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Volume 23. Toronto, Oct. 24, 1912

The Canadian Engineer

An Engineering Weekly

BRICK ROADS: MATERIAL, CONSTRUCTION AND MAINTENANCE.*

By THEODORE A. RANDALL, Indianapolis, Ind.†

Permit me to state briefly what I believe constitutes an ideal roadway. It is a pavement which wears smooth and clean and needs no caretaker to keep it in repair, no matter what the character or quality of traffic which passes over it. A pavement which is weather-proof, flood-proof, dirt-proof, wear-proof, and so practically time-proof. A pavement which affords an open and easy highway from country to city every day in the year for any and all sorts of traffic. A roadway over which pleasure vehicles may speed with safety to the driver and without injury to the vehicle or pavement. A roadway over which heavy service trucks may draw loads of several tons at a speed rivalling, if not exceeding, that of the so-called fast freight trains, without damage to the truck or the roadway. A roadway over which a farmer may easily haul with one horse what requires a team on ordinary roads, or with one team as much as two teams will commonly haul. A pavement over which one may journey in comfort, for it is a dustless pavement.

That is precisely the kind of a pavement you can construct of vitrified brick, and that, too, at a cost but little more than is now being paid for our temporary roadways. When you consider that the only cost of such a pavement is its first cost, you must admit that ultimately it is the cheapest pavement you can build. I think I can demonstrate to your satisfaction that practically there is no wear on a properly constructed brick roadway. Here is my proof, and if "seeing is believing," it is most convincing.

Eighteen years ago there lived in Sandusky, Ohio, a wise and painstaking engineer, Mr. John W. Miller; may his tribe increase. Under his direction a mile of brick pavement, part city street and part rural road, was laid, extending from the centre of the town out into the suburbs. Over this pavement during all these years has daily passed much traffic. To-day the pavement is perfectly smooth from one end to the other.

Fig. 1.—A Section of Pavement.
This illustrates the perfect application of the cement filler.

Fortunately, while this pavement has been torn up at times for the laying of gas mains, water pipes, etc., it has, luckily, always been replaced as carefully as it was originally laid, so that to-day it is as good as any new pavement. As you know, most pavements are damaged irretrievably by being torn up, but when such work is done properly, no harm is done to a brick pavement, as demonstrated in this case. During these eighteen years not one dollar has been spent on this pavement for repairs, yet it is still an ideal roadway and bids fair to continue such for another twenty years, or perhaps twice that length of time.

A portion of the main business street of Sandusky was paved the same year (1904) as the other roadway, and with brick of the same grade, but evidently with much less care in the method of construction. To-day, it is a rough and undesirable pavement. This pavement was laid under the same specifications as the good pavement, but as I will show you, some minor but very essential details of construction were carelessly slighted. Mr. Will. P. Blair, secretary of the National Paving Brick Manufacturers' Association, of Cleveland, Ohio, and others who have been studying this subject for some years, determined if possible to learn the real cause of failure in one pavement and the remarkable success in the other. Accordingly, experts recently visited Sandusky and with the co-operation of the city engineer, had a stretch of some fifty square feet of each pavement, the good and the poor, taken up.

The good pavement was perfectly bonded from top to bottom, every course of brick was intact, just as when it was first laid. The foundation was right to begin with, and there was a two-inch sand cushion, thoroughly compressed, affording a smooth, even bed for the brick, and insuring a comparatively noiseless pavement. The cement filler had been so applied that both sides and ends of each and every brick was imbedded in it. You will see by the pictures

*Abstract of a Lecture delivered before the American Road Congress at Atlantic City, N.J., October 5th, 1912.

†Secretary National Brick Manufacturers' Association.

that the brick and cement formed a solid mass, making the pavement monolithic in character. The result was a perfectly smooth, unbroken surface. From one end of the street to the other, there has been no chipping of brick, or disintegration of the cement filler or binder. A closer inspection of this mile of eighteen-year-old pavement made late in August did not disclose a single defect. The traffic over this pavement has had no perceptible effect upon it, the pavement

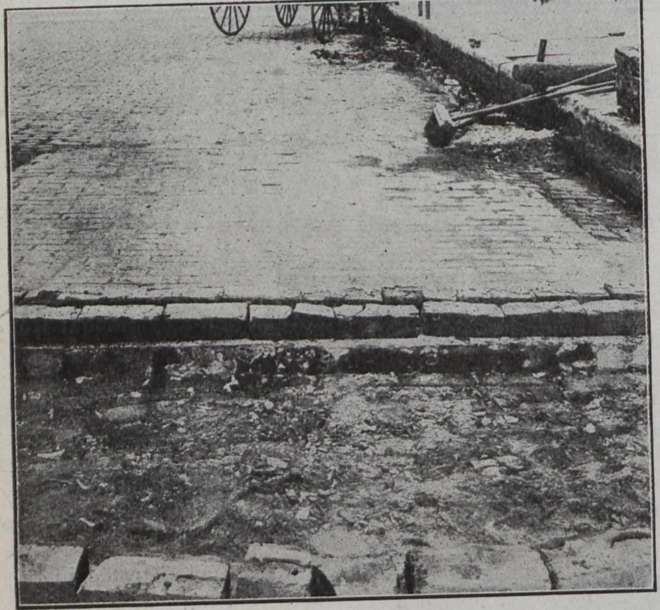


Fig. 2.—A Cut in Pavement.
Showing the imperfect application of the cement filler, to which is due the uneven wearing quality of the pavement.

showing scarcely any wear at all. If left undisturbed this pavement will be just as good at the end of another eighteen years, without a dollar of expense for up-keep.

The section of the poor pavement taken up disclosed the secret of its failure, if a pavement can be called a failure which, after eighteen years of use, is, though rough, still doing service, with no expense incurred for repairs. As a fact, it is a failure only by comparison with the perfect pavement. The same grade of brick was used in each pavement, and the traffic is much the same on each street. Why the difference? The answer is easy. It is in the careless construction of one, and the careful construction of the other.

In the good pavement, the cement filler was properly applied. In the poor pavement, not half of the brick were imbedded in the cement. Some of the brick had cement on one end, and not on the other; some of the brick had cement on the upper portion and little, or none, on the lower, and vice versâ. In some small portions of the removed pavement the cement was properly applied. In such portions the pavement remained smooth; where there was little or no cement, the pavement was the roughest. To my mind, this investigation solves the mystery of good and poor brick pavements. Scientists are at work on the problem and in time a full report of the finding will be made public. I feel quite confident that the report will justify the opinion I have expressed.

They have learned how to build brick roadways in Ohio. Every detail of construction is looked after carefully, no feature of the work is slighted, and as a result the roads are so perfect that it takes an expert to detect any minor faults or defects even. They have over four hundred miles of brick roads in Cuyahoga county alone, and those who use them regularly and appreciate their excellence and economy, demand brick pavements and brick pavements only.

Ohio is not alone in appreciation of good brick roads. They are being built in other States. New York, for instance, has made a fine start. There are about one hundred miles of these brick roads in the vicinity of Buffalo, and the State Highway Department is building about one hundred additional miles this year at other points, and when the efficiency and economy of these roads have been demonstrated by actual use, the taxpayers of the Empire State will become veritable Oliver Twists in their demand for more of the same sort. It is estimated that $50,000,000 have been expended in New York State alone on temporary roadways. Think of the many miles of permanent brick roads this sum would build. There is a vast difference between a roadway that must be looked after and repaired constantly, and these brick roadways which cost nothing at all if once properly constructed.

The proper construction of a brick paved roadway is a simple matter. In general, the requirements are the same as maintain in the building of any good road.

1. Proper drainage.

2. The careful compaction of the roadbed to a grade corresponding with that of a finished street.

3. A concrete foundation in the colder climates, and on soils of slow drainage.

4. A sand bed, two inches in depth evenly compressed, intervening and immediately underneath the brick.

5. Laying the brick best edge up, with lugs lying in in the same direction.

6. Rolling the brick to an even surface.

7. Application of the cement filler in proportion of one to one.

8. Protecting the filler from too rapid setting.

A properly constructed vitrified brick roadway is the ideal highway. Its merits summarized are:

It is easily built.
It is economical as to first cost.
It costs nothing for maintenance.
It is most satisfactory in use.
It is the most sanitary pavement known.

Fig. 3.—Glenwood Road.
Six and one half miles out from Buffalo N. Y. Wire-cut-lug brick being used

It affords the least traction resistance.

It is not a slippery pavement even when wet.

It is adaptable to all climates and all conditions of soil.

It is not an experiment, but a demonstrated fact.

It may be seen and inspected, hundreds of miles of it, in actual use, successfully withstanding excessive traffic.

Its affirmative merits are many and, when the truth is told, there is not one single objection that can be urged against its use for the heavy travelled highways of this country.

If you like speed, you can have it with no "Thank-you-ma'ams" to jar you. If you enjoy beautiful pastoral scenery, you will be delighted. You will be surprised by one feature of these brick-paved country roads—their cleanliness. It is not an uncommon thing for visitors making such a trip for the first time to ask how often the roads are swept. The answer is, "They are swept constantly, but Dame Nature does the sweeping, and she uses no broom." The wind keeps them as clean as the dear old board walk out here that we all love and enjoy.

If, after being convinced, as you will be by such a trip, that the brick-paved roadway is the ideal roadway, and you want to build them in your own district, the National Paving Brick Manufacturers' Association will make it easy for you by supplying you free of charge with complete specifications in which every detail of construction is set forth in plain terms, so that any engineer or road builder can readily comprehend all that is required. If, however, any uncertainty arises, all you need do is to write the National Paving Brick Manufacturers' Association, which is an organization of boosters, which is boosting by methods of education instead of by use of boodle.

In time, brick roads will become universal throughout this country, for there is an abundance of raw materials, shales, and clays, in almost every State in the Union, from which vitrified brick may be made. In sections where paving brick are not now made they can be shipped in, as transportation charges are not prohibitive. On the contrary, brick and cement can be supplied to almost any district in the land at a reasonable price, and the other materials used are found everywhere almost. Indeed, one of the commendable things about brick roadways is the fact that common labor is used in building them, and home products are chiefly used in their construction. They are not a drain on local capital; on the contrary, they stimulate local business by affording employment for labor at fair wages. In short, brick-paved roadways are desirable and commendable from every view point.

CREOSOTING CROSS-TIES.

The annual replacement of cross-ties in Canadian railway lines is about 10,000,000, according to statistics compiled by the Forestry Branch of the Department of the Interior. The average life of a tie, i.e., seven years, could be prolonged to seventeen years if proper preservative treatment were adopted, and an annual saving of 350 million feet, board measure, of timber, could be effected. This is equivalent to three years' cut of one of the very largest mills in the country.

While the initial expense of creosoting would bring the cost per tie from 58 to 93 cents, it would save $1,400,000 annually.

Since 1910 two timber-treating plants have been established, treating, in 1911, 206,209 ties, or 1.5 per cent. of the total cut.

The number of ties purchased in the Dominion in 1911 was 13,683,770, an increase of 4,469,808, or 48.5 per cent. over 1910.

The rapid development of railways in the western provinces is largely responsible for this increase.

Eighteen kinds of wood were used. Jack pine, with 40 per cent.; tamarack, with 19 per cent.; Douglas fir (used to a very great extent in new electric lines in British Columbia) with 14 per cent., and hemlock, with 12 per cent., were the leaders. A remarkable change is that of cedar, in decreasing from 40 per cent. to 5.4 per cent. of the total.

AN ELECTRIC FOUNTAIN OF UNIQUE DESIGN.

By L. M. Edholm.

In San Diego, California, a unique electric fountain has been constructed to stand in a small park on one of the principal streets of the city. The park faces the U.S. Grant Hotel, a magnificent building, and it was necessary to have the fountain harmonize with the surroundings and be an ornament to the park in the day time as well as night.

Mr. Irving J. Gill, a well-known western architect, designed the fountain after classic monuments of Greece and Rome, not a cheap imitation, but original ideas used, that would take a prominent place among the old masterpieces in art.

The details, many of which are unique, seem to have been very carefully thought out and planned by Mr. Gill.

In a concrete basin stands a granite pedestal from which rise eight marble columns of the Corinthian order. These support a dome of prismatic glass and bronze on the top of which rests a bronze lantern.

View of Fountain in Operation.

Even in the morning before the flow of water is commenced the structure is one that delights the eye, being well proportioned, graceful, quiet and dignified.

Every day at noon the water is turned on. A small electric pump forces the flow up through the marble columns to a point below the bronze lantern from which it flows over the prismatic glass of the dome. The bronze framework of the dome protrudes and causes the water to cascade and foam. Through a perforated sheet of metal under the dome the water falls downward in a shower between the columns. Eight jets shoot at an angle from the sides of the basin to meet the shower and together the waters dash, gurgling and splashing, upon the pedestal and runs into the basin in eight miniature waterfalls. It gives the strange illusion of water rising from the pedestal and terminating in the foam-covered dome.

As a matter of economy the water returns to the starting point and is used again and again.

At night the lights are turned on and the color display is very artistically arranged. All the jets and overflows are illuminated in the different colors. Holoplane reflectors are used under each cluster of lights and a flasher is worked automatically.

Clusters of colored tungsten lights are placed under the prismatic glass of the dome and the subdued glow showing through the glass and foam gives it a jewel-like effect.

One rather unusual detail which Mr. Gill used in his fountain was his idea that in a work of this kind the centre should be the point of greatest interest, and in order to bring this out, the costliness of the material should increase as the centre was reached.

In this arrangement first came the concrete of the basin, the granite of the pedestal, while next in value the marble columns, the dome of prismatic glass and the bronze lantern at the top and centre, which is the most costly material used in the construction.

The fountain was a gift to the city from Mr. Lewis J. Wild, a wealthy resident of San Diego, and was installed at a cost of $15,000.

The mechanism for operating the lights and the small electric pump which sets the water in motion is concealed in a chamber under the fountain.

Five dollars a day covers the up-keep of the fountain and includes the time of the caretaker of the park, whose services are all that are required for the running of the fountain.

CANADA'S COKE SUPPLY

The industrial value of Canada's coke supply is discussed in The London Financier by Mr. J. Lawrence-Hamilton, M.R.C.S. As neither anthracite nor lignite, when heated, coalesces, they are both incapable of making coke, he says. Bituminous coal, on the other hand, when strongly heated in the absence of air in suitably closed ovens, is gradually decomposed, yielding its water, gases, tar, oils, nitrogenous and volatile compounds, which are, of course, separated and collected.

Bituminous coals thus heated first fire, or melt or soften, and then, as decomposition progresses, they stiffen to produce a hard, light, porous, or cellular, coke, consisting chiefly of carbon combined with the contained ash from the original coal. The cellular or quasi-fossil, sponge-like structure of the coke is produced by the expansion of the heated escaping gases derived from the molten mass.

In blast-furnace smelting for treating mineral ores and metals, coke is superior to coal as charcoal is to wood, because both coke and charcoal are rich in carbon. Hence, to manufacture this class of fuel it is necessary to spend time, trouble and money to convert the coal into coke.

For metallurgical and allied purposes a superior coke is required. Such carefully manufactured coke is strong, hard and does not soften or crumple, so that when burning in the blast furnace it can carry a heavy charge of ore without crushing or melting, which would obstruct the blast and diminish the heat required.

Good coke burns without producing tar, oils or smoke. It posses a high calorific value.

Experiments show, and experts know, that Canadian coke for cheapness, quality and quantity can successfully compete with the cokes from all other countries and Colonies most of which in the near future will be more or less dependent upon the Dominion's cheap coke, delivered like coal, which is practically inexhaustible. To develop Canadian mines and allied industries, cheap. abundant local coke is necessary. Carbonite, or natural coke, made nature's own laboratory by ingenous rocks cutting across bituminous coal seams, has not yet been discovered in Canada, where, however, it probably exists in large quantities.

Cheap, abundant, pure, solvent water of Canadian "white coal," washes the previously crushed, sized, screened and separated black coal on lines similar to the ordinary methods and machines employed in dressing and concentrating metallic ores.

The commercially valuable materials or products in metallic ores are heavier than the contaminating or containing rock. Coal is the lightest of all important commercial minerals, and its natural adulterants, or impurities, are heavier than the coal itself. In other words, in coal washing, the lighter coal escapes at the top, whilst its impurities, being heavier, are discharged separately at a lower exit. In metallic ore washing the lighter contaminating rock escapes above, whilst the metallic ores are discharged at a lower level.

