes. It is exactly for the large power lay-outs that the advantages are best shown, and the greater the amount of power transmitted the better become both the technical and economic features of aluminum. The only point open to question is, at what section of cable does aluminum become superior to copper? The present investigation is carried down to a section of approximately 1/10 sq. in., or 100 amperes carrying capacity in copper, and it does not seem

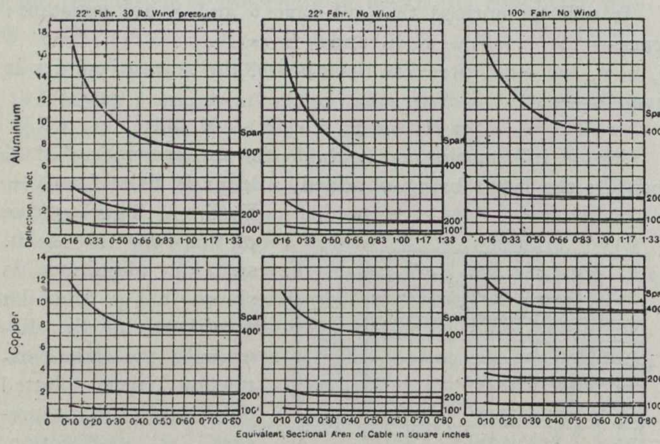


FIG. 7.—DIAGRAMS SHOWING COMPARATIVE DEFLECTIONS ON COPPER AND ALUMINIUM OVERHEAD CONDUCTORS.

that any preponderating disadvantage accrues from the replacement of copper by aluminum. If however, the matter were carried further, down to very small cross-sections, then the large deflections necessary owing to allowance for wind pressure would cause trouble in spacing the conductors.

In dealing with power transmission at the present day, however, there is a far more valid objection to small-section conductors than the matter of deflection, and that is the phenomenon of corona. It has long been known that high transmission pressures occasion a loss due to brush discharge from the conductors, and more recent investigations have shown that the glow which surrounds the conductor below the limits of the brush discharge is, in itself, a source of considerable loss. The most recent theories on the subject are those of Watson ("Losses off Transmission Lines Due to Brush Discharge," Journal I.E.E., Vol. 45, No. 202) and Peek ("Law of Corona," Proceedings Am. I.E.E., Vol. XXX., No. 7), both of which are masterly investigations of an extremely involved problem. The feature which has been brought out most strongly is the rapid augmentation of corona loss, with a reduction in the size of the conductor. At working pressures of 80,000 volts and over, this difficulty is a very real one, and the use of tubular conductors has been proposed in order to increase the radius and diminish the liability to discharge. Although such high working pressures are by no means imminent for British transmission schemes, it should be remembered that in our climate corona will form at an appreciably lower voltage than in the drier atmospheric conditions obtaining on the American Continent. There is thus every reason for believing that, other things being equal, the larger diameter conductor will carry a given pressure with a lower corona loss. This is the main reason which dictated the exclusive use of aluminum on the transmission system of the Ontario Commission, which operates at 110,000 volts. The 30 per cent. greater diameter of the aluminum conductor over the equivalent copper is a powerful advantage for high-pressure systems.

TABLE III.—DEFLECTIONS UNDER EXTREME CONDITIONS.

Section, sq. in.		100-ft. span.		200-ft. span.		400-ft. span.	
Copper.	Alum'm.	Copper.	Alum'm.	Copper.	Alum'm.	Copper.	Alum'm.
(1) *Temperature* 22° *F.* 30 *lb. wind pressure. Deflections in feet.*							
0·10	0·16	0·73	1·08	2·92	4·30	11·68	17·20
0·20	0·33	0·59	0·76	2·36	3·04	9·45	12·20
0·30	0·50	0·52	0·62	2·07	2·48	8·30	9·90
0·40	0·66	0·49	0·54	1·95	2 16	7·80	8·65
0·50	0·83	0·48	0·51	1·90	2·04	7·60	8·16
0·60	1·00	0·47	0·48	1·89	1 92	7·51	7·70
0·70	1·17	0·47	0·46	1·88	1·84	7·50	7·36
0·80	1·33	0·46	0·45	1·88	1·80	7·50	7·20
(2) *Temperature* 22° *F. No wind.*							
0·10	0·16	0·45	0·48	2·17	3·10	10·50	15·30
0·20	0·33	0·41	0·40	1·85	1·85	8·40	10·90
0·30	0·50	0·405	0·35	1·80	1·45	7·70	8·50
0·40	0·66	0·40	0·30	1·75	1·35	7·30	7·30
0·50	0·83	0·40	0·28	1·70	1·25	7·10	6·65
0·60	1·00	0·40	0 27	1·65	1·20	7·00	6·20
0·70	1·17	0·39	0·26	1·60	1·15	7·00	6·00
0·80	1·33	0·39	0·26	1·59	1·10	6·90	6·00
(3) *Temperature* 100° *F. No wind.*							
0·10	0·16	0·96	1·45	3·50	4·70	12·10	16·50
0·20	0·33	0·90	1·40	3·40	3·65	10·20	12·70
0·30	0·50	0·90	1·35	3·35	3·30	9·60	11·00
0·40	0·66	0·89	1·32	3·29	3·25	9·40	9·80
0·50	0·83	0·89	1·30	3·38	3·20	9·30	9·40
0·60	1·00	0·89	1·25	3·25	3·15	9·25	9·15
0·70	1·17	0·88	1·20	3·22	3·12	9·22	9·00
0·80	1·33	0·88	1·20	3·20	3·10	9·20	8·90

The matter of supporting structures for the conducting line has next to be considered, and on this point considerable diversity of opinion prevails. The single wooden pole has been almost totally displaced in America by the built-up lattice steel tower, mainly on the score of mechanical stability. Whilst this is justifiable in the very large transmission schemes common on the American Continent, it is doubtful whether the advantages of steel towers would be as great in this country. Not only would the cost of such structural steelwork be greater on account of the necessarily lower aggregate weight required, but wooden poles can be obtained in England far superior in durability and scientific design to those hitherto used abroad. For span lengths, such as have been considered in this investigation—viz., up to 400 ft.—the **A** type of pole amply takes care of the stresses due to a double three-phase network, except with abnormally large sections of cable, or with extremely high voltages. Neither of these latter conditions need be anticipated in the immediate future of British transmission schemes, and it would seem that this type of pole is amply sufficient for such projects. In estimating the cost per mile in line, therefore, **A**-type poles have been assumed of appropriate strength and of sufficient height to maintain a minimum distance of 22 ft. between the ground and the lowest point of the wire. The approximate cost of such poles is shown in the curves of Fig. 8, and values have been chosen from these curves for plotting in the "cost per mile" diagrams (Fig. 9). The latter represent the cost per mile of material for a high-pressure double-circuit three phase line, comprising the costs of metal, poles and insulators. Analysis of these curves will show that in no case does the extra cost for the poles on the aluminum lines approach the value of the saving effected on the line conductors.

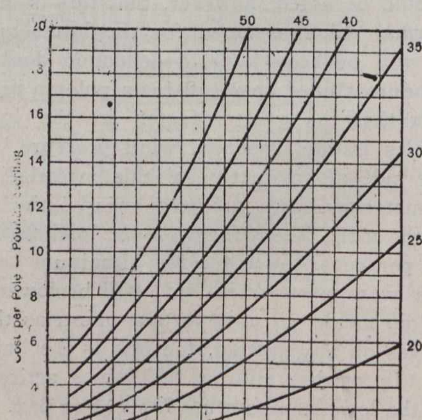


Fig. 8.—Diagram Showing Cost of A-Type Wooden Poles.

This is the most important result, as it refutes the statement often made, that a saving on the cost of line conductors does not imply a saving on the whole expenditure. For very small amounts of power, of course, the cost of poles and insulators will be of relatively greater magnitude, but in such cases the nearest stock size of pole would be requisitioned, and would be pressed into service regardless of the line conducting material.

If it be granted that the poles along the run of the line need to be somewhat stronger and more expensive for aluminum than for copper, the reverse in the case with strain poles, and all structures which have to take the longitudinal stress of the line. The stresses in the aluminum conductors being some 20 per cent. lower than the equivalent in copper, there is much less liability of the poles coming down due to a breakage of one or more conductors. Where, however, steel towers are used they will be designed especially for a copper or an aluminum line. In the former case, the towers will have a greater strength in the direction of the line than the latter, whilst the transverse strength will be in the reverse proportion. Hence, it is reasonable to believe that steel towers for an aluminum transmission line need not cost much more than those for a copper line.

Problems connected with erection are for the most part common to both conducting materials, and for this reason scarcely need treatment in this article. The jointing problem has been solved in both cases by the adoption of the torsion joint, in which the conductor ends are run into a figure 8 or

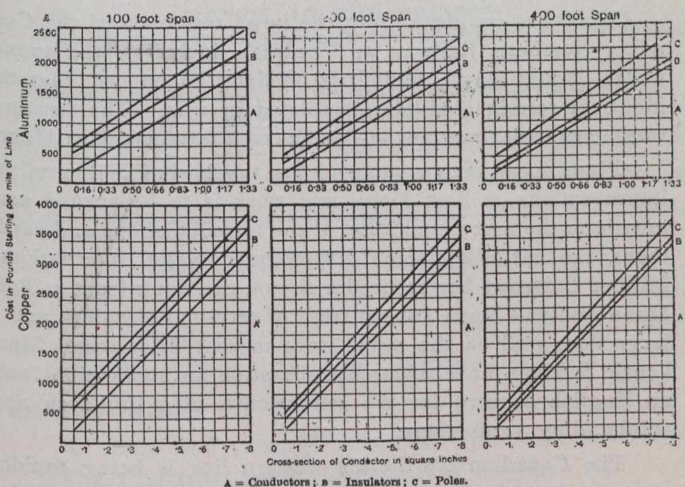


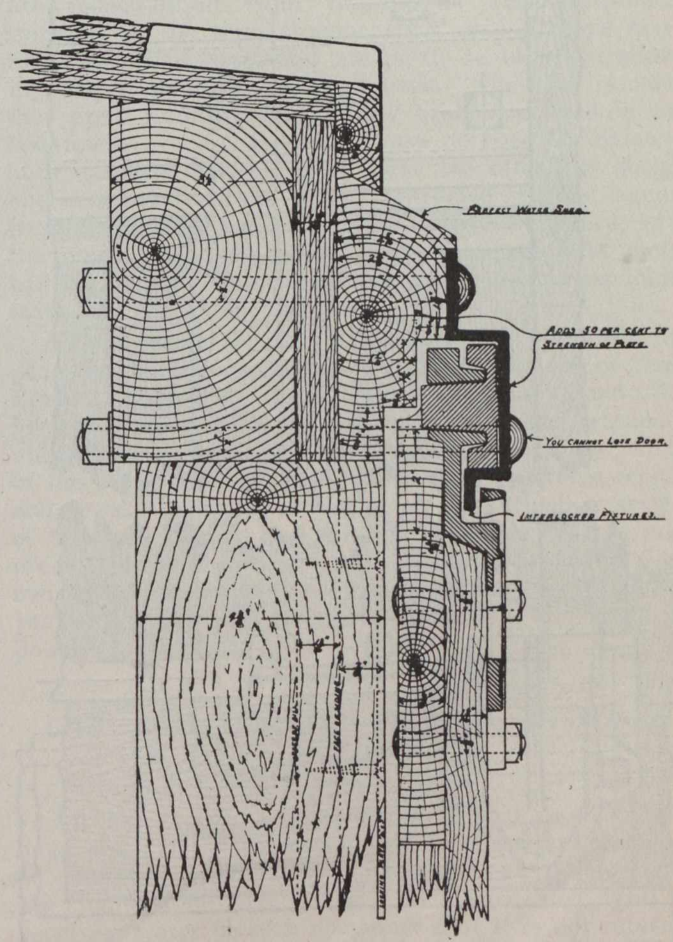
Fig. 9.—Approximate Figures for Cost of Material Per Mile.

oval section sleeve and twisted up. In straining up the conductors the dynamometer should always be used with reference to a table of stresses. Adjustment by gauging the deflection is unsatisfactory, whatever be the method employed. It should be remembered that the cable should be stressed up to its elastic limit and then let down again, for the reason that if this be not done it will take up a permanent set in the first gale of wind and deflect considerably more than the calculated amount. Neglect of this precaution has been largely responsible for the abnormal deflections reported on certain aluminum lines. This operation, of course, calls for the use of a dynamometer, and can in no wise be accomplished by merely sighting from pole to pole. In this paper deflection instead of stress curves have been plotted, but from the former a table of stresses can be readily prepared and should always be employed on erection work.