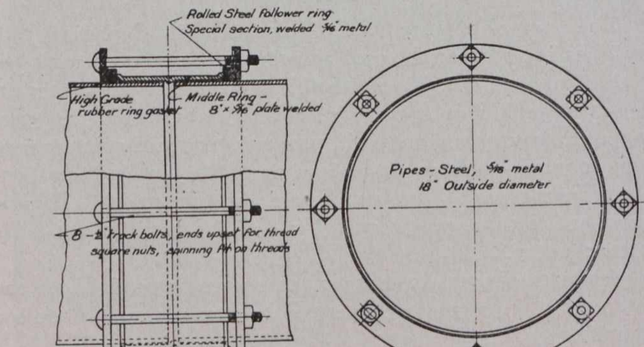
Canada having generally a very dry climate, the quantity of mechanically (not chemically) included water or moisture in Canadian coal as bought or sold averages only about 3 per cent. Of course, during prolonged or excessive wet weather this amount of contained or free water would be augmented, especially where coal is stacked in uncovered yards, or where purposely adulterated or diluted with water from a hose. Evidently small soft coal and coal dust absorb far more moisture than larger harder coals. Damp or damped coal is additionally friable or liable to waste by crumbling. In other words, where coal contains, say, 5 per cent. of free moisture—as it usually does in the United Kingdom—then in every ton there is 1 cwt. of useless water, so that the consumer on every pound's worth of coal purchased gets only 19s. worth of coal and loses a shilling for the coal's contained free water or moisture, which must not be confused with the water chemically combined as a constituent of the native coal.

Good coals as sold in London seldom contain more than 8 per cent. of free water or moisture, with an average probably approximating 7½ per cent.

AN EFFICIENT PIPE JOINT.

A very efficient pipe joint has been used recently on the new pipe line being installed for the Moose Jaw water supply. The water is being brought to Moose Jaw through nineteen miles of eighteen-inch plain end steel pipe.

There are two joints of this kind which are very similar; one is made by the Custer Coupling Company, of Bradford, Pa., and the other by C. J. Dresser Company, of the same place. The Dresser Company prefer a gland detail similar to



that used on an ordinary piston rod. The Custer joint, which was adopted on the Moose Jaw water supply, compresses the rubber gasket in a different way, and gives some latitude for variations in the size of pipe and couplings. It is stated that hundreds of these joints were made on the Moose Jaw work in a foot or more of water. The accompanying sketch gives a clear idea of the joint.

The above information, together with the sketch, has been very kindly furnished us by Walter J. Francis & Co., of Montreal, who are the consulting engineers on the Moose Jaw water supply.

THE VENTILATION OF SEWERS.*

By T. De Courcy Meade.†

In England sewers were originally constructed for the purpose of conveying storm waters from roofs, street surfaces, yards, and so forth, to the nearest rivers or streams, and the admission of fæcal matters into sewers was forbidden by law. When the water-carriage system of sewage came into vogue in the early part of the last century sewers were gradually utilized for the reception of the overflow of liquids from cesspools and for the removal of house drainage. The admission of excremental matters into sewers was not only legalized, but made compulsory in London in 1847, and in the rest of England in the following year.

Prior to that time sewers were constructed with large open shafts placed at or near to the sidewalks for the admission of surface waters; these shafts were untrapped and were covered with grids of large size. There were no ventilating shafts in the centre of the carriageways, nor were there any side entrances for gaining access to the sewers. Ventilation was therefore effected by the gully shafts, the effluvium from which gave rise to very general complaint in London as early as 1830, and as the use of sewers for the conveyance of fæcal matter was extended, these complaints became intensified. Public attention was consequently directed to the subject with the object of devising some means of remedying this evil, with the result that in London and some other English towns the gullies were tapped and shafts were erected in the centre of the carriageways to admit of the escape of the sewer gases at points as far removed from the houses and sidewalks as practicable; this system was completed in the city of London by the end of 1848. The arrangement, however, did not remove the nuisance; it merely transferred it from the sides to the centre of the streets, most of which are narrow, with carriageways largely used by pedestrians.

In 1852 the English Board of Health advised the ventilation of public sewers, and in 1878 "suggestions" as to the preparations of plans for main sewers, etc., were issued under the direction of Sir Robert Rawlinson, C.B., the chief engineering inspector to the local government board (the successors to the Board of Health). The local government board advocated:—

(a) Sewers constructed in straight lines.

(b) Manholes or lampholes at each change of direction and gradient, and terminating at the street surface.

(c) The trapping and ventilation of all house drains.

The advice given by the Government Department has been generally followed by English engineers in the design of drainage works in Great Britain, but the sewer-gas problem still remains unsolved, and the nuisance from sewer emanations continues. . . . Numerous proposals have in the past been made for abating the nuisance caused by sewer gas; for example, mechanical ventilation by means of fans, specially constructed shafts with furnaces to extract and consume the gases, flexible screens to regulate the air currents, connections with factory chimneys, and numerous methods of chemical deterioration were suggested and tried more than fifty years ago with varying results.

The old fallacy that the application of the principles successfully used in ventilating mines would be equally successful if applied to sewers is still retained by some theorists. Those who know how widely dissimilar the conditions are can readily appreciate that the remedial measures which prove successful in the one case may be worthless in the other. Plenum or vacuum systems, either separately or in conjunction, can be applied to mines, sufficiency of power being the principal factor; but in sewers dependent on water-sealed drain traps the application of power sufficient to produce an effective current of air throughout a large system is impracticable.

Most municipal engineers are conversant with the methods here referred to, and doubtless with many others too numerous to mention. They are well aware of the conditions that have to be met and of the impracticability of the suggestions put forward by many inventors, whose proposals although sometimes of undoubted ingenuity, are generally found lacking in essential points.

Among the earliest suggestions should be mentioned those of deodorizing the sewer gases by the admixture of chlorine gas and other chemically produced gases, the application of vegetable charcoal as a deodorizer, and the admission of smoke from factory chimneys forced into the sewer by water-driven fans.

The oxidizing effect of charcoal, which had been determined by the researches of Lowitz, Saussure, Thenard and others in the latter part of the eighteenth century, was, at a later period, investigated by Drs. Stenhouse, Grace-Calvert, Letheby, and others; and under the direction of Colonel Haywood, when city engineer of London, this material was utilized for purifying sewer air by means of trays inserted in the ventilating shafts. Several mechanical arrangements were devised for the practical application of charcoal to this use, notably those of Messrs. Bean and Burgess, and later the spiral tray ventilator of Mr. Baldwin Latham.

The ventilator devised by the last-named gentleman possessed many advantages over the arrangements which preceded it, but in practical use it was found that charcoal, however skilfully applied, rapidly lost its power of deodorization, mainly owing to the moist atmosphere with which it was necessarily brought into contact. Charcoal, therefore, failed to act as a useful deodorizer unless the ventilators were recharged with it very frequently. The air currents also within the sewers were reduced by its introduction. This was fully recognized by Lieut.-Colonel Haywood and Dr. Letheby, who were careful to point out that, while charcoal diminished the escape of effluvium into the streets, it was essential that the dilution of the gases generated in the sewers should not be so lessened by the diminished air supply as to render the atmosphere in the sewers dangerous to the men who work in them. These investigations, however, candidly admitted that, on the other hand, the diminution of the air currents did not appear to have any appreciable effect on the condition of the air within the sewers. The use of this material has been abandoned in the city of London and most other British towns where it had been tried.

The necessity for ventilating sewers conveying fæcal matter was generally recognized by most of the leading English engineers, notably by such pioneers as Mr. Frank Foster, Sir Joseph Bazalgette and Lieut-Colonel Haywood, engineers whose names are well known in connection with the main drainage of London. Recent research, however, indicates that this view must be accepted with some reservation.

Since the period more particularly referred to (1840-70) many methods have been tried experimentally in towns in Great Britain, and much has been written on the subject, not infrequently by those who have had no opportunity for personal research. The author has had the advantage of closely studying the practical aspect of the problem, first under the direction of Lieut.-Colonel Haywood in the city of London, subsequently in other British towns, and more recently in conjunction with Prof. Delepine and other experts in Manchester.

* Paper read at the recent Congress of the Royal Institute of Public Health in Berlin.

† City Surveyor of Manchester, England.

He proposes in the first place briefly to refer to the systems in use in some of the principal English and American towns. A few years ago information was kindly furnished to him by the municipal engineers of upwards of sixty of the principal towns in the United Kingdom, and of several important towns in Canada and the United States, from which it appears that the methods adopted in various towns differ considerably, even in cases where the local conditions are somewhat similar.

For example, we find that Belfast adopted a system of ventilation at the surface of the streets somewhat similar to that already described in relation to the city of London, Birmingham a combination of surface grids and high ventilating shafts, Bristol practically unventilated sewers, and Leicester ventilation by openings at the street surface, superseded by high shaft ventilation.

The cities of Buffalo, Chicago, Detroit, Minneapolis, Philadelphia, Washington, Boston (U.S.), and Toronto adopted surface ventilation with—it is alleged—fairly satisfactory results, the house drains being cut off from the sewers by intercepting taps in seven out of the eight cities named.

Of the sixty towns in England from which information has been derived, we find that eight towns adopted ventilation by surface grids only; five, a complete system of trapped house drains; four, untrapped street gullies; twenty, surface ventilation supplemented by high shafts; twenty-three, a combination of surface inlets and high shaft outlets; four, trapped drains, and sewers ventilated by high shafts only. The sizes given of the ventilating pipes and shafts vary from 4 in. to 12 in. in diameter, according to the size of the sewer. These are usually placed about 150 yds. apart, and in the majority of cases they are fixed against buildings.

In one town the ventilating shafts are supplemented by brick structures 42 ft. in height, with a sectional area of 9 sup. ft.

Bristol.—The method adopted at Bristol is of special interest, as that city is an exception to the rule prevailing elsewhere, being the only large town in England in which no attempt has been made to ventilate the sewers systematically, but the author is informed that the sewer workmen in that city have met with no accident due to poisoning, suffocation, or explosion for many years, although the sewage is combined with trade refuse from breweries, soapworks, tobacco manufactories, cocoa works, tanneries, and so on. The death-rate also compares favorably with that of other towns of similar size and character, being 12.71 per 1,000 in 1911.

In one town, where the brewing industry forms a large proportion of the trade, the sewers are ventilated by connections with tall chimneys. Surface ventilators are not used owing to the objectionable smell arising from the brewery refuse, and the sewers in the residential portions of the town are not directly connected with the main drainage system; sewers in the residential areas are ventilated by high shafts. In another town situated on the South Coast of England the sewage is practically free from trade refuse, but considerable difficulties have been experienced in dealing with the emanations from sewer ventilators, and many methods, such as open gratings, tall shafts, specially devised surface grids and cremation by lamp ventilation, have been tried to obviate the nuisance, but these systems have been found unsatisfactory and discarded, either wholly or partially.

Taking as another example a fashionable residential town in the South-West of England, where the sewage is mainly of a domestic character, there are no surface ventilators, only a comparatively few ventilating shafts being in use; all modern house drains are trapped, and complaints of nuisance are seldom made. Another example will be found in a residential town of about 50,000 inhabitants not far removed from the place last referred to. There is no system of sewer ventilation, the sewage is of a domestic character, the house drains are trapped. Some of the sewers have flat gradients and flushing is resorted to. The public health and death-rate compare favorably with other towns of the same size and character.

In forty-seven of the towns previously referred to the flushing and cleansing of the sewers is systematically carried out. In eleven the sewers have little fall; in four the falls are considerable; in thirty-two the gradients vary; in seven the sewers that have flat gradients are flushed. In six (some of the latter being of considerable size) the sewers are not flushed.

In most of the American towns from which information has been received flushing is systematically carried out.

From the foregoing remarks it will be seen that the modern practice regarding sewer ventilation in England varies greatly, and where ventilation on a uniform system has been attempted the methods adopted have in most cases been subsequently modified to meet the difficulties that have arisen. When nuisance has been experienced by smell from ventilators terminating at the street surface, the remedy most generally adopted by English engineers has been the substitution of vertical shafts fixed in suitable positions and supported by buildings or independently. This arrangement affords a better diffusion of the gases emanating from the sewers, and frequently obviates the complaints by transferring the nuisance from the surface of the streets to a higher point, but it cannot be accepted as a satisfactory solution of the problem. In the city of Manchester the tramway standards have for some years past been utilized as sewer ventilators, and the results have been fairly satisfactory.

Air Currents in Sewers.—The direction and velocity of the flow of air in sewers have been carefully investigated for a period of upwards of sixty years in several towns in England, commencing with the well-known series of experiments conducted in the city of London under the direction of Lieut.-Colonel Haywood about the middle of the last century.

Temperature observations conducted by the author in London and in Manchester show that the conditions in winter and in summer are reversed, the air in the sewers being warmer than the external air in winter and cooler in summer. These conditions, however, vary largely with climate and the character of the sewage, and the latter varies materially in different parts of some large towns where manufactories predominate. Some twenty-five years ago the author made an investigation of air currents in sewers and in pipe ventilators. A number of metal and earthenware pipes varying in diameter and in height were erected; some were placed vertically, both with and without bends, others were erected at different angles for the purpose of experiment. It was found that each pair of right-angle bends diminished the efficiency of an ordinary 4-in. metal pipe in calm weather by from 7 to 10 per cent., but this was largely varied when there was wind. The experiments were carried on continuously for eight months, and the pipes were afterwards used for ascertaining the extracting value of different kinds of cowls. Some of the cowls tested were found useful under certain conditions in preventing down draught, and some of them increased the up current in windy weather.

In experiments on two 30-ft. lengths of 4-in. cast-iron ventilating pipe of heavy section is was found that under favorable conditions the heat of the sun's rays was sufficient to alter the direction of the air currents in a length of 76 ft. of 6-in. diameter house drain, laid with a fall of 1 in 45. One pipe experimented upon was exposed to the southeast and the other to the northwest. With three exceptions the pipe exposed on the southeast was the upcast shaft in the earlier part of the day and the downcast shaft shortly after the sun's ray passed to the other side of the building. The exceptions occurred on days when the wind was high. The experiments were conducted on these latter pipes during hot weather only.

The observations on air currents in sewers showed that where sufficient free openings were provided the direction and force of the wind exercised a great influence and over-balanced all other local conditions due to temperature, gradients, character of sewage, and so forth.

Before the instruments were allowed to record, it was found necessary to restore the normal conditions within the sewer which are invariably disturbed by the opening of man-hole or side entrance covers for the purpose of entry when placing the recording instruments in position. To effect this the writer devised a small case of sufficient size to hold each anemometer. At opposite sides, and facing the fan of the anemometer, were hinged doors; these were opened by pneumatic pressure applied by a small tube brought to the surface. The doors were balanced to close when the pressure was released. By this means the instruments were not brought into use until the normal conditions within the sewer were restored. In order to check the record of each instrument while exposed to the action of the air currents, two anemometers were placed side by side suspended in boxes from the crown of the sewer, and an interval of twenty minutes was allowed to elapse before these instruments were independently brought into action by the means described. Eight instruments in all were used and were carefully corrected from time to time during the progress of the work.

Records were taken under similar conditions with the ventilating spaces in the manhole covers closed and open for a distance of 1 mile on each side of the point of observation, and the results differed so slightly that the author came to the conclusion that the effect produced within the sewer by the ordinary type of ventilating cover was negligible. On the other hand, he found that the action of the wind and variation between internal and external temperatures on the open end of a large sewer, such as a storm overflow, will produce a very material current of air for a considerable distance along the sewer, but the velocity of the current will gradually diminish, and in time cease altogether.

Effect of Wind Pressure.—Where surface ventilating covers are used, wind pressure has undoubtedly an effect upon the air within the sewers, but even with high winds the author has found the effects much smaller than what has often been attributed to this cause.

These remarks apply to large sewers, sufficient for a man to enter. In the case of smaller sewers—pipes varying from 12 in. to 18 in. in diameter—he has found the effect of wind pressure on surface ventilators more pronounced.

In the type of ventilating manhole which has hitherto been in use in the city of Manchester, the proportionate ventilating area amounts to:—

24.5	p.c. of the	cross	sectional	area of	12 in.	diameter	sewer.
2.7	"	"	"	"	"	3 ft.	"	"
.98	"	"	"	"	"	5 ft.	"	"
.24	"	"	"	"	"	10 ft.	"	"

The distances between the ventilating manholes varies from 100 yds. to 150 yds. in the case of the smaller sewers, and from 150 yds. to 300 yds. in the case of the larger sewers. It will therefore be seen that the effect or air pressures under such conditions must of necessity be much less in sewers of large section than in those of a smaller type.