In conclusion, the author would say that this short thesis was intended to be by no means an exhaustive treatise on the subject of the title, but merely an example in the use of some simple rules to facilitate comparison between copper and aluminum line conductors. Much of the information relative to the use of the latter metal is here published for the first time, and the author's best thanks are due to Mr. Arthur Jacob, of the British Aluminum Co., Ltd., for permission to use the same.

A NEW TYPE OF BOX CAR DOOR.

There has always been a great deal of trouble with box car doors. When doors are made tight they offer considerable difficulty in opening, and when they are made loose they are liable to be lost. With the necessity of making the doors wider the car is liable to be weakened very much structurally. For the above reasons the Chicago Car Door Company, Monadnock Block, Chicago, has recently placed on the market a new type of box car door. The illustrations shown herewith give a fair idea of the design.



Section of Chicago Car Door Showing Interlocking Principle and Watershed.

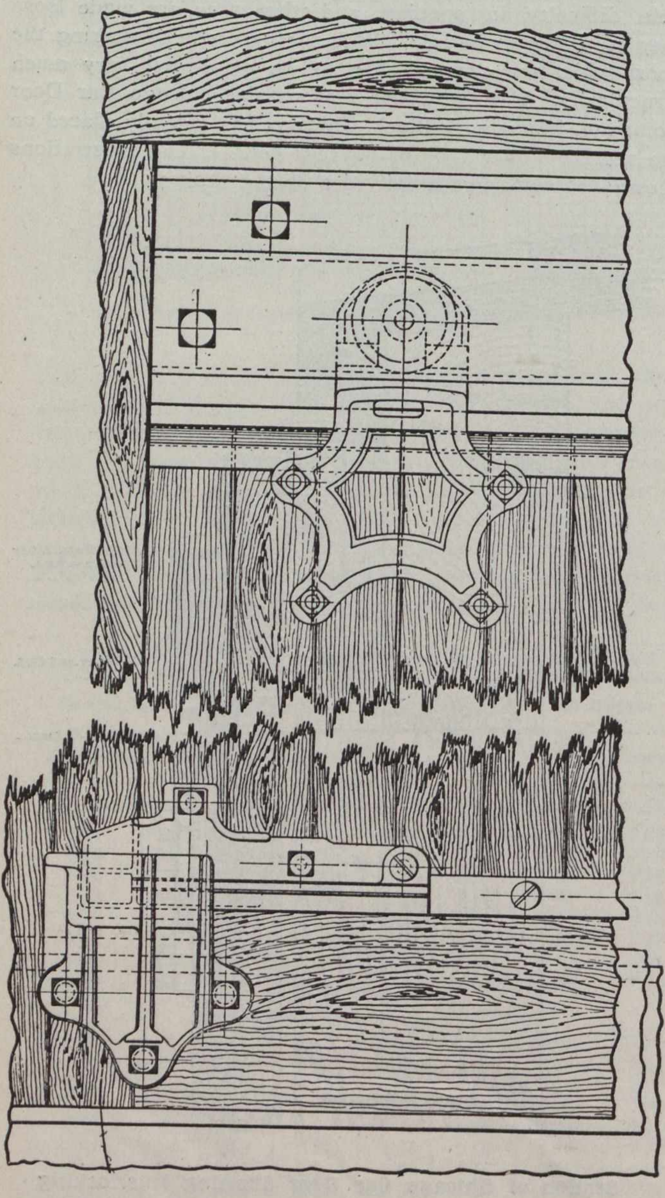
The track is a rolled steel section about five inches wide, and together with the block by which it is attached to the car, it more than doubles the strength of the plate at the doorway.

As the rolls operate on the inside face of the track they are thoroughly protected from snow and ice and are so arranged that either one of them will travel on the inside top of the track if the door is tilted, either in opening or closing, making it impossible to cramp the door, both rolls always being in contact with the track.

The track also forms an indestructible hood and is a perfect water protection at the top of the door. It projects down on the outside face of the door for a distance unusually great. At the same time it is to be interlocked with the hangers that, if the track is hanging loose on the side of the car, the door cannot be removed without taking out the bolt at the end of the track. This makes it impossible to lose the door off the car without wrecking the latter, a feature which is of interest to every railway official.

On the back edge of the door a spark strip is arranged to interlock with a plate on the face of the door post, similar to others in use, and forms a protection against either sparks or water entering the car at this point.

The bottom of the door is protected by burglar-proof brackets, thousands of which have been in service for several years. These brackets form the guides for the bottom of the door and are so arranged that it is impossible to remove one from the car while the door is closed, even if the bolts, by which they are attached to the sill, are taken out, as the bracket has to be raised up a considerable distance before the lag screw can be removed.



Sketch of Car Door Showing Lock Brackets.

The corner irons and wedges on the lower corners of the door are securely attached, and are intended to take the full thrust of the door against the end brackets, when the door is opened or closed, and at the same time hold it firmly against the face of the door posts. The general appearance of the door is particularly substantial and attractive.

PROGRESS OF TRANSCONTINENTALS

Some time during 1914, the Grand Trunk Pacific and the Canadian Northern will be completed across the continent. With three transcontinental railroads, Canada should experience another impetus to further development. At the same time, freight congestion should be relieved and there may also be some adjustment in Western freight rates.

President E. J. Chamberlin, of the Grand Trunk, stated at Winnipeg, that the Grand Trunk Pacific's end of the National Transcontinental will be finished before the end of 1914, and sooner if labor troubles do not interfere. There will be no increased passenger service for the head of the lakes until rights-of-way have been fixed up. The company is getting ready to handle a lot of this year's crop, and to this end elevators and yard facilities are being augmented.

Western advices state that men are working continuously on the big 70-ton steam shovel on the route of the Grand Trunk Pacific from Tofield to Calgary—by the light of the sun in the day time and under the glare of two powerful searchlights at night. It is estimated that the Grand Trunk Pacific will have reached the city limits of Calgary by the end of August, and that steel will be to the waters of the Bow River less than 30 days later.

The bridge over the Skeena, near Hazelton, which has caused delay in laying the rails east of the Skeena crossing, will, it is hoped, be completed by the end of this month. This has been a difficult bridge to construct, the foundations having had to be sunk 25 feet below the bed of the river.

Work has commenced on the large terminals of the Canadian Northern Railway at Montreal, including the tunnel under Mount Royal, and it is officially announced that the Montreal terminal will be completed in 1914. The terminal works are under way at the Pacific coast terminal, Port Mann.

Plans have been completed for the harbor and terminal improvements at Port Mann and work is to be started next month on the first installation of the terminal shops and yards there, the initial cost to be $500,000. The International Milling Company has secured a site on the water front at Port Mann and will begin construction of terminal elevators and a large flour mill on the water front to cost $1,000,000. Mackenzie & Mann have under consideration an application from an English concern for the construction of a dry dock and shipbuilding yards there.

The Canadian Northern's western line is being rapidly extended into the Rocky Mountains this year, and next year will witness the completion of the work in the Yellowhead Pass. Work is proceeding rapidly at all the other points on the system, so as to insure the linking up of the whole road by 1914.

This year 1,053 miles of new road are to be constructed, including several new branches, as follows:—

	Miles.
Montreal to Hawkesbury	58
Ottawa to Ottawa River	32
West from Ruel, Ontario	100
East from Port Arthur	108
Branch lines and extensions in Alberta and Saskatchewan	400
British Columbia	75
Sydenham, Ont., to Ottawa	80
Relaying track on main line west	200

Two thousand men are employed in the construction work, and the approximate amount paid in wages is $1,800,000 a month. In addition to this, 62,000 tons of new steel will be used in laying tracks this year. The probable cost of the tunnel and terminals at Montreal is put at not less than $25,000,000, while $9,000,000 is being spent for new equipment.

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CONTENTS OF THIS ISSUE.

HIGHWAY BRIDGES.

The highway bridge question throughout the country is one to which far too little attention is given. A casual inspection of the greater number of bridges now in existence shows that many of them are in exceedingly bad condition through lack of repairs and maintenance. While it is true that a great number of steel highway bridges have been erected during the past few years, particularly in the more thickly populated parts of the country, we feel satisfied that there has been little improvement in the general safety of the bridges. Probably one of the prime reasons for this is the fact that the responsibility of county councils appears to end when they have installed a new steel bridge. Several reasons may be cited to account for this feeling. County councils do not appreciate the necessity for regular and frequent painting of steel structures. They are misled often from the fact of their misunderstanding of the term "permanent," and perhaps here, too, the bridge companies are partly to blame in allowing the misunderstanding to exist. The fact remains that great numbers of highway bridges erected in the last few years are unsafe because no care or maintenance has been put on them. Far too often the design and construction has been contracted for by agents (responsible or otherwise) of the bridge companies, with the result that poor design and extremely light metal has been used. Thus very often the bridge in its initial state has been none too safe.

The remedy for the above condition of affairs appears to be the institution of a rigid system of continuous inspection throughout the country, and this inspection preferably in the hands of the provincial authorities. This inspection should place in the hands of the provincial authorities the power to enforce repairs and regular painting of the structures. Such a system of inspection would repay itself from the start. Under present conditions the life of a highway bridge of light metal without maintenance may be a matter of twelve years or less; with adequate inspection this could be doubled or trebled.

CHICAGO'S ILLUSIVE SEWAGE DISPOSAL METHOD.

It has always been understood that municipalities have prior rights to water for the necessary purposes of domestic water supply and sewerage. It has never been understood that municipalities have any rights to so divert water in such a manner that it is not returned into the watershed or watersheds from which it is taken.

In 1892 the Sanitary District of Chicago commenced a system of sewage disposal by dilution, but not the ordinary method of dilution practised by simply discharging raw sewage into a large body of water. In this particular case a canal or open sewer was constructed, running south from Chicago and discharging into the watershed of the Mississippi. The water used for domestic purposes and pumped from Lake Michigan was thus not returned to its original source, but was diverted. In order to dilute the sewage and produce a less objectionable character than the raw material it was decided that this open sewer required a quantity of new water added from Lake Michigan. Chicago is divided from the watersheds of the Great Lakes and the watersheds of the Mississippi by a comparatively short and low neck of land, consequently it was an engineering possibility to connect the two watersheds and cause Lake Michigan water to flow to the Mississippi.

This open sewer, or canal, as it is now called, was completed in January, 1900, and the Sanitary District of Chicago have continued to use with a permit from the United States Secretary of War to divert 4,167 cubic feet of water per second from Lake Michigan.

Canada and the shipping interests of both continents have watched this peculiar, extraordinary and isolated method of sewage disposal with no little alarm. The principle that the waters of the Great Lakes may be used not only for sanitary purposes in the usual way, but may also be diverted from the Great Lakes and the Gulf of Mexico, is one which causes every interest on the Great Lakes waterways to hesitate and enquire into the stability of the nature of things in general.

The permit of the United States Secretary of War to allow 4,167 cubic feet diversion was alarming to the degree that an extraordinary precedent and principle was admitted, but when the Sanitary District of Chicago recently followed up this permit with a request to the Secretary of War for 10,000 cubic feet, then it appeared that the various interests interested in maintaining a flow of water to the St. Lawrence Gulf had better make some practical enquiries and know best where they stood.