The results of the author's observations may be briefly summarized as follows:—

(a) Where shaft ventilation only is relied upon, some of the shafts become inlets and others outlets.

(b) These conditions are not continuous, the directions of the air currents are at times reversed, the outlets acting as inlets, and vice versâ.

(c) The air currents within the sewers are governed to a large extent by the differences between the external and internal temperature, the flow of sewage, the construction and character of the sewer and other local circumstances.

(d) All these conditions are neutralized, and at times reversed by the change of direction and force of the wind.

(e) Ventilation by metal shafts is affected, and in some cases materially assisted, by the heat of the sun.

(f) No general rule can be laid down which would be applicable to all cases and under all conditions.

(g) Under normal conditions, in properly constructed and regularly flushed sewers not receiving trade refuse, the perceptible odors are less when they are unventilated than when ventilated.

(h) Air currents do not invariably flow from lower to higher levels, the reverse being frequently the case even where gradients are steep.

(i) Air in sewers in partial use is generally more offensive than that in similar sewers which are used to their full or nearly full capacity, other conditions being equal.

(j) That the regular and efficient flushing of sewers with fresh water is a more important desideratum than the introduction of large volumes of air. A case in support of this view may be quoted where intermediate manholes were inserted in an old sewer in fair condition, which increased the ventilation openings by 100 per cent., but did not appreciably improve the condition of the air within the sewer. Flushing was resorted to and a marked improvement was immediately effected.

(k) All methods which replace or retard natural ventilation are inadvisable except under very exceptional circumstances.

(l) Ventilation of sewers is necessary for the safety of the workmen, and for the free escape of air when sewers are rapidly filled in times of storm.

(m) Methods usually adopted in the ventilation of mines cannot be successfully applied to sewers.

Manchester Corporation's Investigations.—In 1902 the Manchester Corporation appointed a special committee with a twofold purpose: First, to determine—on the generally accepted hypothesis that the ventilation of sewers is necessary—the best method of accomplishing this object; secondly, to investigate the composition of sewer air bacteriologically and chemically obtaining under varying conditions, such as are to be found in the Manchester city sewers, and to determine as far as practicable the influence of sewer emanations on health.

The committee appointed Prof. Delepine, M.B., C.M., M.Sc., director of Public Health Laboratory, Manchester University; Dr. Fowler, D.Sc., F.I.C., consulting chemist, Davyhulme sewage works; and the author, to investigate and report. Prof. Delepine undertook the bacteriological work, Dr. Fowler the chemical work, and the author the experimental installations, investigation of air currents, etc.

As a rule, when matters of public interest are about to be officially investigated in England, numerous remedies are suggested by irresponsible persons from outside. These were anticipated by advertisement in the public press intimating that the special committee were prepared to receive particulars of methods for improving the ventilation of sewers. In response to this invitation twenty replies were received. Most of them contained particulars of some proprietary arrangement or method of ventilating sewers. Each case was carefully considered, and four of those who responded were invited to furnish additional particulars, and after further consideration arrangements were made for a practical test of the method advocated in each of these four cases, which will here be referred to by the letters A, B, C, and D respectively.

Method A consisted of an electrically driven fan to extract air from the sewers and discharge it through an outlet shaft into the open air, fresh air being admitted to the sewers through inlet shafts fixed at suitable points to replace that extracted. The fan used in the experiments was 20 in. in diameter, and had a velocity of 650 revolutions per minute. It was driven by a 4 b.h.p. electric motor, placed in a brick chamber under the roadway. The upcast shaft was of steel, 20 in. in diameter, with an outlet 28 ft. above the road level. The base of the shaft was concreted into the side of the fan chamber and connected to it by a concrete duct. There were twenty-two fresh-air inlet shafts, 4 in. in diameter, varying from 5 ft. to 30 ft. high. Twenty were fitted with inlet caps by means of which the amount of air admitted at each inlet was adjusted so that the extracting power of the fan could be equally distributed throughout the whole system to be ventilated.

The area experimented upon in this case was 39½ acres. The sewers within that area has a capacity of about 25,000 cu. ft., and the resident population was about 3,000. The area included two cotton mills, an india-rubber works, a soapworks, an artificial manure factory, etc., two schools attended by 1,175 scholars; 322 water-closets and 186 pail-closets; the length of the sewers was about 5,560 yds. The area was, in fact, selected because the local conditions made the sewers within it the most difficult to ventilate that could be found in a city where from various circumstances the problems regarding the efficient ventilation of the sewerage system are, perhaps, among the most difficult and complicated in England.

The contractor who had supplied the fan had guaranteed that it would discharge 6,000 cu. ft. of air per minute against a water pressure of an inch, but in actual use only 4,036 cu. ft. per minute was registered. Anemometer tests showed that 247 cu. ft. of air per minute was brought into the sewers through the air inlets, and that four of the inlets at times acted as outlets. The water gauge registered a vacuum of ½ in. in the pipe connecting the sewer with the 20-in. upcast shaft.

This system of ventilation produced a considerable dilution of the sewer air where the connections were good, but only a small proportion was drawn in through the regulated fresh-air inlets that were provided, and this notwithstanding that every care was taken, short of relaying the sewers, to make them air-tight; the system was, however, considered worthy of further investigation. The air escaping from the outlet shaft contained no more bacteria than the street air, and on some occasions much less. It had, however, an unpleasant smell, and it was considered doubtful whether there was any advantage in throwing into the street air at one point large quantities of bad-smelling gases such as escaped from the outlet shaft.

Method B consisted of a special type of lamp column placed on the footways or carriageways, and connected with manholes in the centre of the road or direct with the sewers by earthenware pipes. The pipes used were 6 in. in diameter, enlarged to 9 in. in diameter near the sewer or manhole. The column of the lamp contained a 6-in. diameter vertical copper tube connected at its lower end with a pipe leading to the manhole, and at the upper end to three incandescent gas burners in the lantern. The lantern was air-tight, with the exception of the outlet situated immediately over the burners; the sewer air extracted by the lamp passed through and round the burners, and was discharged into the open air through the outlet at the top.

The current of air passing from the manhole through the pipe was generally so small that the most sensitive anemometer obtainable, when placed in the end of the pipe, did not record it; therefore the end of the pipe was closed with the exception of the space occupied by the recording instrument, in order to set up a sufficient velocity to enable the instrument to register. A small current of air was thus produced in the 6-in. drain attached to the base of the column, but its effect on the air in even the smaller sewers was practically nil, and quite worthless in the case of large sewers. The average quantity of air extracted per lamp was 723.9 cu. ft. per hour.

The amount of coal gas per lamp consumed from June 20th to September 21st was 33,000 cu. ft., at a cost of £3 14s. 3d. At another site the average amount of air drawn from the sewer by this apparatus was about 1,100 cu. ft. per hour.

Prof. Delepine found no evidence of any material dilution of the air in the sewer even close to the ventilating column. When the lamp was not lighted there was an escape of bad-smelling air, but the number of bacteria reaching the lamp outlet was very small. When the gas was lighted, the smell was not noticeable. The temperature of the air at the outlet was so high (exceeding 250 deg. Cent.), that even during a rapid transit it is believed that the bacteria suspended in the air would be destroyed, and this was proved to be so in the case under investigation. The system appeared to be capable of reducing a local smell nuisance without affecting the state of the air in the sewers, and the action of each lamp appeared to be very limited.

Method C consisted of forcing the sewer air, after admixture with fresh air, by a jet pump through clean water, which was supposed to wash it and free it from all impurities. Complaints were received of smells from one of these washing installations, which it was ascertained did not come from defective covers or any points outside the apparatus. Each ejector installation required about 254,000 gallons of water per quarter if worked continuously. The cost for water at Manchester amounted to about £13 13s. per ventilator per quarter.

The proprietors claimed that the sewers would be kept entirely free from sewer air, but this was not justified by the results obtained. Prof. Delepine found that this apparatus did not materially affect the composition of the air contained in the sewer to which it was applied. The air escaping from the outlets at the level of the pavement usually contained about twice as much carbonic acid as the air collected about 5 ft. above the pavement, and distinctly more carbonic acid than air collected at the level of the pavement; the air also had an unpleasant smell.

Method D consisted of a cylindrical casting containing a cotton-wool filter and disinfectants, and fitted into the manhole shaft, and the inventor claimed that by this method the heat of the sewer air could be made use of to prevent the cotton wool becoming saturated by the condensation of warm, damp sewer air, but the results of the tests would not warrant the general application of the system.

Shortly stated, the investigation of the subject at Manchester showed that the air within the Manchester sewers, situated at a depth exceeding 10 ft. below the surface, generally contained more carbonic acid than the worst street air, and that the proportion of carbonic acid in sewers increases with the depth below the surface, and becomes considerable when all openings are closed, a condition necessary to mechanical ventilation. Although a large quantity of of carbonic acid can be extracted by mechanical ventilation, a greater proportion was found in the air of sewers that were so ventilated, which may be accounted for by the restriction of free ventilation, a condition indispensable under Methods A, B, C and D.

Prof. Delepine found that the bacteria in the air of the street sewers ventilated in the ordinary way were subject to variations which appear to be due to sudden disturbances of the air, such as steps in sewers, the fall of sewage from inlets above the level of the flow, and condensation on the sewer surfaces exposed to the air.

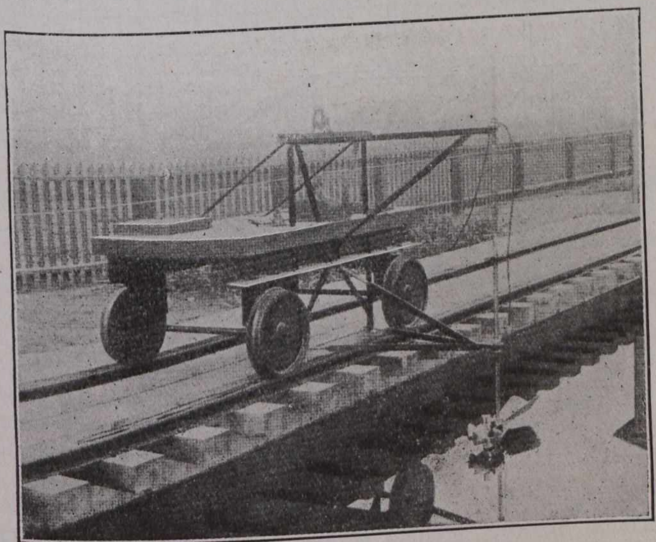
In order to estimate the influence of sewer air upon health, an elaborate system of experiments has been commenced by Prof. Delepine at the Public Health Laboratory, Manchester, and has not yet been concluded; the results obtained up to the present are, however, extremely interesting and instructive.

A CURRENT METER RATING STATION.

The current meter rating station at the Irrigation Office, Department of the Interior, Alberta, was described in a paper read by Mr F. H. Peters, Chief Engineer, to the Canadian Society of Civil Engineers, on October 10th. An abstract of the paper follows:—

The work of stream measurements has been carried on by the Irrigation Office, Department of the Interior, for a long period of years in the two Provinces of Alberta and Saskatchewan, but it was not until the early part of 1909 that the great importance of this work was recognized by the Department, and at that time a special Hydrographic Surveys branch was organized under Mr. P. M. Sauder, C.E., from which time the work of stream measurements has been carried on systematically and extensively.

Prior to this time a current meter rating station had been established on a slack water mill pond on Bow River at Calgary, but its equipment was never very satisfactory, and it finally fell into bad repair and its use was discontinued. Along with the formation of the Hydrographic Surveys branch was considered the matter of establishing an up-to-date and efficient current meter rating station, because it was realized that without this equipment, by which means all current meters used could be frequently rated, the current meter records would be liable to serious errors.



View Showing Meter Suspension Irons.

No active steps were, however, taken in the matter until the winter of 1910, when the plans, speifications and estimate of cost for the station and equipment were prepared by the writer. The contract for the work was let to the firm of Jones, Blackshire & Lyttle, of Calgary, on May 29th, 1911, and was completed by them on July 21st, 1911. In carrying out the construction the steel reinforcing, the steel rails, the cement, and the car were supplied by the Department, and the city of Calgary laid the water supply pipe to the edge of the rating station property. Everything else was included in the contract except some small electrical fittings, which were installed after the work was completed under the writer's supervision. The total cost of the station and equipment was $4,475.39. The total estimated cost for the station was $4,690.24.

In designing the work the aim was to gain the most perfect apparatus possible for rating the current meters and to create a permanent structure, so that it was early decided to use concrete in the construction of the necessary tank.

As no stretch of still water having a suitable length and depth was available, it was necessary to create a tank, and in studying its design two points had to be principally considered. First, as the water supply had to be taken from the city mains the tank had to be made proof against any leakage, as the city authorities were not willing to guarantee any large supply of water such as might be required if any serious leakage from cracks developed in the tank. Secondly, the cross-sectional water area was required as small as possible, and yet of sufficient dimensions to guard against any following-on movement of the water, in running the meters through the tank. To overcome the first difficulty a heavily reinforced structure was designed, such that being emptied and exposed to the weather in winter no temperature cracks could develop, and the inside faces of the tank were waterproofed by Sylvester's process. In deciding on the proper cross-section of the tank to overcome the second difficulty no data were obtainable, but with the tank as constructed no following-on movement or undue disturbance of the water has been observed, even with the largest meters tested at velocities as high as 10 feet per second. The length of the tank (250 feet) was adopted in order to bring the cost of the structure within the limits of the amount of money available, but provision has been made in locating the tank for its future extension to a length of 500 feet, which is desirable in order to attain the highest degree of accuracy.

Meter Rating Car at Rest; Note the Switch Operating Rod Upright at Right and the "Time" Push Switch Opposite, near the Left Wheel.

A description of the station will be given, the various points of which will be made clear by referring to the several plates.

The main feature of the station is a car to which the current meter is attached and carried through the water in the tank at different uniform rates of speed. The three elements, the distance, the time, and the number of revolutions of the meter, are mechanically measured, and from these the velocity of travel of the current meter through the water is related to the revolution per second of the meter, which relation of revolutions to velocity constitutes the rating of the meter.

The concrete tank is 250 feet long with an inside width and depth of 6 feet by 5 feet 6 inches, and the depth of water to be maintained is 5 feet. The floor and walls are

8 inches thick, and are reinforced heavily, longitudinally and transversely, with ½-inch round mild steel rods, in order to absolutely preclude any temperature cracks in the concrete. The concrete was specified a mixture of one part Portland cement to seven parts clean river gravel, to have at least 15 turns in a good machine, and to be placed wet and thoroughly tamped. All the interior faces were thoroughly spaded in order to create a smooth, close-grained surface, to which to apply the Sylvester's wash. All steel rods at joints were overlapped 16 inches, and it was specified that they were to be wired so as to have contact throughout the whole of this length. The tank floor was laid on an 8-inch foundation of large stones overlaid with smaller

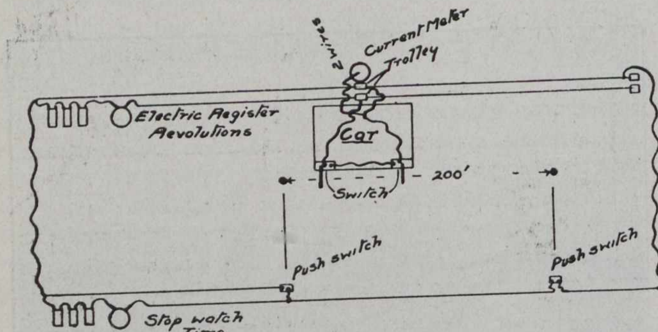


Diagram of Electric Connections

stones and gravel, in order to provide thorough drainage for any water which might leak through the tank, so that when the tank is emptied in winter and exposed to the weather no heaving might result from any water being lodged under the tank bottom. The soil beneath is of sandy character, which is permeable to water. The water supply is from a 2-inch iron pipe laid from the city mains, and a 6-inch tile drain 224 feet long, fitted with an iron gate-valve at the tank, allows the tank to be emptied at any time into the Bow River. After the tank was completed all the inside faces were treated with two coats of Sylvester's wash. At the time of writing, the tank has been exposed empty to two cold snaps with the thermometer at 30°, and no cracking of the concrete whatsoever has resulted, except a few hair-line cracks near the top of the walls. As regards the waterproofing, two observation shafts were left along the tank sides running down to the foundation, and no leakage whatever was observed during the summer when the tank was full except a slight dampness at the bottom of the side walls. It should be noted that another reason why it was desired to make the tank leak-proof is that it is intended to obtain evaporation records at the tank in future seasons.