We have before us a bound copy of papers relating to the application of the Sanitary District of Chicago for permission to divert 10,000 cubic feet of water from Lake Michigan to the Gulf of Mexico, published by the Canadian Department of Marine and Fisheries. The papers deal principally with arguments contained in a brief by Mr. Daniel Mullin, K.C., and others who were nominated by the Canadian Government to oppose the application before the United States War Secretary. The chief argument used is the obvious and practical one that any diversion of water will affect the level of the lakes to the extent of the current of diversion, and that not only will the level of the lakes be affected, but, of more importance to navigation, the levels of all the connecting channels, canals and harbors will also be affected. Measurements and computations have shown that a diversion at Chicago of 10,000 cubic feet will lower the levels at various points as follows:—

	Inches.
Lakes Michigan and Huron	7.4
Erie	6.1
Ontario	4.5
Rapide Plat	6.8
Cornwall Canal	5.0
Coteau	5.4
Montreal	10.25
Sorel	6.0

The United States Secretary of War has also his attention drawn to the fact that Canada by treaty has some interest and right in maintaining the levels of the Great Lakes and waterways. The interests connected with navigation and power development are enormous, and we would refer our readers to the published evidence and arguments. It is sufficient to say here that the Chief of Engineers of the United States War Department in a recent communication to the President of the United States, states that the lowering of Lake Erie by one foot would do $300,000,000 damage to existing conditions.

This is the most serious and far-reaching question in connection with the International Waterways that Canada has had as yet to face. The question of mere dilution of sewage on the part of Chicago is no longer the primary one, but only the secondary.

Mr. Isham Randolph, C.E., of Chicago, in the final winding up of not by any means an engineering appeal, but a crude, impassioned, and essentially egotistical argument (so called) presented to the Secretary of War, states: "Now, I would not leave a doubt in your mind as to what Illinois wants. The question has been raised, For how long a time is the water wanted? As long as water runs down hill or floats a boat, Illinois wants this water. She wants it for the health and life of her people; she wants it for her own water borne commerce and for that of her sister States; she wants it for the power that it will yield; she wants it for the fish that it will produce to feed all the people; she wants it now, henceforth, and forever."

The cat is out of the bag. It is not just a simple little question of the disposal of raw sewage, but a question of a ship canal from Lake Michigan to the Gulf of Mexico, a question of power development by water which is equally the property of both the States and Canada, and also a question of providing sewage-fed fish for all the people.

Well! We are induced to think that Illinois will continue to want, if we are allowed to form any conclusion from the weird nonsense and childish bathos which Mr. Randolph presents as an engineering argument to the Secretary of War. On page 4 of the printed argument we find a paragraph which, as a prime example of egotistical inflation, we quote in full:—

"**I** am a part of the history of the Sanitary District; for fourteen years and two months **I** was its chief engineer, the executive head of its construction, and **I** am, and have been for nearly five years, its consulting engineer, and **I** know whereof **I** am speaking!"

Here is another example of the sort of stuff which Mr. Randolph as an engineer presents to the Secretary of War, page 11. Some printed arguments: "Mr. Secretary, you are looking for the truth in regard to this controversy. You must found your ruling upon the bedrock of truth, or else that ruling will be like the house founded upon the sand; when the rain of criticism descends, and the winds of opposition blow, and the flood of indignation come, the decision will fall, and great will be the fall of it."

We cannot but feel that the Church has lost a shining light in the way of a good advertising preacher, and that Mr. Randolph has missed his vocation. He certainly has no pretensions for the legal profession, as he states on page 14: "My knowledge of law is only that absorbed by thirty odd years contaminating association with learned lawyers." We sympathize sincerely with the lawyers of the United States.

We would not quarrel with the extreme egotism and silly verbiage of this would-be engineering brief, if it only contained the truth on which the author desires that the Secretary of War act. But when we find that the principal argument of the brief is to prove that the abstraction of 10,000 cubic feet will in no way affect the waterways and harbors of the Great Lakes, and that the whole of the evidence is based upon the well-known fact that the levels of the lakes fluctuate from time to time, then we must really ask is Mr. Randolph himself sincere, or is he merely perpetrating what is termed a "huge bluff." Four thousand one hundred and sixty-seven cubic feet, the amount of water now allowed, is more than sufficient to form a decent sized river, and there is no practical reason why Chicago should not partly purify its sewage so as to discharge it in a non-putrescible state into such a river.

The statement that 10,000 cubic feet is necessary to the health of Chicago is absolute bluff. The statement that the diversion of 10,000 cubic feet will not affect the lake levels and damage the shipping interests is also bluff. The statement of sewage-fed fish for all the people is also bluff. The statement that power can be developed is not bluff. The idea of the diversion of Lake Michigan waters for purposes of a ship canal to the Gulf of Mexico is not bluff.

THE PANAMA CANAL.

The following statement gives information relative to the Panama Canal on points about which inquiries are being constantly received from many sources.

Type of Canal.—The canal will have a summit elevation of 85 feet above the sea, to be reached by a flight of three locks located at Gatun, on the Atlantic side, and by one lock at Pedro Miguel and a flight of two at Miraflores, on the Pacific side; all these locks to be in duplicate, that is, to have two chambers, side by side. Each lock will have a usable length of 1,000 ft. and a width of 110 ft. The summit level, extending from Gatun to Pedro Miguel, a distance of about 31.5 miles, is to be regulated between 82 and 87 feet above sea level by means of the spillway in the dam at Gatun. The Gatun Lake, which will have an area of 164.23 square miles, will be maintained by earth dams at Gatun and Pedro Miguel. The Chagres River and other streams will empty into this lake. A small lake, about two square miles in area, with a surface elevation of 55 feet, will be formed between Pedro Miguel and Miraflores, the valley of the Rio Grande being closed by an earth dam on the west side and a concrete dam with spillway on the east side at Miraflores.

The approaches from deep water to the Gatun locks on the Atlantic side, and form deep water on the locks at Miraflores on the Pacific side, will be sea level channels, about 7 and 8 miles in length, respectively, and each 500 feet wide.

Length, Width and Depth of Canal.—The canal is to be about 50 miles in length from deep water in the Caribbean Sea to deep water in the Pacific Ocean. The distance from deep water to the shore line in Limon Bay is about 4½ miles, and from the Pacific shore line to deep water is about four miles; hence, the length of the canal from shore to shore will be approximately 41½ miles.

The channel from mile 0 in the Caribbean to mile 6.70 at the north end of Gatun locks will be 500 feet wide; from the south end of Gatun locks to mile 23.50 not less than 1,000 feet wide; from mile 23.50 to mile 26.50, 800 feet wide; from mile 26.50 to mile 27.00, 700 feet wide; from mile 27.00 to mile 31.25, 500 feet wide; mile 31.25 to Pedro Miguel lock (mile 39.36), 300 feet wide, and from Pedro Miguel lock to Miraflores locks, and from Miraflores locks to deep water in Panama Bay, 500 feet wide.

The average width of the channel in this project is 649 feet, and the minimum width 300 feet. The canal will have a minimum depth of 41 feet.

Gatun Dam.—The Gatun dam along the crest will be about 8,000 feet long, including the spillway, or about 1½ miles, and 2,100 feet wide at its greatest width.

The crest of the dam will be at an elevation of 115 feet above sea level, or 30 feet above the normal level of Gatun Lake, and 100 feet wide. The width of the dam at the normal water level of the lake, i.e., 85 feet above sea level, will be about 388 feet.

The central part of the dam will be filled by hydraulic process, protected by rock toes on both sides of the dam. The upper slope on the lake side of the dam will be further protected by 10 ft. thickness of rock. The other parts of the dam will be filled with available material from canal excavation.

In entering the canal from the Atlantic side, a ship will proceed from deep water in Limon Bay to Gatun locks, a distance of 6.9 miles, through a channel 500 feet wide; passing into the locks, 0.78 of a mile in length, the ship will be carried up to an elevation of 85 feet above sea level in three lifts to the level of the water in Gatun Lake; thence for a distance of 16 miles the channel will be 1,000 feet or more in width to mile 23.7; from this point to mile 26.9 the channel will be 800 feet wide; from this point to mile 27.45 the channel will be 700 feet wide; from this point to mile 31.5, near Bas Obispo, the channel will be 500 feet wide; from Bas Obispo to Pedro Miguel lock, through the Culebra Cut, to mile 39.68 the channel will be 300 feet wide. Going through Pedro Miguel lock, 0.37 of a mile in length, the vessel will be lowered to the level of Miraflores Lake, 55 feet above mean tide through which there will be a channel 500 feet wide to Miraflores locks at mile 41.72, thence through the two Miraflores locks, 0.58 of a mile in length, the vessel will be lowered to tide level and proceed through a channel 500 feet wide to deep water in the Pacific at mile 50.0. It is estimated that the time required for the passage of a ship of medium size through the entire length of the canal will be from 9½ to 10 hours, and for larger vessels from 10½ to 11 hours.

Excavation by the French.—The amount of material taken out by the old and new Panama Canal companies was 78,146,960 cubic yards, of which it is estimated 29,908,000 cubic yards will be utilized in the adopted plan of canal.

Total Amount of Excavation.—The following is the estimated excavation required May 4, 1904, based on the present plans for the lock canal:

	Prism	Diversions, etc.	Locks	Dams	Total
Atlantic Division....	40,355,636	1,732.882	5,139,304	....	47,227,822
Central Division....	100,551,296	1,250,000	....	....	101,801,296
Pacific Division.....	41,034,069	....	5,015,459	244,733	46.294,261
	181,941,001	2,982,982	10,154,763	244,733	195,323,379

Comparison Between Lock and Sea Level Projects.—For the purpose of comparison, it may be stated that an estimate has been made from the latest available data, which shows that the excavation required in the canal prism for a sea level canal as of May 4, 1904, would be 319,146,000 cubic yards.

This estimate is for a sea level canal from the —41-ft. contour in Limon Bay to the —45-ft. contour in the Bay of Panama; the channel in Colon Harbor from the seaward end to Boca Mindi to be 500 ft. wide on the bottom, and 41 ft. deep; from Boca Mindi to near the Sosa tide lock, 150 ft. wide on the bottom and 40 ft. deep in earth and 200 ft. wide on the bottom and 40 ft. deep in rock; approach to the tide lock to be 350 ft. wide and the channel from the tide lock to the —45-ft. contour in Panama Bay, 300 ft. wide. This plan includes a concrete dam at Gamboa and a twin tide lock at Sosa with chambers 110 ft. by 1,000 ft. The average width of channel in this project would be 218 ft. and the minimum width 150 ft.

Estimated Cost of Lock Canal Under Construction.—The cost estimated by the present commission for completing the canal is $325,201,000, which includes $20,053,000 for sanitation, and $7,382,000 for civil administration.

These figures do not include the $50,000,000 paid to the new French Canal Company and to the Republic of Panama for property and franchises. Hence, it is estimated that the total cost of the canal to the United States will approximate $375,000,000.

Time of Completion.—While the official date of opening of the Panama Canal has been set for January 1, 1915, it is the intention to allow vessels to utilize the canal just as soon as practicable. Present indications seem to bear out the opinion previously expressed by the chairman and chief engineer of the Isthmian Canal Commission that this can be accomplished during the latter half of 1913, although it is too far in advance at this time to fix any definite date. Shipping interests will, however, be advised as soon as the commission feels assured that vessels can be passed without unnecessary delay.

Material Excavated by the United States.—The amount of material excavated since the Americans took control on May 4, 1904, is as follows:

	Cubic yards.	Monthly average.
May 4 to December 31, 1904........	243,472	30,434
January 1 to December 31, 1905....	1,799,227	149,936
January 1 to December 31, 1906....	4,948,497	412,375
January 1 to December 31, 1907....	15,765,290	1,313,774
January 1 to December 31, 1908....	37,116,735	3,093,061
January 1 to December 31, 1909....	35,096,166	2,924,680
January 1 to December 31, 1910....	31,437,677	2,619,806
January 1 to December 31, 1911....	31,603,899	2,633,658

Year and Month	Atlantic Division		Central Division x	Pacific Division		Total
	Steam Shovels	Dredges	Steam Shovels	Steam Shovels	Dredges	
Total to Dec. 31-11	Cu. yds. 8,549,205	Cu. yds. 27,472,627	Cu. yds. 85,426.915	Cu. yds. 4,368,559	Cu. yds. 32,193,657	Cu. yds. 158,010,963
1912						
January	34,495	520,228	1,444,392	168,984	412,118	2,580,217
February	24,445	581,399	1,415,714	136,552	432,796	2,590.906
March	254	428,626	1,712,225	149,079	404.939	2,695,123
April	......	403,616	1,626,947	195,117	383,995	2,609,675
May	27,134	430,156	1,418,284	179,277	388,310	2,443.161
Grand Total	8,635,533	29.836,652	93,044.477	5,197,568	34,215.815	170,930,45

x Includes Culebra Cut—188,239 cubic yards were removed by sluicing.