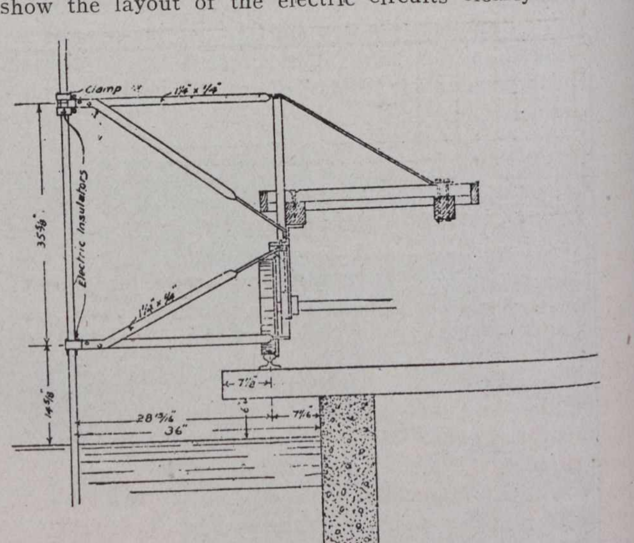
The track laid along side of the tank for the car is of 16-pound rails, and laid to a gauge of 32⅜ inches on 4 x 6-inch ties, fishplates and bolts being used at every joint. In laying the track, the greatest care was exercised to get it laid solid and as level as possible with close rail joints, in order that the car would run on the track as smoothly as possible. The measured run of the car is 200 feet, 25 feet being left at each end of the track in which to speed up the car, and the track at one end runs into the car-house, where the car is kept under lock and key when not in use.

The original idea was that the car should be mechanically driven by an electric motor working on one of the axles of the car. It is an essential that the rate of travel of the car over its measured course should be uniform, but after much consideration the writer was not able to devise any method of control by which the rate of travel of the car could be kept uniform (without acceleration) throughout its run, if driven by an electric motor or some other mechanical means. The car is, therefore, propelled by hand, but its design is such that an electric motor can be easily attached at any future date if any means can be devised of overcoming the difficulty mentioned above.

The main features in the design of the car have been copied from the car used by the Bureau of Standards, United States Government, at their current meter rating station at Washington, D.C., blue prints of the design of which were very kindly lent by an officer of the Bureau of Standards.

The main features of the car are that the axles run in roller bearings, and the platform is attached to the front axle by a pinion joint, which makes the level of the platform entirely dependent on the rear axle, and thus any tendency of the platform to be twisted due to uneven tracks is overcome. It is thought that this arrangement eliminates practically all the sharp vertical movements which might otherwise be transmitted to the current meter in its travel through the water. Two horizontal iron arms project from the car to the centre of the concrete tank. When rating the meter with the rod suspension the meter rods are clamped in these horizontal arms. When rating the meter with a cord suspension and weights the vertical cord is run down through the sockets used for clamping the metor rods and a removable iron arm is used for attaching a wire stay line to the meter. The car wheels have solid flanges, and all the iron in the car is of heavy section, the idea being that with a heavy car running in easy bearings it would be easier to maintain a uniform rate of travel than with a light car.

In making the run with the meter the count of the revolutions of the meter, and of the time interval, are both automatically registered in the car-house by electric apparatus. The electric circuits from the car into the car-house are made by two trolley wires above the car and one wire laid along the ties between the tracks. The circuit from the meter for the count of the revolutions is made by the two trolley wires, while the circuit for the time interval is made by the ground wire with one auxiliary wire, and one of the trolley wires used for the return. The diagram submitted will show the layout of the electric circuits clearly. The



Sketch Showing Method of Suspension of Meter from Car.

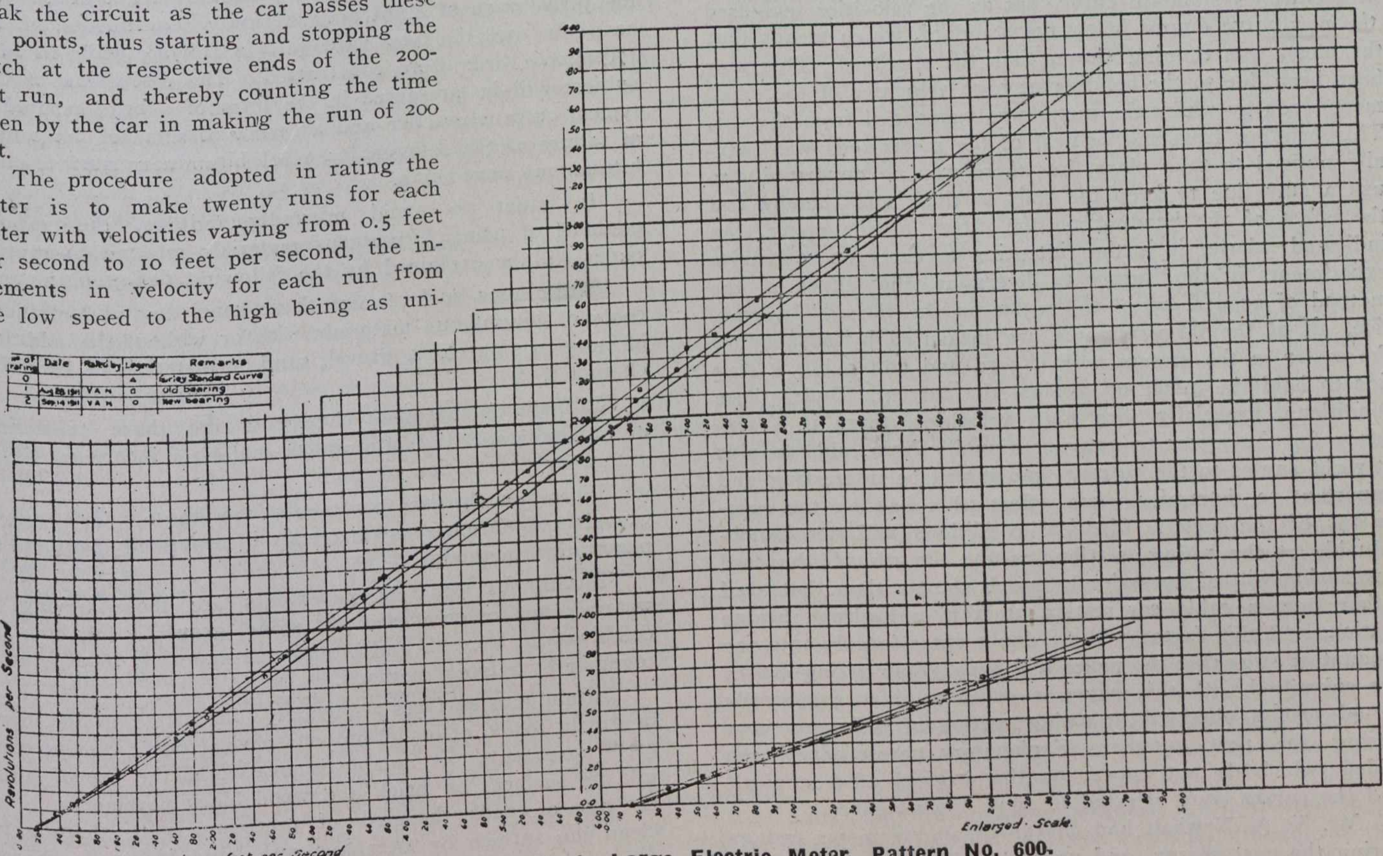
distance over which each run is made is 200 feet, and this distance is marked by two rods set up vertically on the ties at the side of the car. On the car platform are two electric switches with long arms projecting over the edge of the car platform, and these, engaging with the two rods at 200 feet interval, close the electric circuit for this interval, running through the commutator box on the meter, and thus the revolutions of the meter over the interval of 200 feet are transmitted to the car-house, where they are registered by two electric registers set in series in order to check each other on the count. Some difficulty was experienced at first in getting the electric registers to count accurately when running the meters at high velocities, but this difficulty was overcome by always overhauling the commutator box on the meters and making a fine adjustment of the make-and-break apparatus therein. It will be seen that this method of counting the revolutions is liable to be slightly in error, owing to the fact that the registers do not take any count of the fractional revolution of the meter at either end of the run. This error, however, would be reduced to a minimum by increasing the length of the run.

The time interval is counted by a stop watch, which is operated by a simple electro magnet, with a padded lever attachment, designed by the writer, in exactly the same manner that a stop watch is operated by hand. At each rod, marking the 200 foot interval, the circuit running through the stop watch via the two ground wires has inset a one-nipple push switch, and lugs, underneath the car, make and break the circuit as the car passes these two points, thus starting and stopping the watch at the respective ends of the 200-foot run, and thereby counting the time taken by the car in making the run of 200 feet.

The procedure adopted in rating the meter is to make twenty runs for each meter with velocities varying from 0.5 feet per second to 10 feet per second, the increments in velocity for each run from the low speed to the high being as uniformly distributed between the limits as possible. From the data thus gained the revolutions per second with their corresponding velocities per second are computed, the points plotted, and among them the most probable curve is drawn. From the rating curve thus constructed the rating table is prepared for use in the field and office, showing in convenient tabular form the velocities corresponding to the various revolutions per second of the meter, from zero velocity up to 10 feet per second. It should here be noted that the rule in the service is not to measure any stream at a section where the average velocity falls below 0.5 feet per second, and a velocity of 10 feet per second is about the highest met with in practice.

Mathematically, the most probable curve is that drawn from values found from normal equations by the method of least squares. It is considered, however, that the method adopted of taking the values off a curve carefully plotted as noted above is quite accurate enough to meet all practical requirements, and the saving of time and labor by using this method is very great.

For purposes of keeping a graphical office record of the succeeding ratings of the meters a separate sheet is prepared for each meter. On this is first plotted, for purposes of comparison, the standard curve for the meter (Gurley's standard curve for all Price electric meters), and all succeeding ratings of the meter will be plotted on the sheet in different colored inks, with notes as to the date of ratings, conditions of the meter, etc., until the confusion of many curves will require the preparation of a new curve sheet. Revolutions per second are plotted as ordinates to a scale of 4 inches to one revolution per second, and velocities in feet per second are plotted as abscissae to a scale of 4 inches to 2 feet per second. For velocities up to 3 feet per second, an auxiliary curve is drawn with the velocity scale increased to 4 inches to 1 foot per second, to allow for greater precision in taking the quantities off the curve.



Rating Curve for Gurley's Large Electric Meter, Pattern No. 600.

Showing revolutions per second and velocity in feet per second. NOTE.—This meter was in hard use for two seasons and shows a typical condition of the variance of rating curves. Note that with the old bearing the meter ran fastest, and that the introducing of a new bearing brought the rating curves closer to the standard.

It is the intention to carry on extensive experimental work in order to determine the various conditions that affect the rating of the current meter. Especially is it desirable to rate every large meter using the two methods of suspension, that is by meter rods and by cable with stay line. With the limited time available during the past season it was possible to rate the meters only with the rod suspension. Some of the results obtained, however, are surprising and worthy of note. The writer has had a lengthy experience with the use of the Gurley No. 600, large electric meter, and his idea has always been (and he knows that it was shared by other men of experience) that with continued use on account of the pivot bearings constantly wearing, the friction was increased, and the revolution of the meter was thereby retarded. The experience of the past summer in rating nine of these meters has indicated that after considerable use the meters run fast instead of slow. The evidence proves, that with considerable use the bearing points in the meter wear themselves smoother than when received from the makers, and hence have less friction than when they are new. The experiments, however, have not been exhaustive enough to prove anything conclusively beyond the fact that, except when they are perfectly new, no current meter can be relied upon unless it is carefully and frequently rated. The new medium size type of electric meter (Gurley's No. 623) has beeen adopted by this office for the first time this year, and, therefore, no experiments could be made on worn meters of this type. Five meters of this type were tested, of which two had been in light use for one season and three were perfectly new. All of these gave a rating curve practicaly the same as the standard curve issued by Gurley's, but in every case showing the meter running a little faster than Gurley's standard.

Of the small electric meters, Gurley's No. 618, nine were tested, and all showed nearly the same results, although four of them had been in use for two seasons and five of them were new. At low velocities the new curve coincided with Gurley's standard curve, but as the velocities increased the new curve dipped below the standard, which means that the meter was running slower than the standard. This may have been due to the bending at high velocities of the small meter rods by which the meter was suspended from the car. This bending from the vertical of the meter rods was actually noticed to take place, but there was no opportunity to use a stay line to keep the rods vertical, and thereby test the effect of the bending on the rating of the meter. As indicated above, it is the intention to carry on extensive experiments in the future to determine the effect of the method of suspension of the meter on the rating. In practice, all of the large streams are measured by suspending the meter in the stream with a cord and employing a stay line to hold the meter up against the current. Under these conditions, especially with high velocities, there is a tendency for the meter to sway continually from side to side at right angles to the current, and it will be interesting and important to determine what effect this has on the revolutions of the meter. Identical conditions will not be obtainable at the rating station, as the length of the cord suspension will of necessity be much shorter than that used either from a cable car station or from a highway bridge station, and this factor will no doubt enter largely into the amount of sway that the meter will have. Four rating curves are submitted with this paper in order to show graphically actual results obtained in rating meters of different types during the past summer. Explanatory notes have been added (which do not appear on the original office copies), and the curves were selected to show typical cases.

Mr. V. A. Newhall had charge of all the meter ratings during the past season, and under his direction the working parts of the station were put into order and the electric switches and recording apparatus were finally adjusted and improved to overcome difficulties met with in operation. To him, also, the writer is indebted for the notes on the behavior of the several types of meters on being rated.

In conclusion, the writer would note for the information of members of the Society, that the Irrigation Office is prepared to rate any meters that may be sent in by any engineers or others desirous of having their current meters tested, and a certified rating table will be prepared and returned with the meters. A small fee, based on the salaries paid to the men by the Department, will be charged to cover only the actual time of the engineer and his assistant employed in making the rating and preparing the table.

According to a report issued by the Toronto city architect, up to October 12th, 32 permits have been issued for a total of $478,700. These included permits for 54 dwelling houses and four factories, one of which was issued to the T. Eaton Co. for the erection of a six-story brick factory on Louisa Street, at a cost of $150,000.

CONSTRUCTION OF SURFACES WITH BITUMINOUS MATERIALS.*

By Arthur H. Blanchard, M.Am.Soc.C.E.†

Various kinds of bituminous materials have been used in the United States in the construction of roads and pavements for over fifty years. The introduction of the use of bituminous surfaces and bituminous pavements in the construction of highways outside of built-up districts is af comparatively recent origin in this country, dating practically from 1906. Since that period the growth of the use of asphalts, asphaltic oils and tars has been exceedingly rapid. For example may be cited the increase in the yardage of bituminous surfaces and bituminous pavements constructed with bituminous materials, not including light oils, under the jurisdiction of eight state highway departments of the east. In 1908 the total yardage was 416,700, while in 1911, 17,749,000 yards were constructed. The discussion of this subject will be presented in the form of a brief resumé of typical current practice and a review of some of the causes of failure of the different types of bituminous surfaces and bituminous pavements.

In order to avoid misunderstandings, the various methods of using bituminous materials referred to in this paper will be explained by the following definitions:

Bituminous surfaces are those consisting of superficial coats of bituminous materials with or without the addition of stone or slag chips, gravel, sand or materials of a similar character.

Bituminous macadam pavements are those consisting of broken stone and bituminous materials incorporated together by penetration methods.

Bituminous gravel pavements are those consisting of gravel and bituminous materials incorporated together by penetration methods.

Bituminous concrete pavements are those having a wearing surface composed of stone, gravel, sand, etc., or combinations thereof, and bituminous materials incorporated together by mixing methods.

Bituminous surfaces are usually constructed on macadam or gravel roads, or on bituminous pavements or cement concrete pavements. A notable innovation is the use of bituminous surfaces on brick and wood block pavements. In the case of roads, the mode of procedure is to thoroughly clean the surface by sweeping with hand brooms or horse sweepers or combination of these methods. The bituminous material, which is generally heated, is applied to the surface with the aid of pouring cans, hose attached to gravity tanks, hand-drawn gravity distributors, horse-drawn or power-driven gravity distributors and pressure distributors. After a varying interval, some kind of mineral coating is generally applied to cover the bituminous material.

The causes of failure of bituminous surfaces are numerous. They may be considered from the standpoint of the condition and character of the original surface, the material used, the method of construction or local conditions.