Note.—Of the above total of 170,930,045 cubic yards excavated up to June 1, 1912, 30,608,933 cubic yards were excavated in the last twelve months.

		Cubic yards.
Estimated French excavation usable in present plan		29,908,000
Estimated amount of excavation required May 4, 1904, as shown on page 4..................		195,323,379
Total excavation required to complete canal under present plan		225,231,379
	Cubic yards.	
Amount taken out by French prior to May 4, 1904....................	29,908,000	
Amount taken out by Americans to June 1, 1912	170,930,045	
		200,838,045
Amount remaining to be excavated June 1, 1912..		24,393,334

Progress of Work on Locks and Dams.—It is estimated that about 2,000,000 cubic yards of concrete will be placed in Gatun locks and 225,000 cubic yards in Gatun spillway. For the construction of the Pedro Miguel lock about 890,750 cubic yards of concrete will be required; about 1,412,736 cubic yards of concrete will be placed in the Miraflores locks, dam and spillway.

Concrete in Locks, Dams and Spillway.

	Gatun Locks	Pedro Miguel Locks	Mira-flores Locks	Gatun Spillway	Mira-flores Dam
	Cu. yds.	Cu. yds.	Cu. yds.	Cu. yds.	Cu. yds
In place April 30th, 1912.	1,862,123	827,203	866,185	198,471	321
Work in May, 1912.	7,746	10.736	92,095	1,920	...
Total to June 1st, 1912.	1.869,869	837,939	958,280	200.391	321

Fill Placed in Dams.

	GATUN		Pedro Miguel Dry Fill	Mira-flores x Dry Fill
	Hydraulic Fill	Dry Fill		
	Cu. yds.	Cu. yds.	Cu yds.	Cu. yds.
In place April 30th, 1912.	10,158,826	9,641,673	545,355	1,172,634
Work in May, 1912.	194.733	227,017	21,782	31.220
Total to June 1st, 1912.	10,353,559	9,868,690	567,137	1,203,854

x 660,598 cubic yards of wet fill were placed in Miraflores dam up to June 1, 1912.

The figures given in the above table of fill in Gatum dam are in excess of the amount in place, determined from cross-section surveys, due principally to consolidation of material. Up to February, 1912, the surveys showed a difference of 757,068 cubic yards, and this amount should be deducted to obtain the net amount of material in place. An allowance of about 200,000 cubic yards should be made for future consolidation.

It is estimated that the net amount of material in the completed dam will be 22,100,000 cubic yards.

The construction of Gatun dam is being carried on by first building two lines of rock, composed of spoil from the canal and lock excavation, about 1,200 feet apart and parallel to the centre line of the dam. The south of upstream pile or "toe" as it is called, has a height of about 60 feet and the downstream toe about 30 feet. These rock toes confine the body of the dam between them, which is to be mainly of impervious material pumped in by pipeline dredges. At the bottom this impermeable core will have a width of about 860 feet outside of which the body of the dam will consist of spoil, which can be placed with the least expense. Outside of the toes are the waste piles for the spoil of neighboring excavation. These piles will slope down gradually and extend indefinitely, so far as material is available.

Unit Cost of Canal Work (Including Plant Arbitrary Charges).—The average cost of dry excavation in the central division (including the Culebra Cut) for the fiscal year ending June 30, 1911, was 58.80 cents for direct charges, and 4.57 cents for administrative and general expenses of the and general expenses of the Isthmian Canal Commission, making the total average cost 24.33 cents per cubic yard.

The average cost for dredging in the Atlantic end of the canal for the fiscal year ending June 30, 1911, was 22.15 cents for direct charges, and 2.18 cents for administrative and general expenses of the Isthmian Canal Commission, making the total average cost 24.33 cents per cubic yard.

The average cost of dredging in the Pacific end of the canal for the fiscal year ending June 30, 1911, was 25.19 cents for direct charges, and 2.45 cents for administrative and general expenses of the Isthmian Canal Commission, making the total average cost 27.64 cents per cubic yard.

Steam Shovel and Dredge Equipment.—There are now on the Isthmus 100 steam shovels of different capacities, and 18 dredges, the latter being classified as 7 ladder, 3 dipper, 6 pipe-line suction, and 2 sea-going suction dredges.

Force Employed.—In the month of March, 1912, there were approximately 45,000 employees on the Isthmus on the rolls of the commission and of the Panama Railroad Company, about 5,000 of whom were Americans. There were actually at work on April 24, 1912, 36,136 men, 29,354 for the commission, and 6,782 for the Panama Railroad Company. Of the 29,354 men working for the commission, 4,276 were on the gold roll, which comprises those paid in United States currency, and 25,078 were on the silver roll, which comprises those paid on the basis of Panama currency or its equivalent. Those on the gold roll include mechanics, skilled artisans of all classes, clerks and higher officials, most of whom are Americans; those on the silver roll include principally the common laborers, who are practically all foreigners. Of the 6,782 Panama Railroad employees, 831 were on the gold roll.

Finances of the Canal. Appropriations and Expenditures Down to April 30, 1912.

Receipts.

Appropriations by Congress—		
Purchase of canal rights, June 28, 1912		$ 40,000,000.00
Purchase of canal zone rights, Apr. 28, 1904		10,000,000.00
Construction of canal, June 28, 1902		10,000,000.00
Construction of canal, Dec. 21, 1905		11,000,000.00
Construction of canal, Feb. 27, 1905		5,990,786.00
Construction of canal, June 30, 1906		25,456,415.08
Construction of canal, March 4, 1907		27,161,367.50
Construction of canal, Feb. 15, 1908		12,178,900.00
Construction of canal, May 27, 1908		29,178,000.00
Construction of canal, March 4, 1909—		
Construction engineering and administration		5,458,000.00
Construction of canal, March 4, 1909		33,638,000.00
Construction of canal, Feb. 25, 1910—		
Civil administration		76,000.00
Construction of canal, June 25, 1910		37,855,000.00
Construction of canal, March 4, 1911		45,560,000.00
Expenses in the United States	$ 180,000.00	
Construction, engineering and administration	43,100,000.00	
Civil administration	680,000.00	
Sanitation and hospitals	1,600,000.00	
		$293,561,468.58
Armament and fortifications, March 4, 1911		3,000,000.00
Private acts for relief of individuals		5,460.18
Total credited by U.S. Treasury to April 30, 1912		$296,566,928.76
Miscellaneous—		
Water rentals, Panama and Colon		751,331.18
Value of French material used in construction or sold		1,198,725.70
Collections account sale of government property, etc.		5,586,426.77
Miscellaneous collections and collections account individuals and companies		335,938.69
Total receipts		$304,709,351.10

Disbursements.

Classified expenditures			$ 254,818,475.17
Department of Civil Administration		$ 5,577,318.30	
Department of Sanitation		14,547,085.02	
Department of Construction and Engineering		146,899,666.09	
Atlantic Div.	$ 42,382,833.95		
Central Div.	75,355,690.21		
Pacific Div.	29,161,141.93		
Fortifications		766,333.22	
General items		87,028,072.54	
Paid into U.S. Treasury account sale of government property, etc.			5,856,426.77
Services rendered and material sold to individuals and companies			4,167,762.42
Bills collectible, outstanding			485,506.88
Unclassified expenditures, including material and supplies			6,491,629.27
Total			$ 271,819,800.51
Less amounts included in above but unpaid on April 30, 1912			1,635,389.74
Net disbursements			$ 270,184,410.77
Balance available April 30, 1912			34,524,940.33
Congressional appropriations 34,524,940.33			
Total			$ 304,709,351.10

RAILROAD EARNINGS.

The gross earnings of the Canadian Pacific Railway for the past three fiscal years are as follows:—

July 1, 1911, to July 1, 1912	$122,856,000
July 1, 1910, to July 1, 1911	103,525,000
July 1, 1909, to July 1, 1910	94,490,000

The Grand Trunk May statement shows net profit, as follows: Grand Trunk proper, **increase** £500 sterlin[illegible] Atlantic, net profit decreased £3,250; Grand Trunk western, net profit increased £23,950; Grand Haven, net profit increased £1,650. The total net profit for the whole system increased £22,850.

The gross earnings of the Canadian Northern Railway for the twelve months ending June 30, 1912, were $19,538,600, as compared with $15,199,200 in the previous twelve months, a gain of $4,339,400.

The gross earnings of Toronto Railway for June were $444,598.91, as compared with $401,185.88 in the corresponding month last year, an increase last month of $43,413.03. In the past five years the street car receipts for the month of June have increased by $153,141.41, and the percentages paid to the city for June have increased by $45,201.17.

Traffic is increasing steadily on the Timiskaming and Northern Ontario Railway, although heavier operating charges keep net earnings from gaining much on last year's figures. The gross earnings for April amounted to $142,525, compared with $118,181 in May, 1911. Operating charges increased from $78,000 to $107,000, leaving a net revenue of $50,869. In April, 1911, the net for the month was $40,467. From the beginning of the financial year on November 1st to the end of April, net earnings amounted to $278,000, compared with $272,000 for the corresponding period last year. A considerable portion of the road's earning revenue this year is represented by ore royalties, the total being $71,900, compared with only $12,391 for the corresponding period of 1910-1911.

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

	1911.	1912.	Increase or decrease.
C.P.R.	$2,807,000	$3,293,000	+ $486,000
G.T.R.	1,629,178	1,552,647	— 76,531
C.N.R.	469,700	579,700	+ 110,000
T. & N.O.R.	32,048	33,423	+ 1,375
Halifax Electric	6,311	6,871	+ 560

IRRIGATION PROJECTS OF THE CANADIAN PACIFIC RAILWAY COMPANY IN ALBERTA.

By A. S. Dawson.*

Supplying moisture to desert and semi-arid lands by artificial means is no new thing in the enterprises of civilization, and has been practiced on one portion or another of the globe since the dawn of history.

It was practiced by the Egyptians, Arabians and Assyrians many centuries past; and history records that the flood waters of the Nile were used to irrigate its valleys many hundreds of years ago. The Romans operated vast systems, which are in use at the present time; and the Chinese are credited with having put water on their rice lands by artificial means several centuries before the Christian era.