The failure of bituminous surfaces from the standpoint of the character of the original surface is many times due to failure on the part of those in charge to place the surface in satisfactory condition before the application of the bituminous material. Many cases are noted where bituminous materials are applied over a surface in which are found many pot holes and ruts, or which is dirty, due either to

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* Presented before the American Road Congress at Atlantic City on October 4th, 1912.

† Professor of Highway Engineering, Columbia University, New York City.

accumulated dust and dirt or to the original method of construction. With certain kinds of materials a damp condition of the surface has resulted in failure.

From the standpoint of the physical and chemical properties of the material, many instances may be cited in which failure is due to materials not having the proper characteristics for the conditions under which they are employed. As an example might be cited the case of a prominent thoroughfare in one of our large cities which is subjected to motor 'bus traffic and a large amount of motor car and horse-drawn vehicle traffic. This road is constructed of gravel upon which has been applied an asphaltic oil and gravel top dressing. The surface at the present time in many sections is full of ruts caused by the traffic pushing the material from side to side. Again, the large percentage of volatile constituents contained in certain asphaltic oils has rendered surfaces constructed with them unsatisfactory because of the long period required for these surfaces to "set up" so that the bituminous material will not track or the carpet thus formed will not creep and form waves and humps. In certain cases the use of light oils on tar or asphalt surfaces has softened the original bituminous surface to such an extent as to render the road or pavement unsatisfactory for use.

From the standpoint of construction, we find failures due both to the use of too small an amount of the bituminous material and an excess of material. Improper application, resulting in uneven distribution, is accountable for many failures of bituminous surfaces, while in other cases a lack of sufficient covering of stone chips or material of a similar character has rendered the surface sticky, mushy, sometimes in the first season, but sometimes not until the second summer.

There are numerous instances where bituminous surfaces have been adopted under conditions which call for the construction of bituminous concrete pavements or even some type of block pavements. A mat type of construction, which has been employed to a considerable extent, has proved inefficacious in cases where horse-drawn vehicle traffic has been more than a certain amount in combination with a motor car traffic which in amount was not sufficient to satisfactorily iron out the calk holes caused by the horse-drawn vehicle traffic. There are cases where esthetics should govern the selection of the type of surface, and generally in such cases the black or brown surface resulting from the use of bituminous material does not harmonize well with the environments.

Bituminous macadam and bituminous gravel pavements are of many types, one of the primary differences in construction being the use of one or two applications of the bituminous material. The efficacy of many of the types depends upon the combinations of sizes of broken stone or gravel and the combinations of bituminous materials used when two applications are employed. Variations in types also exist dependent upon the manner in which the different courses may be filled and the treatment of the filled course prior to the application of the bituminous material. The one application method is very similar in its simplest form to the construction of a bituminous surface except that the bituminous material is applied upon a much more open surface. In the case of the two-application method in certain instances an attempt is made to build up a two-course pavement, while in others the second application is in reality used as a seal coat.

Unfortunately many are the instances where improper bituminous materials have been employed. In some cases the materials were satisfactory in themselves, but were used improperly. Many engineers having charge of bituminous work do not appreciate the cold fact that different types of bituminous materials have entirely different physical properties and require entirely different treatment in use, although they may have been purchased under one and the same specification covering chemical and physical properties. In some cases entirely unjustifiable combinations of materials are employed. For instance, one case is in mind where an asphalt of excellent characteristics was used for the first application, while for the second application an asphaltic oil having decidedly solvent and fluxing properties was employed. Overheating of the material has likewise proved the cause of many failures, as thus the properties of the materials are sometimes changed and in many cases the materials are ruined.

Under the heading construction, we find failures due to the uneven distribution resulting especially from the improper use of hand pouring pots and hand-drawn distributors, and also in many cases when horse-drawn or power-driven distributors are employed. Many unsatisfactory bituminous macadam pavements result from the use of the wrong sizes of broken stone. One instance will be cited where a hard broken stone ranging from 2 to 3½ inches was used for the wearing surface. After rolling, 1½ gallons of bituminous material was applied and the road finished with a layer of chips. The rapid formation of fine cracks, due to the rocking movement of the individual stones under traffic, finally resulting in raveling and general disintegration, is of common occurrence. Segregation of sizes of stone preventing uniform penetration results in weak spots in some cases and "fat" spots in others. In certain cases after a rain the construction has been carried on before the broken stone immediately below the surface has dried out. Many of the causes attributed to the failures of bituminous surfaces may likewise apply to bituminous macadam and bituminous gravel pavements.

Bituminous concrete pavements other than sheet asphalt and pavements laid by companies as proprietary articles have received more attention during the past season than at any time since the days of Abbot, Leverich, Scrimshaw, and Van Camp. Less fear of litigation proceedings and the introduction of economical mixing machines equipped with heating attachments have exerted a marked influence. But, furthermore, the rapidly growing recognition of the inherent advantages of bituminous pavements constructed by the mixing method has been largely instrumental in its adoption for traffic conditions for which it is believed to be economical and suitable.

This type of bituminous pavement is constructed usually by one of three methods. These methods, although overlapping to a certain extent, may be described as follows when broken stone is used as an integral part of the mineral aggregate.

Type A consists of so-called one size crusher run broken stone mixed with bituminous material. It should not be considered that the designation "one size crusher run stone" means an aggregate composed of broken stone of uniform size. This term, as used here, refers to the product obtained at a crushing plant which passes over one size of screen holes and through the next larger, or passes through a screen of one size of holes and is retained upon a screen having smaller holes. It is evident to those familiar with the operation of crushers that the product thus obtained does not usually consist of stone of uniform size. For example, broken stone commercially designated as "three-quarter inch," used in the vicinity of New York City, is obtained in some cases by passing over ½-in. and through 1¼-in. openings. The size of the stone varies from one inch to one-eighth of an inch. It is self evident that this variation in size produces a more stable pavement than if the aggregate consisted of broken stone of uniform size. Type A has been constructed by both hand mixing and machine mixing and by using both unheated and heated stone. Many kinds of bituminous materials have been used, while in some cases one kind of bituminous material has been used in the mix and another kind for the seal coat; one of the most common combinations being the use of tar in the mix and asphalt for the seal coat.

Type B consists of one size crusher run broken stone and sand or other fine mineral matter mixed together with bituminous material. The wearing surface of this mix is sometimes finished by rolling in fine stone chips, but generally a seal coat is used together with fine mineral matter for a top dressing. When constructed on a commercial scale, the mineral aggregate is always heated and mixed in a specially constructed machine. Usually the same grade and type of bituminous material is used for the mix and the seal coat.

Type C consists of a wearing course composed of a graded aggregate of broken stone and sand with or without other mineral matter, which aggregate is mixed after being heated with a bituminous cement in a specially designed machine. As with Type B, this pavement is finished with and without seal coats of bituminous material. The Topeka and the Bitulithic pavements may be cited as examples of Type C.

Having reviewed the fundamentals of the various types, consideration will now be given to causes of failure of some bituminous concrete pavements. It should be noted that the percentage of failures of bituminous concrete pavements is much smaller than in the case of bituminous macadam and bituminous gravel pavements.

Poor and unsuitable materials have been accountable for certain failures. Attachment for a material of a certain type has led to a blind adoption of any material belonging to a given class. For instance, in one case coming under the writer's observation, crude coal tar from one gas works had given good results on the average. Based on this fact, any crude coal tar was finally used, although those in authority had had an object lesson in a failure due to the haphazard purchase of crude coal tar. Experiments in Rhode Island and in the Borough of Queens seem to have demonstrated that high carbon tar of a certain consistency is not as satisfactory or advisable for a seal coat as some types of asphalts, when the percentage and volume of horse-drawn vehicle traffic is large. In some cases an apparent cause of failure has been an excess of flux or of the volatile constituents in asphalt cements. Pavements constructed with such materials many times are wavy, due to the movement of the surface under heavy traffic. Many cases are reported where materials have been overheated at the construction site due to the belief that all materials may be, and even should be, heated to the same temperature before using and that it is impossible to injure bituminous materials by heating to high temperatures.

During construction there are various details which demand careful supervision. Either too large broken stone or stone of too uniform size may cause a failure. Especially is this the case with very hard and tough broken stone. The rocking of the stone causes the formation of fine cracks which eventually lead to disintegration. Naturally, the amount and character of the traffic is intimately connected with the condition of the pavement, but cases have occurred where failure, even under very light traffic, was due to using large uniform size broken stone for the mineral aggregate of the mix. Poor combinations of sizes of broken stone and sand have resulted in segregation during mixing, transportation or spreading, resulting in a pavement of varying density and stability. Overheating of the mineral aggregate has caused burning of the bituminous material in some instances or the formation of a thin film of bituminous material over the broken stone which is not of sufficient amount to bind the adjacent stones together. The use of a wet aggregate will usually result in a poor mix with consequent unsatisfactory results. In many instances the seal coat has been applied ununiformly. The result is either uneconomical, due to the necessity of a second application before seventy-five per cent. of the surface requires treatment, or the disintegration of the pavement wherever bare spots occur in pavements where a coarse aggregate was used and where there is considerable horse-drawn vehicle traffic. Although of minor import to-day, some failures have been caused by using with unheated stone bituminous cements which will not adhere satisfactorily or which only mix with great difficulty under such conditions.

Many failures are due in both the case of bituminous macadam and bituminous concrete pavements to poor foundations. Sufficient attention has not been paid to this important part of the pavement.

Many of the above causes of failure would be eliminated if engineers would devote more time to a consideration of the physical and chemical properties of the materials which they employ. Records should be at hand covering this data and details of the success or failure of every road noted. If a bituminous material laboratory is not connected with the department, it should not be either expensive or difficult to secure certified analyses made by reputable chemical engineers.

In closing, the writer wishes to emphasize the fact that a careful consideration of the causes of failure of bituminous surfaces and bituminous pavements constructed during the past five years will result in material benefit, inasmuch as a comprehensive knowledge of the various causes of failure is one of the most valuable assets of engineers having in charge the construction and maintenance of bituminous surfaces and bituminous pavements.

AMONG BRITISH COLUMBIA'S MINES.

With a production of 26,683 tons for the third week in September the Granby Company at Grand Forks, B.C., set a new record for smelter treatment in one week and brought the company's total output for the year to 905,782 tons.

Blister copper shipments were also heavy, a total of 523,000 pounds being sent to the refineries. Another Boundary property, the Mother Lode mine of the British Columbia Copper Company, made an unusually heavy shipment, sending 8,201 tons to the smelter at Greenwood, B.C.

Among the silver-lead properties which continued to make the heavy shipments which are one of the striking features of this year's Kootenay and Boundary mining, a new shipper was the Panama near Kaslo which is being operated by Mr. Henry Giegerich and associates.

Work on the tramway at the Rambler-Cariboo mine is making rapid progress and when completed will result in a heavy increase in ore shipments from the property.

Ore production totalled 52,666 tons for the week and 1,764,904 tons for the year to date. Smelter receipts for the week were 47,451 tons and for the year to date, 1,607,190 tons.

Ore production in detail is as follows:—Slocan and Ainsworth production, week 2,472 tons, year 77,373 tons; Boundary production, week 42,332 tons, year 1,445,334 tons; Rossland production, week 5,519 tons, year 174,335 tons; East Kootenay production, week 1,069 tons, year 31,309 tons; Nelson production, week 1,274 tons; year 36,553 tons. Consolidated Company's smelter receipts, Trail, B.C., week 6,755 tons, year 224,918 tons.

British Columbia Copper Company's receipts, Greenwood, B.C., week, 14,013 tons, year 476,490 tons.

Granby smelter receipts, Grand Forks, B.C., week 26,683 tons; year 905,782 tons.

The Canadian Engineer

ESTABLISHED 1893.

ISSUED WEEKLY in the interests of the CIVIL, MECHANICAL, STRUCTURAL, ELECTRICAL, RAILROAD, MARINE AND MINING ENGINEER, THE SURVEYOR, THE MANUFACTURER, AND THE CONTRACTOR.

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Present Terms of Subscription, payable in advance

Postpaid to any address in the Postal Union:

One Year	Six Months	Three Months
$3.00 (12s.)	$1.75 (7s.)	$1.00 (4s.)

Copies Antedating This Issue by More Than One Month, 25 Cents Each.
Copies Antedating This Issue by More Than Six Months, 50 Cents Each.
ADVERTISING RATES ON APPLICATION.

HEAD OFFICE: 62 Church Street, and Court Street, Toronto, Ont. Telephone Main 7404, 7405 or 7406, branch exchange connecting all departments. Cable Address: "ENGINEER, Toronto."

Montreal Office: Rooms 617 and 628 Transportation Building, T. C. Allum Editorial Representative, Phone Main 8436.

Winnipeg Office: Room 820, Union Bank Building. Phone M. 2914. G. W. Goodall, Business and Editorial Representative.

London Office: Grand Trunk Building, Cockspur Street, Trafalgar Square. T. R. Clougher, Business and Editorial Representative. Telephone 527 Central

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Everything affecting the editorial department should be directed to the Editor.

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

NOTICE TO ADVERTISERS:

Changes of advertisement copy should reach the Head Office two weeks before the date of publication, except in cases where proofs are to be submitted, for which the necessary extra time should be allowed.

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Printed at the Office of The Monetary Times Printing Company, Limited, Toronto, Canada.

Vol. 23. TORONTO, CANADA, OCTOBER 24, 1912. No. 17.

CONTENTS OF THIS ISSUE.

THE PROPOSED WORKS OF THE LONG SAULT DEVELOPMENT COMPANY AND THE ST. LAWRENCE POWER COMPANY.

Our readers will remember that about two years ago there was considerable discussion over the proposed power development at the Long Sault Rapids on the St. Lawrence River. The company who are promoting this development have so far failed to secure a charter on account of the vigorous protests of different Canadian bodies, among them the Commission of Conservation. They have also failed to secure sanction of their project by the Federal authorities of the United States. The St. Lawrence Power Company, Limited, owns the power development at the foot of Sheek Island, near Mill Roches, Ontario. It takes water from the Cornwall Canal, on the north side of Sheek Island, and furnished electric power and light for the Cornwall Canal. The fall in the St. Lawrence River adjacent to the plant of the St. Lawrence Power Company, Limited, would furnish a substantial amount of power. Investigation has shown that without the co-operation of the riparian owners on the opposite American shore, the company can develop this power only to a very slight extent.

The Long Sault Development Company, a New York State corporation, is empowered by its charter to construct dams, power-houses, locks, and other works in the St. Lawrence River, so far as these works will be in American territory. By co-operation and developing the work of the Long Sault rapids, these two companies expect to realize the full potentiality of the river.

Although the project has received two years of strong opposition, still the company continues its campaign to acquire a charter from the Canadian and the United States governments. It is rather expected that the United States charter will be granted this coming session.

The company claims, among other things, that the construction of the works will afford abundant reliable and cheap power to all districts within the radius of transmission of electricity from the power-house; that the furnishing of cheap power will create many new industries, and will be of great advantage to those already established; that the construction of the proposed dams and power-houses will require the expenditure of many millions of dollars, which will be distributed among the transportation companies, manufacturers, tradesmen and workmen, and that the power from the entire development will be used almost exclusively for manufacturing purposes, which will mean increased revenue to the transportation companies, who will distribute these products by boat and rail. It is also stated that navigation will be very much improved; that the South Sault lock will duplicate the means now afforded by the Cornwall Canal for navigation past the Long Sault Rapids, and thus prevent delay due to failure or accident; that the construction of these works will enable boats passing the Long Sault to make a round trip in approximately four and a half hours less time than at present. It might be added that the charter would also allow them to develop a half million horse-power at a very low rate per horse-power.

The above claims of benefits accruing to the country as the result of this proposed development are very interesting, and on their face value, very fine. It must be remembered, however, that at the point where this development is suggested on the Canadian side there are very few industries at the time who would use electric power. How easy it would be for the company, after obtaining their charters, to locate the power-houses on the American side of the river. In fact, the location of the dams, canals and power-houses leads one to believe that practically all of the development will be on the American side of the line; therefore, the expenditure of many millions of dollars on the development will not mean a great deal to Canadian manufacturers. Under present conditions the development of this vast amount of power would not find a ready market for many years in Canada. The outcome of the matter would be this: from power-houses erected on the American side of the line, and developing 500,000 horse-power, the largest available market must be secured. In all probability a great portion of this power would be transmitted to New York city, which is, roughly, 400 miles. This is quite within reason with the present status of electric power transmission.

So far as we can see at the present time there are many reasons why the proposal of this company should be viewed with suspicion from the Canadian standpoint. There are two many chances against an equal division of the results of the development. It is understood that the Commission of Conservation are preparing a report containing a large amount of data dealing with the whole proposition. No doubt no action will be taken by the Dominion government until the whole matter has been carefully investigated. Certainly no such charter should be granted until the government are absolutely sure that Canadian interests are adequately safeguarded.