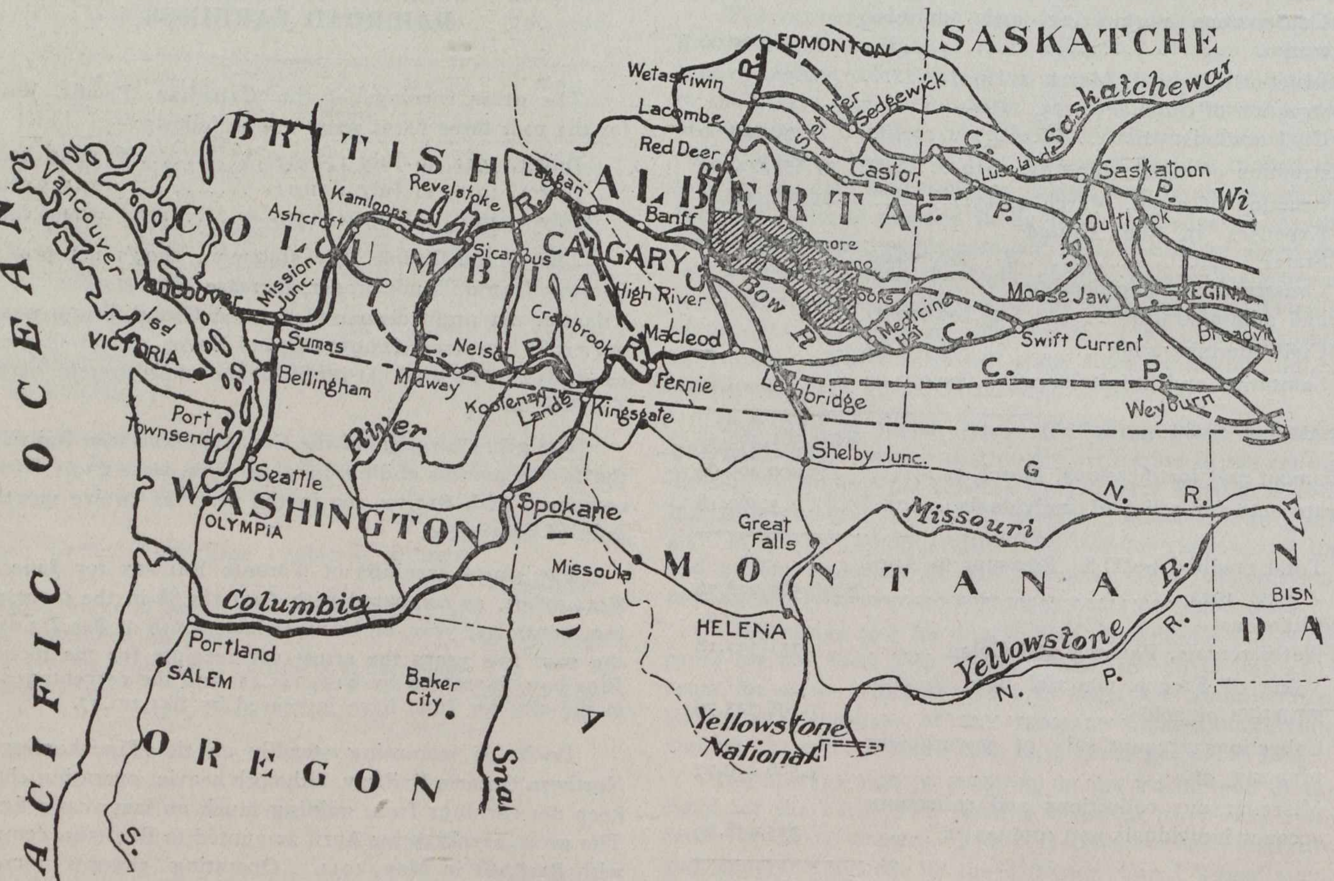
This ancient art had its origin in America in prehistoric times with the Pueblo Indians, who inhabited what are now portions of New Mexico and Arizona.

construction projects involving an expenditure of over $60,000,000; and has undertaken to complete 35 projects, to serve 3,200,000 acres of land, at an estimated cost of $145,000,000.

The extent to which irrigation is practiced to-day is ofttimes overlooked; amounting as it does to 53 million acres in the Indian Empire, 8 million acres in Egypt, 5 million in Italy, 3 million in Spain, 15 million in the United States, with smaller areas in China, Japan, Australia, France, South America, and elsewhere.

The works providing for the irrigation of these vast areas represent an investment of over one billion dollars; and produce annually crops valued at over that amount.

Irrigation in Southern Alberta may be said to date from 1892, when a series of dry years turned the attention of the settlers to the possibility of aiding the growth of their crops by the artificial application of water. The question subsequently assumed such importance as to warrant its being taken up by the government; with the result that well-considered and comprehensive laws relating to the use of water for irrigation were passed; a system of general surveys un-



Map Showing Location of the C.P.R. Irrigation Block. Area is Shown in Cross Hatching.

Mormons settling on the shores of Great Salt Lake were the first English-speaking people to make a systematic application of the principles of irrigation in Western America; and this was shortly followed by the use of ditches in California, originally constructed for placer mining. The results obtained therefrom soon induced settlers in the states of Idaho, Washington, Oregon and Wyoming to resort to similar means in the cultivation of their crops. This was followed by large private enterprises; and the passing in 1902 of the Reclamation Act by the government of the United States. This vast enterprise, under the direction of the Secretary of the Interior, has now either in operation or under

*Chief Engineer, Department of Natural Resources, Canadian Pacific Railway Co.

dertaken to determine the source and value of available supplies; and the location of the areas where such water could be used to best advantage.

These surveys showed that three extensive areas offered special advantages for irrigation; one containing some 250,000 acres, situated in the Lethbridge district, which could be supplied from the St. Mary's river; a second containing about 350,000 acres lying near the Junction of the Bow and Belly rivers, in townships 11 to 14 inclusive, ranges 11 to 16 inclusive; and a third, a much larger one, situated along the main line of the Canadian Pacific Railway, and extending about 150 miles east of the city of Calgary. It is interesting to note that the works to serve all of these tracts have either been built, or are now under construction.

It is the last mentioned project that this paper deals with specifically.

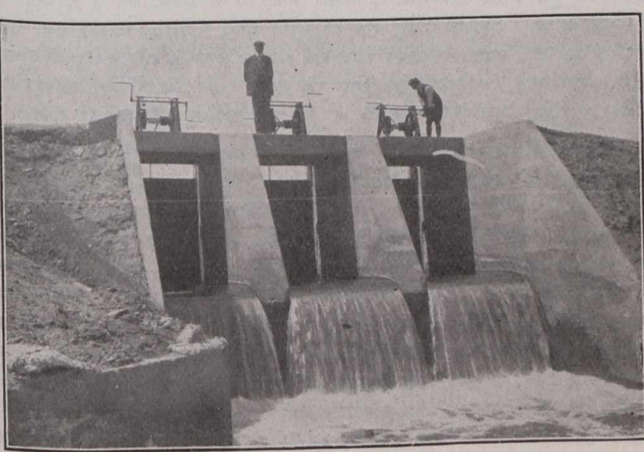
This tract of land eventually passed into the hands of the Canadian Pacific Railway Company, and is now known as the Bow Valley Irrigation Block. It was conceded that its development and colonization along proper lines would add materially to the selling prices of the land; would do away with the uncertainty of getting sufficient moisture for certain crops in certain years; would admit of intensive farming on smaller areas; and would result in settlers being attracted in greater numbers than could otherwise be expected; all of which are the basis of the revenue-producing value of any agriculture country as far as traffic receipts are concerned.

The Bow River heads, as you are aware, in the Bow Lakes on the eastern slope of the Rocky Mountains; and with its tributaries has a drainage area of about 3,800 square miles at Calgary, and about 5,100 square miles at Bassano. It generally reaches its highest stages between June 15th and August 15th of each year, and its lowest stages during January and February. Its maximum flood discharge at Calgary has probably been close to 100,000 second feet, although the hydrographic records for both extreme high and low water are rather meagre.

The Block is an open prairie plateau with a general elevation of about 3,350 ft. above sea level at its westerly limits, sloping gradually until a general elevation of about 2,300 is reached at its easterly boundary. Its topography is rolling, particularly in the western portion; whereas large areas of almost level plains are found in its easterly limits. The soil is good, consisting of a heavy black loam and clay subsoil in the westerly portions; and a lighter sandy loam of great depth overlying clay and hard pan in its easterly limits.

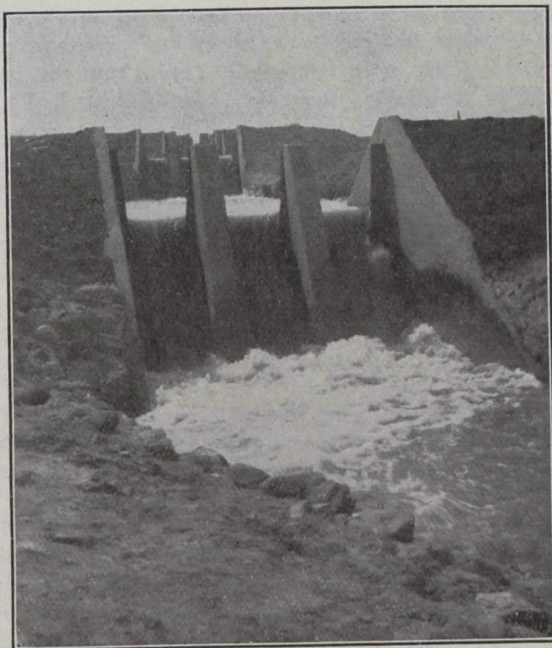
It is bounded on the west by the Fifth Meridian; on the south by the Bow River; on the east by the line between ranges 10 and 11, west of the Fourth Meridian; and on the north by the Red Deer River and the north boundary of township 28. Its length east and west is about 140 miles, and it has an average width north and south of about 40 miles. It is intersected by the main line of the railway company, and numerous other railway facilities are being provided in various directions. It contains an area of 4,840 square miles, or 3,097,580 acres.

The precipitation varies considerably from year to year, and decreases easterly as the altitude becomes lower. Meteorological records only exist subsequent to 1886, and are only applicable to the westerly portion of the Block. The average annual precipitation at Calgary between 1886 and 1910 was 15.15 inches; the minimum for the same period being 5.90 inches in 1889, and the maximum for that period 31.90 inches in 1902. The average for the irrigation period of five months, from May 1st to October 1st, covering the same years, was about 11 inches.



Combined Headgates and Drop. Secondary Canal System, Western Section.

This moisteure, however, is not always available when most needed; and it is a recognized fact that without irrigation certain crops cannot be raised to advantage; and that in any year the certainty of crop production with large yield can only be assured by artificial means.



String of 17 Concrete Drops. Secondary Canal System, Western Section.

Surveys in connection with the project were commenced by the railway company in 1903, and have been gradually extended in detail since that date. As you may understand, this represented a vast amount of work; as an irrigation project demands surveys and examinations far more complete than those for a railway line. Elevation is the controlling feature; and lateral extent or width of country is as important as length; and width, length and height have all to be considered.

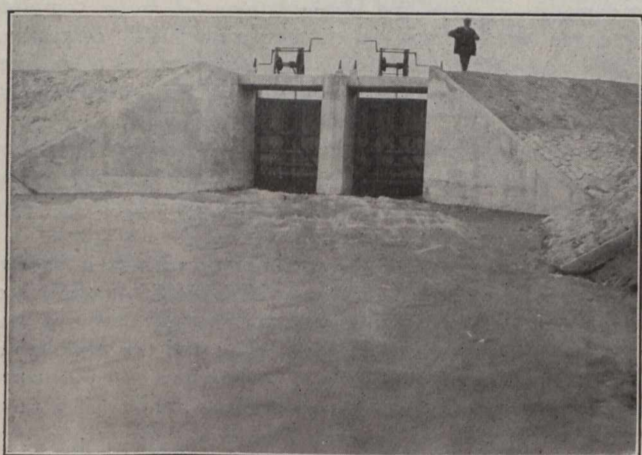
Accurate topographical surveys have been carried on by plane-table methods over practically the whole Block at an average cost of about ten cents per acre, on which the complete system has been projected.

On the completion of the preliminary surveys it became evident that the Block naturally divided itself into three sections, which were designated as the western, eastern and central, of about one million acres each; and the work is being carried on along the lines of development in the order named. The western and eastern sections are complete units in themselves, whereas the central section, owing to its general elevation, could only be served by an enlargement of a portion of the trunk lines in the western section.

Western Section.—The western section comprises an area of 1,039,620 acres, of which about 370,000 acres have been brought under ditch. Construction was commenced in 1903 and completed in 1910, and water was first used in 1907. Water for this section is diverted from the Bow River at a point near the present easterly limits of the city of Calgary. The head works are of timber, and are well protected by a pile and timber wall along the river bank, extending 350 feet above and 1,400 feet below the structure. Their sill elevation is 3,353, and they consist of 20 openings, three feet wide and ten feet high, subject to side and top contractions. The gates are of wood, of the straight lift type, and are operated by rack and pinion through a triple reduction gear with a power ratio of 100 to 1, arranged on a movable winch mounted on a travelling truck. It is the intention to replace this structure in the near future with permanent works; and at the same time to build a collapsible dam in the river which will admit of obtaining the full head of about ten feet required, during all stages of the river.

Main canal "A" heads at this structure, its capacity being 2,000 cubic feet per second at full supply of ten feet. Its section varies to suit conditions, its maximum section being 60 feet bed width, 120 feet at the water level, with 3 to 1 slopes, and a grade of .01 per cent. Throughout the greater portion of its length its dimensions are 44 feet bed width, 84 feet on the water line, with 2 to 1 slopes, and a grade of .02 per cent.; which, with an assumed value of $n = .025$ gives a calculated discharge of 2,050 cubic feet per second. At a point about 2½ miles below the headgates, this canal was crowded close to the river banks by heavy excavation, and at this point a set of escape or regulating gates was provided, with sill elevation one foot below canal grade. This structure is of timber, and consists of four openings 6 ft. by 11 ft. each controlled by wooden gates. These are known as balanced pressure gates, and are so designed that they will rise of their own accord when the head against them is about 5 feet. Each consists of a rectangular barrier working freely between parallel walls without guides. Each gate is hinged to four long arms arranged in pairs, the location of the hinges being so chosen that the weight of the gate is balanced by any required pressure. They are made practically watertight by rubber flashings, and are lifted by an ordinary chain windlass provided with pawl and brake.