EXPERIMENTS IN ROAD-MAKING IN SASKATCHEWAN.

One of the elements of most vital importance in the development of any country is its transportation facilities, and the public road is probably the most important of the different means of communication. That we are beginning to appreciate this, more and more, is evidenced by the fact that the Dominion government and the several provincial governments are now lending assistance in the form of grants of money and by the establishment of highway boards to further the good roads movement. A recent communication from Mr. A. J. McPherson, chairman of the Board of Highway Commissioners of Saskatchewan, gives some interesting facts concerning the work being done in that province. Saskatchewan has gone about it in the right way in its initiation of a system of good roads. The provincial government has appointed a highway commission under the chairmanship of a technically trained man with a great deal of practical experience. As a result, they are proceeding along right lines in finding out, first, the type of construction which will be most economical and efficient for the province. To illustrate their methods some of the work of the commission may be instanced. Dr. W. W. Andrews, of the Highway Board, has been engaged for some time past in investigating the practicability of treating the gumbo clays, which are spread so extensively throughout the province. Quite a large section of the province lying from Weyburn north-west to the Elbow, on the South Saskatchewan River, and north of the South Saskatchewan to the Alberta line, consists of a gumbo clay which does not lend itself to making satisfactory roads. Even an application of gravel or broken stone is not a success, as the clay is of such a nature that when dry, is exceedingly hard, and it is practically impossible to prevent hummocks or lumps forming on the road. When wet it turns into a liquid; and in a very short time any porous material that is put on the road becomes impregnated with this liquid and is lost. Experiments have been made with tannic acid, which, when applied to this clay, will take away some of these qualities, the tannic acid being obtained from ordinary straw or hay by means of a certain process. It is understood that this method has not proved itself up to the present to have a likelihood of success. Dr. Andrews has also devised a method of calcining the clay by means of burning lignite or straw in the form of a kiln on the road. The results from this method seem to show that there is some hope of success. When the clay is calcined in this way it does not form a mud, as it will in its natural state. An experimental piece of road is now being tried on a practical scale with the object of seeing how the resulting products from the calcination process will stand the test. It will also give the Commission an idea of the cost of a unit length of road by this method. The Highway Commission of Saskatchewan are to be congratulated on their enterprise. This Commission is an example of what may be secured when technically trained men are appointed to positions calling for technical knowledge.

UTILIZATION OF PEAT FUEL.

A report on the utilization of peat fuel for the production of power has just been published by the Department of Mines. It is a record of the experiments conducted at the fuel-testing station at Ottawa during 1910 and 1911 by Mr. B. F. Haanel, B.Sc. This report is enthusiastic regarding the result of these experiments. Describing certain alterations made to the peat gas producer and cleaning system, Mr. Haanel says: "The main difficulty, however, still exists, as in the old form of the producer, namely, the formation of a variety of tar; as a thin liquid when condensed, and as finely divided particles carried in a state of suspension after passing through the cleaning system. This objectionable by-product cannot be obviated in the producer itself, but must be separated out mechanically.

In estimating fuel costs Mr. Haanel assumes that peat with a moisture content of 25 per cent. can be delivered to the producer for $2 per ton. "In order, however, to take advantage of this, or a lower cost for fuel, the power plant will have to be situated at or near the bog where the peat fuel is manufactured. For small plants this might not prove feasible in many cases; but will prove entirely feasible and practicable when the plants are of large capacity and when the energy developed is transmitted, in the form of electricity, to neighboring towns and villages, for lighting, power and other purposes.

"Since the fuel burned in the producer does not require to be of the best quality," he continues, "the fuel cost may be considerably reduced, since the broken peat bricks and considerable fines—which always occur in the manufacture of peat, and otherwise represent a loss—can be efficiently utilized in the producer. Assuming, however, that peat can be delivered to the plant for $2 per ton, and that the plant is run with a power factor of 75 per cent. for 3,000 hour, the fuel costs would be $8.40 per B.H.P. year, including standby losses"

No doubt this report is made only after most careful thought and investigation. There have been so many reports during the past fifty years regarding the successful utilization of peat, that reports to-day are received with some measure of reserve. We sincerely hope that Mr. Haanel's predictions will be justified, for the utilization of our peat fields will mean a great deal for the industries of Canada.

DESIGNING BRICK AND STEEL CHIMNEYS.

In designing chimneys the height is generally decided upon first. This involves consideration of the height of surrounding buildings or hills, the length of all horizontal flues necessary, the character of fuel to be used, etc., as well as any local laws or ordinances that may apply. The chim- ney diameter may then be calculated, based upon the selected height and the boiler horsepower or the amount of fuel to be consumed. In the October 8th issue of Power, Mr. Everard Brown discusses the designing of chimneys and we herewith reproduce the article.

The minimum height necessary, however, will be governed to a great extent by the fuel—wood usually requiring the least and fine anthracite coal the greatest—the character of the installation and the number of furnaces served. Obviously the smaller and more round-about the flues, the higher must be the stack; likewise, a single furnace will require less height than several discharging into a common flue. On account of these variables, it is practically impossible to evolve a general formula applicable to all cases. Except in rare instances, extremely tall chimneys are not necessary and any increased efficiency gained by them hardly ever justifies their greater cost. The tendency is to build two or more smaller ones rather than one high one, which can very often be done at less cost.

A chimney should be proportioned to give sufficient draft for the boiler to develop much more than its commercially rated power, or, according to Kent, to bring about the combustion of 5 lb. of fuel per rated boiler horsepower per hour. By assuming such a liberal rate of combustion, the stack will certainly be large enough. Based on this assumption Kent gives the following equation:

$$E = \frac{0.3\ Hp.}{\sqrt{H}} = A - 0.6\sqrt{A}$$

where:

E = Effective sectional flue area of stack in square feet;
Hp. = Horsepower of boilers;
H = Height of chimney;
A = Actual sectional flue area of stack in square feet.

The actual is not the effective sectional area because friction retards the ascending gases. The annular stratum of gas retarded by the wall in reality diminishes the flue area.

Molesworth gives:

$$A = \frac{Hp.}{1.28\sqrt{H}} = \frac{C}{12\sqrt{H}}$$

where

C = Pounds of coal consumed per hour.

From this equation, H may be found if the sectional area is known or assumed, or by the same process the horsepower may be found for which an existing stack is sufficient. Sometimes wind-caps are used to increase the stack capacity, but this is only rarely advisable because of their dangerous position.

Stability and wind resistence are next to be considered. Wind pressure is usually assumed to be horizontal and uniformly intense at all levels. Where a chimney is shielded by buildings, only the part actually exposed need be considered. Generally a maximum pressure is assumed of 50 lb. per square foot, although this would require a wind velocity seldom reached. A simple rule for calculating wind pressure is:

The square of the velocity in miles per hour divided by 200 equals the pressure in pounds per square foot.

The total pressure against a round chimney is about one-half that against the diametral plane of that chimney. It is therefore the product of the pressure per square foot by one-half the total projected area of the exposed part. Similarly the total pressure may be calculated for chimneys of almost any form.

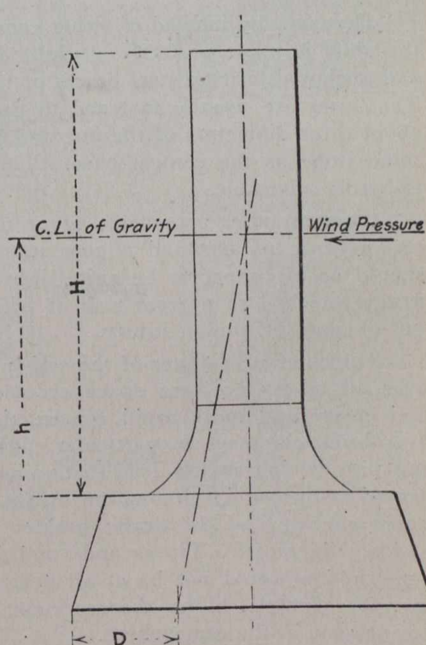
The resultant of this pressure may be assumed to act horizontally through the centre of gravity of the exposed part. The stability of a wholly exposed chimney, therefore, is determined by finding the moment of this pressure acting through the centre of gravity. From the accompanying illustration this moment is

$$h \times P_1 = H \times P \times \frac{A}{2}$$

where

h = Height of the centre of gravity above the top of the foundation;
P_1 = Total pressure exerted;
H = Total height of the stack;
P = Pressure in pounds per square foot;
A = Total vertical sectional area.

For chimneys with vertical axes, the moment of stability is the same in every direction, but few chimneys have exactly vertical axes; therefore, the least moment of stability must be considered as that which opposes the lateral pressure in the direction in which it leans. The stability at any height of a chimney, for example at a certain bed-joint of a brick structure, may be established in the same way by simply considering that part of the chimney above the point at which the stability is to be determined. Opinions differ regarding the strength of brickwork, which, together with the varying qualities of materials and workmanship, makes it exceedingly difficult to accurately calculate the power of resistance. Consequently a large factor of safety is always advisable.



Determining Stability of Chimney.

Fundamentally, a chimney's stability depends upon the weight of its outer shell and the diameter or width of its base, and, while the cohesion of the mortar in a brick stack may add something to its strength it is too uncertain to be relied upon. The effect of the two forces—the weight of the chimney and the pressure of the wind—is to shift the centre of pressure at the base from the axis toward one side, extent depending upon the relative magnitude of the two forces. A comparatively safe rule to follow is to make the base diameter not less than one-tenth of the height. This rule has been approved by many years of actual practice.

Steel Chimneys.—Probably the cheapest chimney is a straight steel shell guyed with rods or wires. These are secured to the shell, usually by an encircling band, and should be anchored to incline at an angle of not more than 45 deg. with the ground. Where other structures are convenient the guys may be fastened to them. This type of stack is rapidly being supplanted by the so-called self-sustaining stack. It can be lined or not. Ordinarily when working to full capacity, the high velocity of the ascending gases allows little heat to be lost by radiation even through an inclined shell. If the gas temperature is high, a lining is desirable at least part way up. Firebrick is sometimes used, but probably more often hard-burned red brick that can withstand temperatures up to 750 deg. without injury. This lining should never be less than 4½ in. thick at the top, whether it goes up only part of the full height of the stack and should be thicker toward the bottom by 4½ in. for about every 35 or 40 ft. Not less than 1 in. should be allowed between the shell and the lining with no rigid bond between them, thus making both self-sustaining and allowing for expansion and contraction.

For ease of construction and economy, uniform diameter of the shell for all sections is preferable; the bottom of each section should lap outside the top of the next section below, except for brick-lined structures, when the reverse is often preferred. The rivets in horizontal joints should be double staggered, thus giving more lap for the sheets and, consequently, more stiffness to the shell. Single-riveted joints usually answer for vertical seams. If possible, each section should be made of a single plate, to avoid the extra riveting. In the flaring base both the vertical and the horizontal seams should be double staggered. The cone-shaped base is naturally the strongest, but bases curved like a bell are quite common, and may be equally strong if thicker material is used. Better appearance is the only advantage of the curved base.

Occasionally instead of either cone- or bell-shaped bases, the shell is made perfectly straight down to the foundation and anchored to it by steel braces or cables with turnbuckles. The latter are usually fastened to the stack at a height of about three diameters of the flue and have approximately the same slope as the conical base. This type of construction is hardly advisable.

Caps or other ornaments at or near the top of a steel chimney are no use and a poor investment, but if desired should be of copper to be quite light and rust-proof, and firmly attached to prevent risk of being blown down, causing damage or human injury.

The chief advantages of the self-sustaining steel chimney over all others are less space occupied above the ground, and easier and more rapid construction and erection; and over brick chimneys in particular, lighter weight often saving pile driving in low load-sustaining soils; less area presented to the wind; elimination of air infiltration and consequent checking of the draft; greater strength and safety, and smaller cost. Places and conditions where steel shell construction would not be at all practicable nor economical are, for example, along the sea coast or where acid fumes are present in the atmosphere.

Brick Chimneys.—The most common brick chimney is the radial type. While initially costing somewhat more usually than a steel structure, it does not have the latter's expense for painting, replacements, etc. A brick chimney is usually made up in two shafts, the shell or outer casing and the lining or core. There is no bond between these rigid enough to retard movement due to expansion caused by the hot gases. Generally the core is run up to within a few feet of the top and then battered to connect with the shell. The outer casing diminishes in thickness, section by section toward the top. The joints between sections and at the base, called bed-joints, are less stable than intermediate ones and always must be given primary consideration. A failing chimney nearly always begins by opening one of these bed-joints on the windward side and cracking along both sides diagonally downward, tending to separate the structure into two parts: an upper leeward and a lower windward. Therefore, to withstand extreme intensity of wind pressure, the vertical pressure should be sufficient to counteract and prevent tendency for the joint to open.

The lengths of each section vary according to the height of the chimney and the quality and kind of brick used. For ordinary red brick the lengths may be from 25 to 30 ft. with an outside batter of 1 to 30 or 35, or they may increase gradually from the lowest division to the highest. Using bricks of greater crushing strength, these divisions may be made longer. The wall thickness and the batter must conform to the various lengths to insure stability. The former, giving weight to the structure, and the latter, presenting a sort of lever arm, combine to resist wind pressure. Since a swaying motion is usually set up by the wind, it is never desirable to connect the chimney rigidly with any other structure.

Naturally, much depends upon the workmanship and material; both should be of the best. Important, also, is not to erect too rapidly for the mortar to properly set and the foundation should have plenty of time to harden and settle. In several ways the brickwork may be bonded satisfactorily. The most common bond is probably one row of headers for every five rows of stretchers, although alternate rows of headers and stretchers, or two of the latter for one of the former are also used. Often in large chimneys an iron or steel hoop or tee iron is laid within the brick wall every few feet. This is good, especially where the wall thickness exceeds, say 10 to 12 in.

Concrete Chimneys.—Reinforced-concrete chimneys are least common and were introduced only about 10 years ago. Information regarding them is meagre and they have hardly had time to demonstrate their durability. Ordinarily, they have inner and outer shells with an annular air space between. The shell thickness depends upon height, diameter, etc. The steel reinforcement is usually vertical bars with ends overlapping, spaced according to the size of the chimney. These bars are encircled by steel rings and are extended down into the foundation to insure a good anchorage. They are calculated to resist all pressure by the wind and any tensile strength in the concrete is usually considered an addition to the safety factor.

Foundations.—Logically, the first detail is the foundation and in its design must be considered any local building laws that apply. These laws usually specify the loads allowed in tons per square foot of area for ground of various kinds. Where the soil is very loose or sandy, piling is often necessary, but, regardless of expense, a solid, amply large foundation is imperative. Brick, stone or concrete may be used either individually or collectively. Concrete is commonly used for the subfoundation with brick or large stone above. The area of the foundation should be sufficient to prevent unequal steeling. It will receive greater pressure from above on the leeward side to the prevailing wind, resulting in a canting of the chimney if the foundation is not broad and substantial. The foundation should be such that wind pressure against the chimney will not unduly increase the load on it at any point.

To determine the stability of the chimney in relation to its foundation: first, find the greatest total wind pressure to which the chimney might be subjected and its moment about an axis in the plane of the base of the foundation; second, the total weight of the chimney, including its lining and also that of the foundation itself. The former divided by the latter will give the distance from the outer edge of the foundation, or the lever arm of the combined weight of the chimney and foundation producing equality of moments. If this distance D is one half the foundation diameter at the base, the chimney may be considered as just stable with no margin of safety; as it is lessened the factor of stability is, of course, increased.