At a point about 15 miles below the headgates, the main canal makes a vertical drop of ten feet, where an important timber structure was built. The excessive velocity resulting from this drop was taken care of by the contraction of the opening above to 25 feet, and by a water cushion 5 feet deep below, with an enlargement of the opening to 43 feet terminating in wings. Piling was extensively used in this and all



Spillway, East Branch Secondary Canal "C," Western Section.

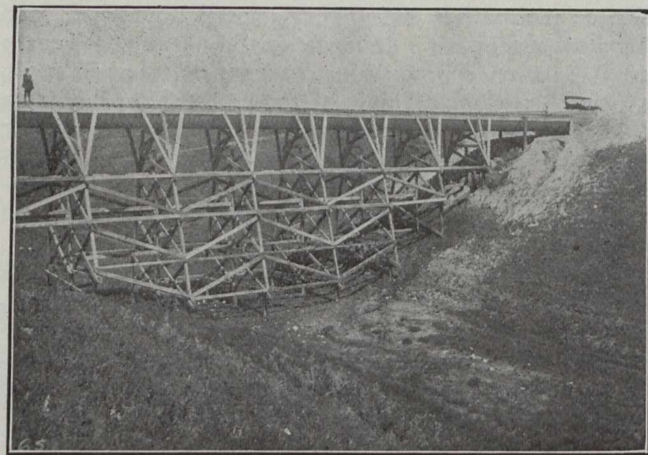
other important structures built in the early stages of the project.

About two miles beyond this point, or 17 miles from the headgates, this canal terminates in reservoir No. 1, which, however, is in reality only a balancing pool with slight storage for sudden drafts of water; thus relieving the secondary canals from small fluctuations in head. The reservoir referred to, which is about three miles long and half a mile wide, was formed by the building of an earth dam 2,000 feet long, with a maximum height of 30 feet, faced with heavy rip-rap on the water side.

From this reservoir the water is taken out in three secondary canals, known as "A," "B" and "C," having a combined length of about 250 miles. These are each controlled by timber headgates with sill elevation of 3,321.50, and are of a type similar to those described in connection with the main canal spillway.

Numerous large structures are located on all of the secondary canals, including headgates, drops, flumes and bridges.

Secondary canal "A" heads out from the south end of reservoir No. 1, and secondary canal "B" and "C" together are taken out at the north end. Secondary canal "A" at its



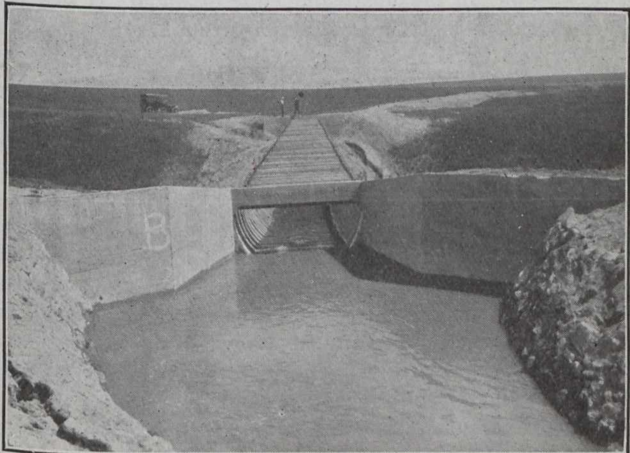
Metal Flume, 7 ft. dia. Secondary Canal System, Western Section.

outlet is 18 feet bed width, carrying 8 feet of water, with 2 to 1 slopes, on a grade of .03 per cent.

It drops twice to cross the railway line; and about 15 miles from its head again drops about 30 feet and expands into what is known as reservoir No. 2; at which point its section was changed on account of grade to 22 feet bed width, carrying 6 feet of water, with 2 to 1 slopes, on a grade of .035 per cent. About 30 miles beyond, near Strathmore, it again drops and crosses the railway line, splitting into a north and south branch. North "A" is 10 feet bed width, carrying 3.2 feet of water, with 1 to 1 slopes, on a grade of .06 per cent. South "A" is 18 feet bed width, carrying 4½ feet of water, with 2 to 1 slopes, on a grade of .04 per cent. Both continue easterly to the vicinity of Gleichen, covering lands to the Crowfoot Creek at an elevation of about 2,970.

Secondary canals "B" and "C" together utilize a natural channel for three miles from the north end of reservoir No. 1, and there divide, "B" turning easterly and "C" northerly. "B" is 28 feet bed width, carrying 6 feet of water, with 2 to 1 slopes, on a grade of .025 per cent., continuing for four miles to split gates dividing it into a north and south branch. "C" is 40 feet bed width, carrying 6.4 feet of water, with 1½ to 1 slopes, on a grade of .03 per cent., and serves all the land lying between the Rosebud River and the Serviceberry Creek. At a point about eight miles from its upper end it splits into an east branch—which is 37 feet bed width, carrying 5 feet of water, with 1½ to 1 slopes, on a grade of .035 per cent.—and a west branch, which is 12½ feet bed width, carrying 5.7 feet of water, with 1½ to 1 slopes, on a grade of .04 per cent. The east branch utilizes about ten miles of natural channel, in which 175 feet of grade is disposed of. The west branch crosses the valley of the Crowfoot Creek by a wood stave pipe siphon of 53 inches internal diameter and 1,600 feet long, working under a maximum head of 82 feet, in which 8 feet of grade is used up.

Exclusive of the main canal, secondary canal "B" north branch is the most important waterway in the western section, as it is intended ultimately to be used for the main supply channel to the central section of the Block. After leaving the junction of its north and south branches, it follows a natural channel for about 16 miles, this channel being straightened in places by artificial cut-offs. In this distance



Metal Flume, 7 ft. dia. Secondary Canal System, Western Section.

it falls about 250 feet, the elevation of the split gates being 3,284 and of the headgates at the lower end of the natural channel, known as Weed Creek, being 3,031. At the dam on this channel the canal heads out 18 feet bed width, carrying 4½ feet of water, with 2 to 1 slopes, on a grade of .045 per cent., and extends a distance of 14 miles to a summit with an elevation of 2,998. Before crossing this summit one branch is taken off to serve lands in the vicinity of the south branch of the Crowfoot Creek. After crossing the summit it again splits; the main branch continuing on the north side of an elevated ridge until Summit Lake is reached, which is the controlling point for the central section of the Block, and where a broad low valley of about elevation 2,884 will be crossed by a siphon.

From the secondary canals the water is again taken out, and distributed through a comprehensive system of distributing ditches, which bring it to each parcel of land to be served.

In the western section of the Block the following mileage of canals has been constructed:—

	Miles.
Main canal	17
Secondary canals	254
Distributing ditches	1,329
Total	1,600

and in addition to the above there are several hundred miles of small ditches constructed by the farmers.

The structures, consisting of headgates, spillways, drops, flumes, bridges, etc., are numbered in thousands; and in their construction 10 million feet board measure of timber, and over four thousand cubic yards of reinforced concrete were used.

In constructing the system in the western section over 10 million cubic yards of material was excavated. Practically all the work was carried out under contract at prices ranging from 12½ cents to 43 cents per cubic yard; the latter price including overhaul on the heavy work. The average price was about 17½ cents per yard. The cost of timber work in place has been slightly over $55 per thousand feet; and of reinforced concrete about $23 per cubic yard; both figures including all material used as well as excavation, trenching, and backfilling.

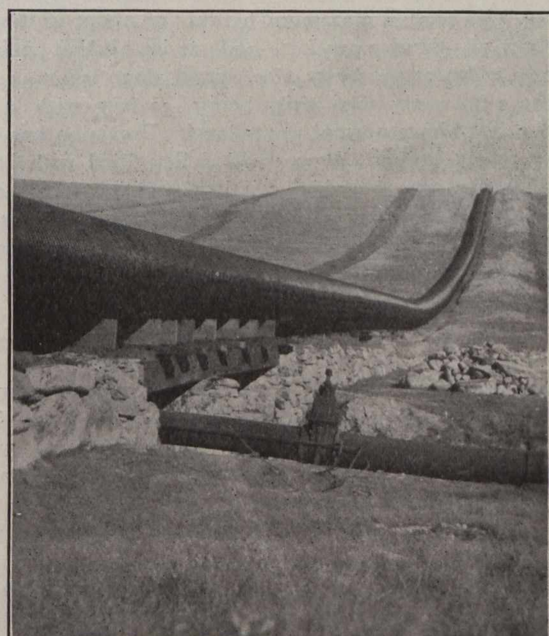
Central Section.—This section contains 901,740 acres, and it was at first contemplated to irrigate about one quarter of this area. Detailed surveys, however, showed that the cost of serving such an area would be excessive, and at present it is not contemplated to serve more than about 75,000 acres of this section, with an elevation at its westerly boundary of about 2,940.

As previously intimated, this section could only be reached through an enlargement of a portion of the trunk system already constructed to serve the western section of the Block; and due consideration has been given this matter wherever possible by spreading double banks far enough apart to admit of carrying the additional amount of water which will be required.

Up to date the construction of this portion of the system has not been started.

Eastern Section.—The eastern section of the Block contains 1,156,220 acres, of which 440,000 acres are to be rendered irrigable. Most of the land is of a gently rolling character and susceptible to good drainage. The soil for the most part is a rich sandy loam overlying hard pan and shale at various depths.

The idea of the peculiar topographical conditions existing in this section is necessary before the scheme as worked out can be understood. The main watershed of the country between the Bow and the Red Deer River starts, as far as this section of the Block is concerned, at a point on the Bow river locally known as the Horseshoe Bend, about three miles south-west of Bassano, a station on the main line of the Canadian Pacific Railway 83 miles east from Calgary.



Wood Stave Pipe Syphon, 53 in. dia., 1,800 feet long. Western Section.

It parallels the river for a few miles to near the south-east corner of township 18, range 17, west Fourth Meridian, from which point it runs almost due east to a point three miles south-east of Brooks station, thence north-easterly to Tide Lake in township 19, range 11. At the Horseshoe Bend the ridge is cut across by a wide valley, which apparently is an old river channel, the summit of which is only 95 feet above the river bed and about 600 feet from the same. A stream known as the Mat-zi-win Creek has its source in the valley above referred to; and this is the natural boundary between the lands served by the two main branches of the system.

This project as outlined from the surveys takes advantage of a low pass in the watershed referred to, to take water from the Bow River by an intake located at the Horseshoe Bend. A dam is being built across the river at this point, which performs two functions. First, it will raise the water level at the intake, thus enabling the system to command a much larger area of land than it otherwise would have done; and secondly, it reduces the quantity of material to be removed from the main canal heading at the dam. At this point the ordinary low water level elevation is 2,515. The elevation of the canal headgates will be 2,549.6, and normal depth of water in the pool will be 11 feet higher, or 2,560.6. The dam is to be a composite structure, consisting of a long and high earthen embankment on the west bank of the river, and a reinforced concrete spillway in the existing river channel, connected at its easterly end with the canal headgates. Just above the site of the dam the river makes a long bend in the shape of a horseshoe, which gives the locality its name, the dam being located at its toe. At this point the river is approximately 600 feet wide, its north or left bank having a narrow bench immediately at the water's edge and only a few feet above it, beyond which is a cut bank rising over one hundred feet above the bed of the stream. The west or right bank has a gravel beach rising gradually until it forms a tongue between the two legs of the horseshoe. This tongue has a broad flat top several hundred feet in width and rising gradually to the general prairie level, its general elevation near the river being about 25 feet above the bed of the stream.

On this tongue an earth dam is now under construction, to which the spillway structure will be joined. This embankment will have a maximum height of about 45 feet, a total length of about 7,000 feet, and at its highest point is 310 feet in width at the base. Its wetted slope is 4 to 1, and dry slope 3 to 1, the top width being 32 feet, with a free board of 9 feet above normal water level. Provision has been made for under-drainage by a wooden box filled with boulders and gravel with suitable offtakes, and its upper slope will be paved with concrete slabs. It will contain about one million cubic yards, which material is being transported from the excavation from the main canal across the river over a double track timber trestle. The foundations of this dam consist of a deposit of river silt overlying coarse gravel and boulders, which in turn overlie dense blue clay.

The spillway referred to is designed to pass over its crest 100,000 second feet without raising the surface of the pool above elevation 2563.6, or 14 feet over the crest, which required a free length of weir of about 600 feet. To allow for end contraction on account of the piers necessary to support the movable crest, a clear length of 650 feet between piers was decided on.

As the crest of the dam and the sills of the canal headgates were fixed at elevation 2549.6, the additional depth of 11 feet for which the canal was designed, had to be maintained by some form of movable crest for the entire length of the spillway in order to pass extreme floods. This movable crest will be divided into 24 sections, and supported between piers giving 27 feet clear spans, and these openings will be regulated by structural steel gates, of the well-known "Stoney" type. In the determination of the spacing of the buttresses due consideration was given to the effect upon cost of construction, the time required to build the structure, and to the limitation in length of the gates corresponding to the spacing of the buttresses; with the result that these are to be at 15 centres, with every second buttress carried up in the form of a bridge pier. Emergency gates will also be provided in case of necessary repairs having to be made to the main gates.

The spillway proper is a reinforced concrete structure of the so-called "Ambursen" type, consisting of a heavy floor built upon the bed of the stream, and upon this floor are erected parallel buttresses of substantially triangular outline, having a slope on the upstream edge of about 45 degrees. Upon brackets or haunches projecting from the faces of the buttresses and parallel to the upstream edges, is built a concrete slab forming a deck, terminating at the top of the buttresses in a curved crest, and passing down over the downstream edge of the buttresses in the form of an apron suitably curved to correspond as nearly as possible to the path of the overfall flood waters. In front of the dam the floor is being carried downstream a distance of about 75 feet, forming a tumbling hearth. In general, the cross section of the spillway is what is known as the Ogee section, and consists of constructing the downstream face of the dam between the crest and the floor in the form of a reverse curve; the lower edge of this curve being tangential to the floor of the structure, so that the overfalling nappe shall be let down the face of the dam and turned into a horizontal direction parallel to the river bed with the least possible disturbance.

The spillway is founded on a deposit of sand, gravel and boulders, overlying a thick stratum of stiff blue clay.

At the upper and downstream edges of the structure heavy cut-off walls are carried well down into the clay and bonded to the body of the carpet. A concrete apron extends about 12 feet above the upper cut-off wall, and boulder concrete will be placed in the river bed for some distance below the tumbling hearth.

The structure is to be 720 feet in length between abutments, with a maximum height of 40 feet to the overflow crest, above which 11 feet of water will be retained by the gates above referred to. It will contain about 40,000 cubic yards of concrete, and 2½ million pounds of reinforcing steel.

(To be continued.)

BONUS FOR THE PRODUCTION OF QUICKSILVER.

The Mines Department of New Zealand has recently sent out a notice regarding a bonus for the production of quicksilver. We are indebted to Mr. Egerton R. Case, patent attorney, Temple Building, Toronto, for furnishing us with a copy.

Notice is given that a bonus of fourpence (8 cents) per pound will be paid on the production of the first one hundred thousand pounds weight (100,000 lb.) of good marketable retorted quicksilver, free from all impurities, from any mine in New Zealand, on the following conditions:—

That at least one-third of the quantity is produced on or before the 31st March, 1914, and the remaining two-thirds on or before the 31st March, 1915.

No bonus will be payable until the whole of the one hundred thousand pounds (100,000 lb.) of quicksilver has been produced as stipulated to the satisfaction of an officer to be appointed by the Minister of Mines, and on whose certificate alone the bonus will be paid.

In the event of more than one person producing the required quantities of quicksilver before the dates named, inquiry will be made by the officer above referred to, when, if it is found that each applicant is equally entitled to a bonus, the amount will be divided in proportion to the quantities produced by each applicant, but in no case shall any bonus be paid until at least one hundred thousand pounds (100,000 lb.) of quicksilver has been produced in the aggregate.

ORIGINALITY IN BRIDGE DESIGN.

H. G. Tyrrell, Evanston, Ill.

While writing my latest book, entitled "Artistic Bridge Design," which is now in press, my attention has been called to the general lack of originality in the designs prepared by American engineers. In our haste we seem as a nation of engineers to have followed a few accepted types, favored by the various bridge building companies, as the most easily made and usually the cheapest. While it is a fact that America has many of the world's finest bridges, a greater amount of originality can often be found in foreign works, such as the Sukkur and Connel Ferry cantilevers, the Blaauw Krantz, Assopos and Nami-Ti Gorge - arches, and many works (Fig. 2) of the earlier engineers such as George and Robert Stephenson. Even in concrete bridges, we find that as early as 1840 European engineers were experimenting with surface treatment when one with a span of nearly 40

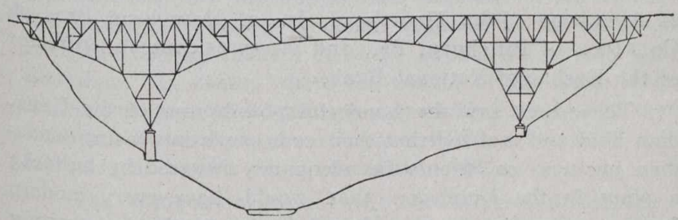


Fig. 1.

feet was built in France by the eminent engineer LeBrun.

It is, therefore, a pleasure on new American works to see the old stereotyped forms laid aside, and plans made with their parts evidently arranged to fulfil their purpose and duties, and not simply copies of some former ones. For this reason the new arch bridge over St. Croix River on the Minneapolis, St. Paul and Sault Ste. Marie Railway (Eng. News, Dec. 28, 1912) is to be commended, not that it is necessarily the cheapest or most appropriate type for the place, but that the designer had the courage to depart from accepted practice by building a series of arches with large rise, instead of a trestle or deck lattice bridge on high piers. In lower outline the bridge is somewhat similar to the central span of a cantilever with an opening of 750 feet, and deck 370 feet above water (Fig. 1) which was designed by the writer in 1906. In these designs, instead of supporting the framing in the usual way on high piers, the chords are

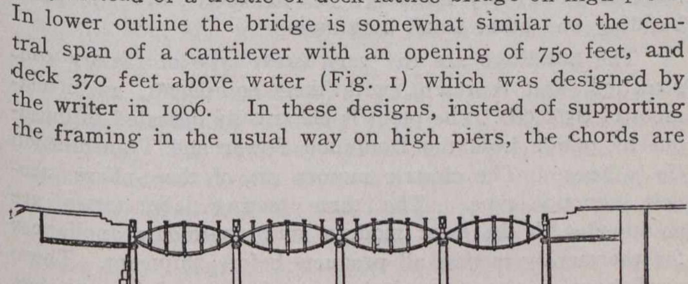


Fig. 2.

curved down to deliver their reactions on comparatively low blocks of masonry. It is gratifying to find that there are many other evidences of improved bridge design in America, where parts are proportioned not only to perform their duties in the most logical manner, but at the same time, to be artistically worthy of preserving and in keeping with other public works of a great nation. Progress in this direction is due chiefly to the leadership of such prominent engineers as Gustav Lindenthal, Chas. C. Schneider, A. P. Boller, Theodore Cooper, and others, and to the eminent architects who have been associated with them in their work, such as Thomas Hastings, Whitney Warren, Palmer & Hornbostle, and Paul Pelz.

OUTLOOK FOR BRITISH COLUMBIA'S MINES

The British manufacturers in their visit to the coast have seen for themselves the possibilities for commercial and industrial enterprises there.

Apart from the interest thus awakened in Great Britain, from where much money comes for development purposes in Canada, the attention of business men in other countries will be attracted. Capital has come to the West from France, Germany and Belgium, and when it is seen that Britain is alive, these other countries will be alert to opportunities. Present trade conditions are in favor of greater commercial relations with western Europe, with the round-the-world steamship lines that have been established in recent years, and in the expansion of commerce that is confidently looked for within the next few years many countries will participate. It was gratifying to note the strong feeling of imperialism in the speeches at the banquet here, indicating that in fututre trade Britain will have the preference. These manufacturers have come, after trips that have been made by several special representatives, press and otherwise, who reported on conditions, and now the principals themselves will be able to judge first hand just what is in Canada and what the possibilities of the future are.

In this letter a couple of weeks ago, mention was made of the prosperous condition of the lumber industry. Note may be made also of the activity in mining. News from the interior is encouraging, and the outlook is better for the operation of metalliferous properties. Prices of silver and lead are very favorable, one of the reasons being the trouble in Mexico, which has interfered with the supply from that country. Higher prices mean better conditions for the low grade properties in the interior of British Columbia, in the Slocan and Boundary, mine owners are very sanguine. Lead has gone up so that the bounty granted by the Dominion has been withdrawn for the time being, and operations are more extensive in the southeastern part of the province.

The Lucky Jim Company has been re-organized and this mine will be shipping as soon as the Canadian Pacific Railway branch line has been extended to the property. Mr. T. G. Proctor, of Nelson, has been successful in interesting capital in the Lucky Jim and the directors now include Premier Roblin, of Manitoba; Hon. G. R. Coldwell, minister of education; Hon. J. H. Armstrong, attorney-general; Hon. Hugh Armstrong, minister of finance, all of Winnipeg; Mr. Joseph Morris, Edmonton; Mr. S. Montgomery, St. Paul, and Col. G. Weaver Loper, Spokane. Mr. A. G. Larson, Vancouver, has been appointed consulting engineer for the company. This is the only one of the fine properties in the Slocan, another being the Standard, which is being developed by Spokane people, and is a money maker.

The British Columbia Copper Company is again among the dividend payers, the latest dividend of three per cent. being an increase of one half per cent. over the dividend of June, 1911. This company is operating full capacity, production running over a million pounds per month, with estimated earnings of about $60,000 per month. The British Columbia Copper Company has an option on the Voight property, comprising several claims near Princeton. Developments there have been highly satisfactory, in the vicinity of Princeton, are many properties and development on a large scale in that district will do much in attracting capital.

The Nickel Plate owners have bonded an adjoining group for $150,000, and an American company, controlled by Mr. C. H. Brooks, has taken over the Kingston group. It has been the wonder of those who know the mineral resources of the Similkameen, why some of the properties with excellent showings have not been taken up by men with capital. The Nickel Plate is in the midst of a number of fine claims, and its earnings show what money is to be made. The Nickel Plate is now paying dividends of twenty-five per cent. per annum, and another quarterly dividend of five per cent. has just been declared. Their plan is to declare three quarterly dividends of five per cent. and a fourth of ten per cent. This company now has an output of about 6,000 tons a month of gold ore, which runs about $12 to the ton.

Reports such as these indicate activity in mining that will result in considerable progress. Metalliferous mining will be the great backbone of prosperity in British Columbia, and while it is coming to the front perhaps only gradually its advancement is substantial.

CANADA'S NEW INDUSTRY.

A substantial addition to the industrial life of Canada has just been consummated by the entrance into the field of the Standard Underground Cable Company of Canada, Limited. The large new plant of this company at Hamilton, Ont., has begun operating several of its various departments and others, we understand, will be started as rapidly as possible.

It will be of interest to our readers to know something of the history of this newcomer into Canadian industrial life. It is not strictly correct to speak of this company as a "newcomer" because its associate American Company has been selling to the Canadian trade for many years, its wires, cables and cable accessories, being well represented on many important electrical installations in the Dominion. Tracing back the new company's lineage through its associated company, we find the latter to have been the pioneer on this continent in making electric cables for underground service. Being the pathfinder, it has always blazed its own trail and has the enviable reputation of having hewn its marks high so that those who follow in its footsteps had to look up, as well as ahead, in their efforts to maintain the progressive pace.