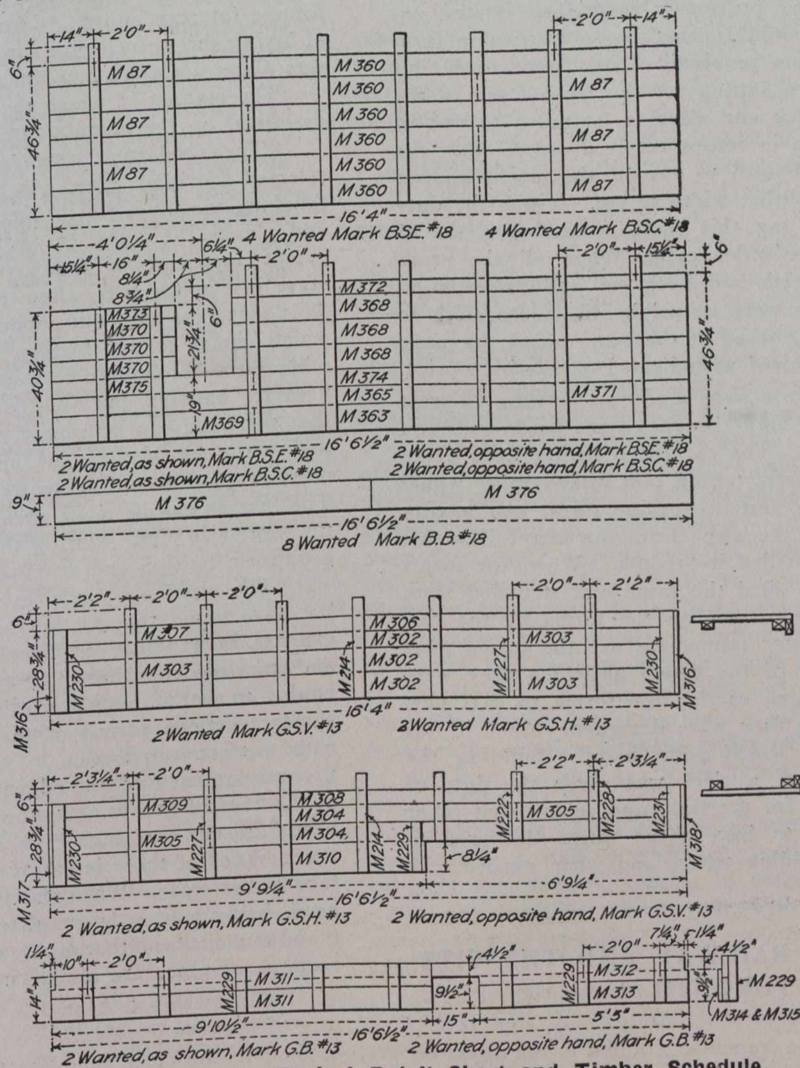
This distance should never be more than one-third that across the base of the foundation even with the best construction and anchorage. In addition some strength will be obtained from the ground surrounding the foundation, but it will be too variable to be counted on. Evidently, the greater the combined weight of the foundation and chimney, the more stable will the whole structure be made.

SYSTEMATIZING FORM WORK.

Reinforced concrete contractors recognize that the cost of form work is one of the dominant factors in determining whether a given job is executed at a profit or a loss. During the last few years a number of construction companies have been investigating methods of form work with an endeavor to devise some system whereby the cost could be reduced. One of the most successful efforts in this direction has been that of the Aberthaw Construction Company, Boston, who, by detailing the forms in the drafting-room of their home office and by a careful routing of the material, have reduced the cost of their form work 20 per cent. in the last three years. Those who have been in contact with this work have called it "scientific management," but a prominent construction engineer calls it "systematizing," and very aptly puts it: "We pay thinking men to think, and carpenters to saw boards."

Perhaps the very best way to illustrate the system is to consider the question of form work at the ten-story Larkin Terminal at Buffalo, N.Y. This building was erected by the Aberthaw Construction Co., while the consulting engineers were Lockwood, Greene & Co., of Boston. The total quantity of form lumber used was nearly 1,000,000 board feet. In order to understand that which follows it should be noted that this structure is 580 ft. long by 109 ft. wide, the floor space being over fourteen acres, and is bounded by Van Rensselaer, Carrol, Exchange and Hydraulic Streets.

First of all, at the home office a location plan of all beams was made. In this, similar beams were given identical numbers irrespective of location in the building itself. From this location plan form drawings in detail were made, a detail drawing being required for each different sized form, both for sides and bottoms, and the beams of different varieties of column forms were also detailed.



Lumber Schedule 1st & 2nd Stories			
Wall Beam #18			
No. Pc's.	Size	Length	Mark
48	1¼"x7¾"	11'2"	M360
48	1¼"x7¾"	5'2"	M87
24	1¼"x7¾"	11'9½"	M368
8	1¼"x7¾"	11'3¼"	M363
8	1¼"x7¾"	5'3¼"	M369
24	1¼"x5¾"	3'3½"	M370
8	1¼"x5¾"	11'3¼"	M365
8	1¼"x5¾"	5'3¼"	M371
8	1¼"x4½"	11'9½"	M372
8	1¼"x4½"	3'3½"	M373
8	1¼"x5½"	11'3¼"	M374
8	1¼"x5½"	5'3¼"	M375
16	1¾"x9"	8'3¼"	M376
80	2"x3"	4'4¾"	M239
16	2"x3"	3'4¾"	M240
32	2"x4"	4'4¾"	M241

Lumber Schedule 1st & 2nd Stories			
Wall Beam #13			
No. Pc's.	Size	Length	Mark
12	1¼"x7¾"	12'2"	M302
12	1¼"x7¾"	4'2"	M303
8	1¼"x7¾"	12'3¼"	M304
8	1¼"x7¾"	4'3¼"	M305
4	1¼"x5½"	12'2"	M306
4	1¼"x5½"	4'2"	M307
4	1¼"x5"	12'3¼"	M308
4	1¼"x5"	4'3¼"	M309
4	1¼"x8¼"	9'9¼"	M310
8	1¾"x7"	9'10½"	M311
4	1¾"x7"	6'8"	M312
4	1¾"x7"	5'5"	M313
4	⅞"x9½"	9'10½"	M314
4	⅞"x9½"	5'5"	M315
8	1¼"x4¼"	2'4¾"	M316
4	1¼"x3¾"	2'4¾"	M317
4	1¼"x3¾"	1'8½"	M318
32	2"x3"	2'10¾"	M214
8	2"x3"	2'2½"	M228
36	2"x3"	1'2"	M229
12	3"x4"	2'4¾"	M230
4	3"x4"	1'8½"	M231
12	2"x4"	2'10¾"	M227
4	2"x4"	2'2½"	M222

Typical Detail Sheet and Timber Schedule.

The system of lettering used on this work is of particular note. In order to show the exact location of each form in the building, letters were suffixed to the beam numbers. For instance, a form marked BSE18 would mean that it was for the beam side of beam No. 18 on Exchange Street. The bottom form for this same beam would have the symbol BBE18.

An additional number had to be added to the symbol in the case of the column forms, as there is a variation in the height of the floors. The figures prefixed to the ordinary column symbol designated that the particular form was for the second story columns. To illustrate, a column form with symbol 2CSE19 would mean second story form column side Exchange Street, while 19 is the number of column proper as specified by the original location plan.

Form details were designed complete for two stories, and to each form detail was given a symbol to be stenciled on this form when made up, together with the number or quantity required in the first two stories of the structure. On this same form detail the width of the form was divided into an exact number of boards, which were to make up this total width of the dimensions written on the drawing. Therefore, having given the exact length of form and the width of the different boards going to make up this form and the total number of forms required for the job, it is quite readily seen how the sum total of boards, with the exact dimensions, was easily summed up.

Aside from these form details, it was, of course, necessary to draw plans showing assembling of forms, the chief object of this being to specify the spacing of posts and jacks, amount of bracing, and location. From this assembly plan, together with a layout plan of the building, the exact number of pieces and size of lumber constituting the centering could be scheduled. On this completed schedule bids were obtained from the various lumber dealers before ordering the material for the job.

It was very vital that a systematic plan of piling and laying out the lumber should be adopted, inasmuch as 1,000,000 board feet were used. Particular attention was given the dressed stock going to make up the forms proper, since this was taken to and from the mill to the benches. The lumber was so piled that when the laborer wanted a certain number of boards of a particular size he could find them quickly, for a plan was drawn showing the lumber layout and the relative location of different piles of lumber according to widths and lengths. Signs were placed in front of each individual pile, stating the dimensions. On the Larkin job the Aberthaw Company found it best to build two distinct saw mills, since 90 per cent. of the dressed stock had to be cut to exact length. Both mills had practically identical equipment, but were laid out slightly different. The most used piece of machinery in those mills was a cut-off saw, on either side of which was a table, where the stock was placed before being cut. The other equipment consisted of a rip-saw, boring machine, planer, and emery wheel.

To illustrate the methods employed in making up a complete form from the blue print as received from the central office it may be desirable to follow in detail a single operation.

The form details, as previously mentioned, stated exactly the boards which would constitute a particular form and the number of forms required. Cards were made out at the route clerk's office stating for the labor foreman the number of pieces of stock and sizes to be taken to one of the mills. The mill men in return received orders from the route clerk stating the length to cut off the stock, and, if ripping was required, to what width to rip. It was the duty of the labor foreman to tag this stock according to the M number indicated on his order card. When all the stock required for a certain form had been cut and delivered to the proper bench, orders were issued by the route clerk to the two carpenters, who worked at the same bench, to make the number of forms required as indicated on the blue print.

In order that the forms were made up in time to erect as planned by the office, eight benches were used, with two carpenters at each bench. The carpenter having been given his orders by the route clerk, telling him what lumber would be tagged to make up a certain specific form, and having been given blue print of the same form, he merely laid his stock on the bench and nailed it together. When the forms were completed a laborer oiled the same and stenciled them according to the symbols printed on the forms by the carpenters. If not required for immediate use the forms were piled systematically back of the bench at which they were made. When needed, teams carried the forms to that part of the building for which they were designed. Since it was previously determined at which point of the building the erection was to be started, a clerk was given the duty of listing forms as required for erection, and seeing that labor foreman received orders to have these forms delivered to the exact part of the building where and when needed.

TORONTO STREET RAILWAY AND THE CITY OF TORONTO.

Under the terms of the franchise granted to the directors of the Toronto Street Railway a certain percentage of the cash receipts must revert to the citizens under the care of the corporation financial department. The amount received for two years past and the various proportions are as follows:—

1911. Total receipts.	1911. City's share.	1912. Total receipts.	1912. City's share.
$1,000,000.00	$ 80,000.00	$1,000,000.00	$ 80,000.00
500,000.00	50,000.00	500,000.00	50,000.00
500,000.00	60,000.00	500,000.00	60,000.00
1,000,000.00	150,000.00	1,000,000.00	150,000.00
1,643,651.94	328,730.38	2,176,170.87	435,234.27
$4,643,651.94	$668,730.38	$5,176,170.87	$775,234.27
Mileage rent	83,140.00	Mileage rent	88,329.40
	$751,870.38		$863,563.67
Average mileage	103.92	Average mileage	113.50

CONSTRUCTION OF A WOOD STAVE PIPE.

In discussing a recent paper given before the American Society of Engineering Contractors on the construction of a 48-inch continuous wood stave pipe, Mr. Willard D. Lockwood gave some interesting facts regarding the laying of a 24-inch machine-made wooden pipe, five miles in length.

The pipe was made by the A. Wyckoff & Son Company, of Elmira, N.Y., of selected Canadian pine, cut into lengths of 8 to 12 feet. The speaker found it advantageous to use the shorter length, as it permitted piling the pipes crosswise in a box car.

On good ground a foreman and eight men could easily lay 1,000 feet of 24-inch pipe per day. With the cost of $5.50 for the foreman and $1.75 for the men for 9 hours, the cost of laying the 24-inch pipe for four miles across wet meadows was about 4½ cents per lineal foot for labor alone.

The manner in which the pipe was made at the mills is described by the manufacturers as follows:

"The wood from which our wood-stave pipe is made is selected Canadian pine. As the staves are run through the finishing machine, which cuts the double groove and tongue and planes the faces to circular and radial lines, a competent inspector of many years' experience handles every stave just at the time when its defects can best be detected. This inspector culls out about fifteen per cent. of the timber which comes to our factory and these culls are used for other purposes foreign to wood-pipe. The winding machine used for banding the wood staves together is so arranged that the band can be wound at any desired tension, according to the set of the machine, which is regulated for each class of pipe according to diameter and pressure specified. The tension can be made great enough to crush the wood in the large size pipe. During the manufacture of one standard a uniform tension and spacing is absolutely assured.

"The pipes are made in maximum lengths of 12 feet. We have found that sections of 12 feet require a minimum expense in handling at factory, loading and unloading in and from box cars, by which means they are always shipped, hauled to work and placed along the conduit line. The shorter sections permit of the pipes being laid in a curve with perfect satisfaction. As each stave is made, two grooves are cut into one edge ⅛ inch deep and ⅛ inch wide at the base of groove. On the opposite edge two tongues or heads are cut 3/16 inch high and 3/16 inch wide at base of head. Each of these is cut ⅜ inch from the outer and inner face of the stave. When the staves are banded together the head, being a little larger than the groove, is squeezed into it and thus makes a thoroughly water-tight joint. The shorter sections of pipes are always used to make up the curves.

"The coating is heated in tanks by steam to a temperature of between 250 degrees and 300 degrees Fahrenheit and applied to the steel bands as they are being wound around the wood by running them through the tank which stands upon the winding machine; this method insures a full and complete coating between the steel and the surface of the wood, thus preventing the moisture, which may sweep through the outside of the wood, from coming into direct contact with the steel bands.

"After winding, the chambers and tenons are cut on the pipe, each being four inches in depth by one-half the total thickness of the shell of the pipe, which is usually 1⅞ inches thick. After leaving the finishing machine the pipe is placed on the top of the two-grooved roller, set parallel and horizontal, with one-half their diameters submerged in a tank of the hot Hydrolene. As these rollers revolve, the pipe revolves, and the coating which adheres to the rollers is thus applied to the outside surface of the pipe, covering the bands and wood. After all is applied that the surface will hold, the pipe is rolled on to a table filled with saw-dust, the sawdust adheres to the hot coating and protects it from being knocked off or abrased in shipping or laying."

COLLECTION AND DISPOSAL OF MUNICIPAL WASTES.

In the monthly bulletin of the Ohio State Board of Health Mr. Irvin S. Osborn, consulting expert in charge of garbage disposal for Columbus, Ohio, makes some comment on the above question. He states that the collection and disposal of municipal waste is one of the most serious problems that confronts nearly every municipality. In the smaller communities it receives little attention without serious results, but as the municipality grows it becomes necessary to adopt some definite plan, by means of which the work can be carried on in a systematic manner.

The experience of the majority of cities has been unsatisfactory. An investigation of the methods employed in cities will show that desired results have not been obtained except in a few cases, indicating that the methods employed are radically wrong in regard to the way the work has been handled. Many cities have expended large amounts trying to obtain better results, both as to the sanitary conditions and also as to cost, but have failed, because as a rule they have either acted on the recommendation of manufacturers of equipment, who make impossible guarantees, or they have copied the method used in some other city where the conditions are radically different.

The work has not been taken up as a problem to be solved, but has been considered as a condition to be overcome in the easiest manner. In other words, sufficient study has not been made of the conditions that affect the problems, and the result has been the adoption of methods that were not suited to the conditions as they really existed. These conditions must be known in advance and the work planned in accordance with them. Many municipalities have adopted some plan, only to find that after all they are no better off than they were before, except that they have gained considerable experience at a large cost.

The engineering and municipal publications have published many articles giving results obtained in various cities and detail descriptions of the various plants for the disposition of wastes. The data and descriptions are of great aid from an educational standpoint for officials who are obtaining enlightenment on the subject, but on comparison they will be found of little value in determining what will apply to the local conditions. The articles are oftentimes written by men who are interested in some special method of disposal or for advertising purposes, so that the opinions expressed are oftentimes biased. The reports or data given on the operation of various plants are oftentimes misleading in regard to the cost for conducting the work, since many items are omitted. This also applies to the estimated value of the returns from the sale of by-products of a reduction plant, or the value of the power that can be developed if disposal is made by burning. The problem must be considered from the standpoint of actual values that can be obtained under the conditions to be met, and not on theoretical values based on what would be the results with ideal conditions. To determine what results can be obtained information should be such that the official can show what the actual results would be.

The collection and disposal of municipal waste is an engineering problem, and only when the municipalities take it up as such, will the advance be made and a desirable solution obtained. At the present time there is no branch of municipal service where the need of study and expert advice is as great as in connection with the collection and disposal of municipal waste. Other branches of municipal service have received the study required and definite information concerning them collected from long experience, but it is only during the past few years that this branch of the service is being recognized as important. Modern methods for disposing of municipal wastes involve problems in civil and mechanical engineering which must be solved in a sanitary and economical manner. If the waste is to be burned, the engineer must understand the combustion of the material to be disposed of and the results that can be obtained in the development of power. Experience shows that all furnaces will not dispose of various classes of waste in either a sanitary or economical manner. If garbage is to be utilized or disposed of by the reduction method, the need of engineering advice is still more essential in order to obtain results that will be satisfactory.