The parent company began the manufacture of lead covered cables and transmission of electricity about 1882 in Pittsburg, Pa. It originated and developed many of the types of cables and manufacturing processes in use to-day and was for years the only manufacturer of such materials in the United States. From the small plant in Pittsburg the company widened the scope of its business and increased its lines of products until now, in addition to the plant at Pittsburg, enlarged from time to time, it has a large aggregate of plants at Perth Amboy, N.J., and Oakland, Cal., a total floor space of over 12 acres. The products that come from these various plants include electric wires and cables of all kinds, for street railway, light and power, signal, telephone, telegraph, fire alarm, and any other service involving transmission of electric current by underground, aerial or submarine circuits. These products also include cable accessories such as terminals and junction boxes, insulating materials, cable splicing tubes, hangers, etc.

It will be seen that while the company's name carries the implication that it is concerned chiefly with the manufacture of "underground cable" yet, as a matter of fact, its products include almost every kind of conductor known to the electrical industry. Indeed, in range of products and in the aggregate value of gross business, this company exceeds any exclusively electric wire and cable manufacturer on the American continent and probably in the world.

A glance at the men who have built up this flourishing business and also who were instrumental in transferring part of its activities into Canadian channels will be of great interest, as they include many of the most noted American financiers and business men, connected, unless otherwise stated, with the following Pittsburg institutions:

President J. W. Marsh is also president of the Exchange National Bank, one of the oldest financial institutions of Pittsburg. His keen unerring business judgment was signally recognized when he was made chairman of Merchandise Creditors' Committee and that some years ago cooperated most effectively in reorganizing the Westinghouse Electric and Manufacturing Co., of which company, as also of the Colonial Steel Co., he is now a director and Executive Committee member. William Conner, vice-president and manufacturer, also vice-president of the Perth Amboy Trust Co., Perth Amboy, N.J.; Frank A. Rinehart, secretary and treasurer; Albert H. Childs, capitalist and director of the Exchange National Bank; L. W. Dalzell, capitalist and director of the Exchange National Bank; Joseph Wood, first vice-president of the Pennsylvania Lines west of Pittsburg; B. F. Jones, Jr., president of the Jones & Laughlin Steel Co.; J. N. Davidson, president of the Second National Bank of Allegheny; John Moorehead, Jr., of Moorehead Bros. & Co., Inc., of Pittsburg, Pa., and vice-president and director of the Exchange National Bank.

These men saw the wonderful possibilities of the Canadian field and realized that their company's increasing Canadian business could only be adequately fostered by building a plant in the Dominion that would have every modern facility possessed by the United States plants for turning out high quality products and in sufficient volume to keep pace for many years with the increasing demand resulting from the rapid electrical development of Canada. Naturally the choice of location fell upon Hamilton, Ont., the "Electrical City," and there the new plant was erected on a tract of land fronting 400 feet on Sherman Avenue and extending 600 feet along the T. H. & B. Railroad, a location which has every advantage in the way of manufacturing and shipping.

The buildings erected so far include: One three-story brick and structural iron building, 64 x 335 feet; one one-story saw tooth building, 60 x 224 feet; one one-story saw tooth building, 60 x 250 feet; one one-story building, 64 x 90 feet; one one-story building, 30 x 70 feet; also an office building and other small buildings.

The buildings are the very latest type of factory construction, and represent, with their equipment, an investment of $500,000. The plant is electrically operated throughout by power from the Dominion Power and Transmission Co.'s lines. The electric motors are of three-phase, 220-volt induction type. The three testing laboratories are equipped with the most modern and up-to-date appliances for thoroughly testing all products before shipment. These appliances consist of regulating transformers giving voltages as high as 60,000 volts, Wheatstone bridges, D'Arsonval galvanometers, Fisher testing sets, etc., for determining insulation resistances, capacity, conductivity, locating grounds, leaks, crosses or other faults in cables.

True to their policy of employing, so far as practicable, Canadian skill in this Canadian venture, the company employed, in the main, Canadian contractors to erect the new buildings and the Hamilton Bridge Works Co., Limited, supplied the structural iron. The sub-contractors and workmen were all Canadians. The architects were Prack & Berrine, factory experts of Pittsburg and Hamilton.

The officers of the Standard Underground Cable Co., of Canada, Limited, are: President, J. W. Marsh; vice-president and manufacturer, W. A. Conner; vice-president and general sales manager, P. H. W. Smith; secretary and sales manager, W. H. Marsh; treasurer, F. A. Rinehart; assistant to sales manager, H. G. Burd.

BIG BRITISH ENGINEERING ENTERPRISE IN CANADA.

Further details of the Canadian British Engineering Company, Limited, are available. The company's share capital is £205,000 divided into 200,000 7 per cent. preferred ordinary shares of £1 each and 100,000 deferred ordinary shares of one shilling each. The company have made a public flotation of 100,000 of the preferred ordinary shares. Every subscriber when applying for preferred ordinary shares is entitled to subscribe for at par and be allotted one deferred ordinary share for every five preferred ordinary shares allotted to him. The deferred ordinary shares are payable in full on application.

This company has been formed to carry on the business of an engineering supplies and construction company in Canada. It will establish branches in the principal centres in the Dominion, where stocks of standard appliances, spare parts, etc., will be carried. The company will carry out contracts for the supply and erection of all clases of machinery, purchasing the plant required as far as possible from the leading makers of such appliances in the United Kingdom. In cases, where the nature of the work is such that it can be more advantageously carried out by the manufacturers themselves, the company will act for such manufacturers as agents on a commission basis.

The company's capital will be utilized principally in carrying stocks of standard machinery and engineering appliances and in executing contracts for the construction and equipment of engineering works. The directors anticipate that the profits on this portion of the business will be sufficient to provide for a substantial dividend on the whole of the subscribed capital, in which case all profits accruing from the various agency or commision agreements, for which little or no capital is required, will be applicable for surplus dividends on both classes of shares.

The company will have a London office or buying house, through which all communications and negotiations with manufacturers will pass. The London staff will purchase all machinery and appliances required by the company for the fulfilment of its contracts, will inspect plant in course of construction, and generally take the necessary steps to ensure that all such orders receive proper attention.

Sole agency agreements have been obtained by the company from the following firms:—Sir W. G. Armstrong Whitworth and Company, Limited, hydraulic and electric cranes and conveyors, dock and harbor equipments, etc.; Ashmore, Benson, Pease and Company, Limited, gas works plant, etc.; Cammell Laird and Company, Limited, high grade steels, railway and tramway tires and axles, springs, etc.; Dorman Long and Company, Limited, steel beams, angles and channels, etc.; Galloways Limited, pumping plant, mill engines, blowing engines, rolling mill engines, large gas engines and boilers; Power Gas Corporation Limited, Mond gas producers for power and furnace heating and by-product recovery plants; Ransomes, Sims and Jefferies, Limited, agricultural machinery; Sandycroft Foundry Company, Limited, mining plant equipments; and Willans and Robinson, Limited, steam turbines Diesel oil engines and condensing plant.

The directors of the company are as follows:—C. Leonard Agnew, Northwich; W. H. Patchell, M. Inst. C.E., M.I. Mech. E., M.I.E.E., London; Leonard Andrews, M. Inst.C.E., M.I.E.E., London, managing director in Great Britain; William A. Martin, Toronto, managing director in Canada; local board in Canada: William A. Martin, Toronto; Ernest M. Sellon, M.I.E.E., Montreal; Charles Ruttan, Winnipeg; Nicol Thompson, Vancouver.

PULPWOOD CONSUMPTION IN CANADA.

The quantity of pulpwood manufactured in Canada in 1911 showed an increase of 73,801 cords (or 12.3 per cent.) over 1910. In 1911, 672,288 cords were manufactured, as compared with 598,487 cords in the previous year. The value of the wood also increased, with the result that the 1911 product brought to its vendors $4,338,024, as compared with $3,585,154 for 1910, an increase of $752,870. The value of the wood ($6.45 per cord) was greater than it had been for years.

Of the total amount, Quebec consumed in its 28 mills 58 per cent. Ontario used nearly one-third of the total consumption; this province has the highest consumption per mill of any, viz., 12,450 cords. New Brunswick mills were hampered by low water during the year. The consumption of pulpwood in these four mills was 45,824—over twice as much as in the depression of the previous year. Nova Scotia, where only mechanical process of pulp-making is used, in its seven mills consumed 22,221 cords of pulpwood. In British Columbia pulpwood manufacture was still in the experimental stage.

Quebec used four species of wood for pulp, namely, spruce, balsam fir (or balsam), hemlock and poplar. Ontario and Nova Scotia employed spruce, balsam fir and poplar, while New Brunswick used spruce and balsam fir only.

PERSONAL.

MR. MALCOLM R. BOW, of Regina, has resigned his position as assistant bacteriologist for the province of Saskatchewan.

MR. F. A. GOBY, B.A.Sc., has been appointed chief engineer of the Ontario Hydro-electric Power Commission to succeed Mr. P. W. Sothmann, who has just resigned.

MR. J. CHISHOLM has been appointed master of bridges and buildings on the Ottawa division of the Grand Trunk Railway, in place of Mr. J. H. Johnston, promoted.

MR. ALAN FRASER, B.A.Sc., has been appointed to fill the vacancy on the staff of Mr. R. A. Baldwin, district engineer, Mackenzie and Mann, 23 Victoria Street, Toronto.

MAJOR J. E. HUTCHESON, superintendent of the Ottawa Electric Railway since its construction, nearly 21 years ago, has accepted the general managership of the Montreal Tramways Company.

MR. CHARLES WILLIAM DILL, formerly of Toronto, and a member of the firm of contractors, Chambers, Dill and Russell, has been appointed a member of the Board of Highway Commissioners of Saskatchewan.

MR. P. W. SOTHMANN, for six years chief engineer of the Hydro-electric Commission, has resigned and will sever his connection with the Commission on September 1st. Mr. Sothmann is going into private practice. He will organize a firm of consulting engineers under his own name and establish headquarters in Toronto.

MR. JOHN T. DICKERSON, Associate Member American Society of Civil Engineers, has been appointed sales engineer of the Strauss Bascule Bridge Company, in charge of the eastern territory, with headquarters in New York city, succeeding Mr. G. C. Bartram, who has resigned. Mr. Dickerson has been associated with the Scherzer Rolling Lift Bridge Company in their engineering and sales department for the past seven years, prior to which time he was engaged in engineering work for the Burlington, Rock Island and other railroads. Mr. Dickerson is a graduate of the Rose Polytechnic Institute.

OBITUARY.

MR. FRANK T. CONLON, son of Mr. Thomas Conlon, of St. Catharines, Ontario, passed away on July 10th, after a long illness. Mr. Conlon was a graduate of the Faculty of Applied Science and Engineering of the University of Toronto in the class of 1902. For some time he had been employed on the engineering staff of the Welland Canal.

COMING MEETINGS.

THE WESTERN CANADA IRRIGATION ASSOCIATION.—Sixth Annual Convention Kelowna, Okanagan Valley, B.C., August 13, 14, 15 and 16, 1912. Secretary, Normon S. Rankin, P.O. Box 1317, Calgary, Alta.

THE UNION OF CANADIAN MUNICIPALITIES.—August 27, 28 and 29. Meeting at City Hall, Windsor, Ont. Hon. Secretary-Treasurer, W. D. Lighthall, K.C.

CANADIAN FORESTRY ASSOCIATION.—Convention will be held in Victoria, B.C., Sept. 4th-6th. Secy., James Lawler, Canadian Building, Ottawa.

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

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

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

EIGHTH INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.—Opening Meeting, Washington, D.C., September 4th, 1912. Other meetings, Business and Scientific, in New York, beginning Friday, September 6th, 1912 and ending September 13th, 1912. Secretary, Bernhard G. Hesse, Ph. D., 25 Broad Street, New York City.

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

ENGINEERING SOCIETIES.

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

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

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

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

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

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

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

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

MUNICIPAL ASSOCIATIONS

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

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

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

THE UNION OF CANADIAN MUNICIPALTIES.—President, 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, A. A. Dion, Ottawa Secretary, T. S. Young, 220 King Street W., Toronto.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

ONTARIO 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, Hon. W. R. Ross, Minister of Lands, B.C. Permanent Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

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.