The following will outline briefly a few items that must be considered in studying the problem to arrive at a conclusion that will warrant the adoption of any particular method or a combination of the different methods:—

1. The topography of the city studied to determine the type of wagons and location of central stations or disposal plants, to determine what bearing it will have on the collection of the material from the standpoint of economy and efficient service.

2. The character of the population studied in regard to classes and nationalities to determine the quantity and quality of the various classes of waste as produced in different sections of the city.

3. The plan of the city and character of the residences should be studied with reference to the number of houses to be served and the access to the same in making collections.

4. The production of each class of waste should be studied with reference to the average daily quantities. The monthly variation of each class to determine the maximum and minimum quantities to be disposed of. This is one of the most important determinations to be made. Estimates are often made, taking the average for monthly collections from the total yearly amounts without reference to seasonal fluctuation. Garbage during the maximum months will increase more than 100 per cent. over the average collection during the minimum months, and the combustible waste will often decrease 75 per cent. during the same period, with the result that there is not a sufficient material of combustible nature to destroy the garbage without using additional fuel.

5. Records of the quantities of each class of waste should be obtained over as long a period as possible to determine the relative increase and provide for future growth.

6. What service is to be rendered to residences and places of business.

7. Analysis of all classes of waste from a mechanical standpoint, as well as chemical analysis to determine the value of the various classes in respect to calorific value, water, ash, volatile matter, etc., and when utilized determination as to available grease and tankage and value of the same.

8. The past practice should be studied to determine the work that will be required to systematize the future developments.

9. Estimates of the first cost that would be necessary to adopt each method of disposal. Estimated annual cost for operation, maintenance and fixed charges for each method to determine the most economical method that can be adopted. The estimates will vary with local conditions, quantity and quality of the wastes to be handled.

After making a complete study the question is to determine what method is best suited for the conditions to be met from a sanitary standpoint with proper allowance made for the annual charge for maintaining and conducting the work. It is not a theoretical, but a practical problem to be solved, and can only be solved by obtaining the proper knowledge and experience necessary to decide what is suitable. The correct solution cannot be obtained by trying to copy what some other city has or by what is claimed for various methods. It must be studied with all the information possible obtained, and then applied to the problem to be solved in a practical manner from a sanitary and economical standpoint.

ECONOMICS OF POWER TRANSMISSION LINES.

The following is an article by Mr. Alfred Still, engineer at the Magpie mine, Michipicoten District, Ontario, which was printed in a recent issue of Western Egnineering. It will be remembered that we published an article by Mr. Still entitled "Steel Towers for Overhead Transmission Lines" in our issue of October 10th, 1912.

"True engineering is based on economics." These are the words of R. D. Mershon; and every engineer does or should realize the truth of the statement. On the other hand, there are many engineering undertakings, or portions of such undertakings, in which this fundamental principle has been disregarded. In the case of transmission lines a certain system, or an exceptionally high pressure may have been adopted because of its peculiar interest as an engineering problem; or duplicate lines, spare generating plant, and costly automatic gear may have been installed to ensure continuity of supply, apart from the economic value of such increased protection against possible interruption. This, however, is not engineering in the commercial sense. The determination of the economical size of conductors for the transmission of any particular amount of current, in accordance with the principle generally known as Kelvin's law, is now well understood; but this is a very small part of the problem to be solved by the transmission line engineer. An attempt will be made in this article to deal with the economics of the overhead power transmission line from a broad practical standpoint. Some approximate figures for use in getting out preliminary estimates will be given, and in the working out of any numerical examples it will be assumed that the principles governing the selection of the most economic size of conductor require no explanation. When considering any scheme of power transmission from a generating plant of limited output, it is important to bear in mind that it does not pay to cover distance greater than that within which there are reasonable prospects of supplying all the power available at the generating station. The importance of this principle should be fairly obvious; yet there are instances which prove that it has been disregarded.

Choice of System.—On this continent it is usual to transmit electric power by means of three-phase alternating currents, the periodicity being 25 or 60 cycles per second. In Europe the Thury system of continuous current transmission at high voltages has met with success; it has much to recommend it, and there appear to be no reasons why it should not meet with equal success on this continent; but it is probable that three-phase transmission, at pressures even higher than those now in use, will hold its own for a considerable time to come.

Type of Transmission Line.—The structures for supporting the overhead conductors may be of wood, steel, or reinforced concrete. The wood supports may be of the ordinary single-pole type spaced 100 to 300 ft. apart, or they may be **A** or **H** frames built up of two poles suitably braced, and capable of supporting longer spans. The steel poles may be of the simple tubular type, or built up of three or four vertical tubes or angles. The more common construction for high-pressure transmission lines consists of light-braced towers with wide rectangular bases, except where the "flexible" type of structure is adopted. These flexible towers are modeled generally on the **A** and **H** types of double wood pole supports. It is by no means an easy matter to decide upon the most suitable type of supporting structure to be used on any particular transmission scheme. In some cases a composite line including two or more types of support may be found advantageous. Among the factors influencing the choice of the supporting structures may be mentioned the character of the country, the means and facilities of transport, climatic conditions, the nature of the soil, and the scarcity or otherwise of suitable timber in the district through which the line will pass. In undulating or hilly country, advantage may frequently be taken of the heights, by erecting upon them comparatively low and cheap structures and spanning the depressions or valleys without any intermediate supports. The engineering features must, however, be very carefully studied in all such exceptional cases.

Length of Span.—Even when the type of structure has been decided upon, the height, strength, and cost of the structures will be dependeent upon the distance between them. The determination of the average length of span is indeed a very important economic question. The material of the conductor will, to some extent, influence the choice of span length, because aluminum conductors will usually have a greater summer sag than copper conductors, and this will necessitate higher supports to give the same clearance above ground at the lowest point of the span. In considering span length, the first cost of the individual support is not the only question which has to be taken into account; the cost of maintenance is almost equally important. The longer the span, the fewer will be the points of support; and if the line is well designed and constructed, there should be less trouble through faults at insulators. Again, where rent has to be paid for poles placed on private property, it is generally the rent per pole apart from the size of pole which has to be considered, and this is another factor in the determination of the best length of span. In level country, the economic span for steel tower construction is usually in the neighborhood of 550 ft. If substantial, braced, wooden towers of considerable height are used in a district where such structures can readily be constructed, the economic span would probably be greater than 600 ft. It is hardly necessary to mention that, when comparing costs of various kinds of supports, the relative life and cost of upkeep of the poles or towers must be taken into account.

Effect of Span Variations on Cost of Steel Towers.—The height of towers in level country depends on (1) the minimum clearance between the lowest conductor and ground when the sag is greatest; (2) the voltage, since this has an effect on the spacing of the conductors and also to some extent on the clearance above ground level; and (3) the maximum sag. This last is determined by the lengths of span, the material and size of the conductors, the range of temperatures, and weather conditions generally. For the purpose of rough approximations suitable for preliminary estimates I have made use of the empirical formula

$$H = 35 + 0.3\ V_k + 0.6\left(\frac{l}{100}\right)^2 \quad (1)$$

This gives the approximate overall height of towers in feet. The voltage Vk is expressed in kilo-volts and the length of span l, in feet. The formula is especially applicable to towers carrying a duplicate three-phase circuit. The constants have been worked out on the supposition that there are six No. 0000 aluminum conductors and a grounded guard wire joined to tops of the towers. It is not intended to apply to spans greater than 600 ft. In the case of larger spans advantage is usually taken of inequalities in the ground levels. The cost of steel towers will depend not only upon the height, but also upon the stresses which the tower has to withstand. These again will be dependent upon the size of the wires, the length of span, and the weather conditions. It is probable that, with an increase in height the cost increases less rapidly than the square of the overall length, but for approximate calculations it is convenient to assume the relation cost varies as H^2. Also, if the weight of a tower measuring 60 ft. overall is taken at 1,800 lb., and the price per pound of the finished (galvanized) tower at 5c.,* the cost per tower in dollars is

$$\frac{H^2}{40}. \qquad (2)$$

The cost of the flexible type of tower is appreciably less, being about seven-tenths of the cost of the rigid type with square base, or

$$\frac{H^2}{57}. \qquad (3)$$

It is, however, usual to provide rigid strain towers in place of the flexible type at, say, every mile, and as the cost of such structures is about double the cost of the flexible tower, the cost of supports per mile of line may be calculated by assuming $n + 1$ flexible structure per mile, when the actual spacing is n to the mile.

Duplicate Lines.—A point of great importance in connection with power transmission undertaking is the means adopted to guard against interruption of supply. If it is allowed that the least reliable part of a transmission system is the line itself, it is certainly advisable, when circumstances permit, to duplicate the lines; the two sets of conductors being connected in parallel under normal conditions. The best protection against interruption would be afforded by carrying the two sets of conductors on separate poles, preferably by different routes; but this would almost double the cost of the line, and it is usual to carry duplicate lines either on one set of poles, or on two sets of poles erected side by side on the same right-of-way. As an alternative to the duplication of the lines, the provision of reserve generating plant at the receiving end may be considered, and a comparison should be made between the relative advantages and costs of the various alternatives.

A good example of steam-driven auxiliary plant in connection with hydro-electric power stations, is the recently completed oil-burning steam-generating station of the Southern California Edison Co., situated 25 miles from the city of Los Angeles and capable of connecting in parallel with the 60,000-volt and 30,000-volt systems ordinarily supplied by the Kern River and other hydro-electric generating stations of this company.

Costs of Typical Transmission Lines.—It would be possible to give a large number of figures relating to material and labor costs of completed transmission lines; but the conditions of transport of materials and quality of labor differ widely, and without complete knowledge of these conditions, such figures are liable to be misleading. For this reason two ideal preliminary estimates, one referring to a wood pole line, and the other to a steel line, are here reproduced, in the hope that they may be useful as a basis on which somewhat similar estimates may be shaped.

Preliminary Estimate No. 1.—Wood pole transmission line, 20 miles long, carrying one three-phase line. Line pressure 22,000 volts. Span 130 ft. There is no grounded overhead guard wire; but two telephone wires are carried on the same set of poles. An allowance of 20 per cent. is made for extra insulators and fixtures to permit of doubling these on corner poles and in other selected positions.

*This cost may be anywhere between 3½ and 6c. per pound.

Preliminary Estimate No. 1.

Materials (Excluding Conductors)			
40 creosoted cedar poles, 35 ft. long, 8 in. diam. at top	$400.00		
48 cross-arms, 3½ by 4½ in. by 4 ft. long	14.50		
96 galvanized-iron braces, 1¼ by ¼ by 28 in. long	9.00		
32 galvanized bolts, ⅝ by 12½ in., with washers }			
8 galvanized bolts, ⅝ by 16 in., with washers }			
16 galvanized spacing rods, ¾ by 16 in., with nuts and washers }	7.50		
48 galvanized lag screws, ½ by 3½ in. }			
96 galvanized carriage bolts, ⅜ by 4½ in. }			
1500 ft. galvanized 7-strand 5/16 in. guy wire	12.00		
12 anchor rods with nuts and washers and necessary timber for			
anchor logs	7.00		
24 galvanized guy clamps with bolts	3.00		
8 galvanized sheet-iron bands to prevent cutting of poles by			
guy wire	0.50		
12 standard thimbles for guy wire	0.40		
20 galvanized-iron lightning conductors, with bolts	5.50		
20 ground plates or galvanized-iron pipes	8.00		
Staples and sundries, including allowance for breakages and			
contingencies	15.00		
80 telephone wire insulators (glass) }	10.00		
80 side brackets for same (wood); 5-in. wire nails }			
144 H.T. porcelain insulators	36.00		
96 galvanized-iron insulator pins with porcelain bases	14.40		
48 special pole-top insulator pins, with bolts	19.20		
Total material cost per mile of line		$562.00	
Labor			
Clearing 50 ft. on each side of pole line @ $30 per acre	363.00		
Distributing poles and other materials along the line	30.00		
Trimming poles, cutting gains, drilling holes, setting cross-arms	30.00		
Digging holes and erecting poles, including the necessary guying	80.00		
Fixing insulators and stringing wires, including telephone line	90.00		
Supervision and sundry small labor items	30.00		
Loss and depreciation of tools	10.00		
Management and preliminary work	25.00		
Total cost per mile for charges other than materials		$658.00	
Total cost per mile, excluding cost of conductor material			$1220.00
Conductors			
16,000 ft. No. 1 copper conductors (hard-drawn); 700 ft. No. 4 copper for ties (soft); 10,800 ft. No. 10 copper for telephone circuit; 4550 lb. @ $15 per 100 lb.			682.50
Total cost of finished line			$1902.50

Preliminary Estimate No. 2.—"Flexible" type steel tower line, 60 miles long, with two sets of three-phase conductors. Line pressure = 80,000 volts. Average span, 480 ft. Spacing between wires, 8½ ft. A Siemens-Martin steel cable, acting as grounded guard wire, joins the tops of all towers. Insulators of the suspension type. No telephone wires. Minimum clearance between lowest H.T. conductor and ground = 40 ft. Cost of right-of-way not included in estimate.

Preliminary Estimate No. 2.

Materials (Excluding Conductors)			
10 flexible type, galvanized-steel, A-frame towers @ $85	$850.00		
1 galvanized-steel strain tower	170.00		
concrete foundations where necessary	80.00		
5600 ft. 7/16 in. galvanized Siemens-Martin steel-strand cable for guard wire and head guys on half-mile flexible towers	128.00		
4 anchor rods, complete with clamps and thimbles for guy wire	4.00		
90 sets of suspension-type insulators, including strain insulators and small allowance for breakages, complete with clamps	338.00		
Sundry small items or special material	50.00		
Total material cost per mile of line		$1620.00	
Labor			
Clearing 60 ft. on each side of line at average cost of $25 per acre	$363.00		
Distributing towers and other materials along the line	100.00		
Foundations for towers	75.00		
Assembly of parts and erection of towers	160.00		
Fixing insulators and stringing wires	170.00		
Supervision and sundry small labor items	50.00		
Allowance for loss and depreciation of tools	15.00		
Allowance for management and preliminary work	35.00		
Total charges other than materials per mile		968.00	
Total cost per mile not including conductor material			$2588.00
Conductors			
No. 00, hard-drawn, stranded-copper conductors; small amount of No. 2 soft copper for occasional ties; special clamps, shields, jointing materials, etc.; 13,350 lb. @ $15 per 100 lb.			2002.00
Total cost per mile of finished line, not including right-of-way			$4590.00

The cost of insulators increases rapidly with the rise of the working voltage. The curve of Fig. 1 gives approximate average prices of insulators complete with pins or suspension links for pressures up to 100,000 volts. The prices are per insulator or per series of insulator units. The suspension type of insulator consisting of a number of units in series is almost universally used for pressures exceeding 60,000 volts. One golden rule which applies to all overhead transmissions is that it is false economy to reduce first cost by putting in cheap and possibly unreliable insulators. The curves of Fig. 2 are intended to supplement the figures of the typical estimates. They give approximate costs of transmission poles or towers, with and without in sulators fixed in position. These costs are the averages of many actual figures, and give an approximate idea of the total expenditure per mile of line for various voltages; they do not include any clearing that may be necessary in wooded country, or payments for right-of-way. It is assumed that the conductors are of average size (No. 000 B and S gauge), but the actual cost of the conductors, whatever the size, must be added to the costs indicated by the dotted curves B and D in order to arrive at the total cost of the finished line. These dotted curves, however, do include an amount to cover the labor of stringing the wires. The curves A and B refer to wood poles or rigid steel towers (for the higher voltages) carrying three conductors; while curves C and D refer to a single set of poles or towers carrying six conductors. The cost of a line with flexible steel structures for voltages above 44,000 might be about 75 per cent. of the costs given by curves A and C. It is understood that the curves of Fig. 2 give only an approximate indication of the probable capital expenditure on the line. The actual cost will depend upon the character of the country, the nature of the ground, and other local conditions such as cost of labor and facilities for transportation. These, together with the weather conditions, force of wind and possible loading of wires with sleet or ice, will determine the most economical span and the average height of pole or tower. The cost, as previously mentioned, will also depend upon the material of the conductors, as a larger or smaller sag will influence spans and height of poles. The weight and diameter of conductors, by affecting the required strength of the supports, will be factors in determining the cost of the complete line, apart from any difference in the value of the conductors themselves. The actual cost of stringing very light or very heavy conductors will also differ from the average amount allowed for the purpose of plotting the curves. The number and style of lightning conductors, if any, and whether or not one or more grounded guard wires are strung above the conductors will obviously modify the average figures. Although steel or concrete poles, or steel towers, will generally be found more economical than a wood pole

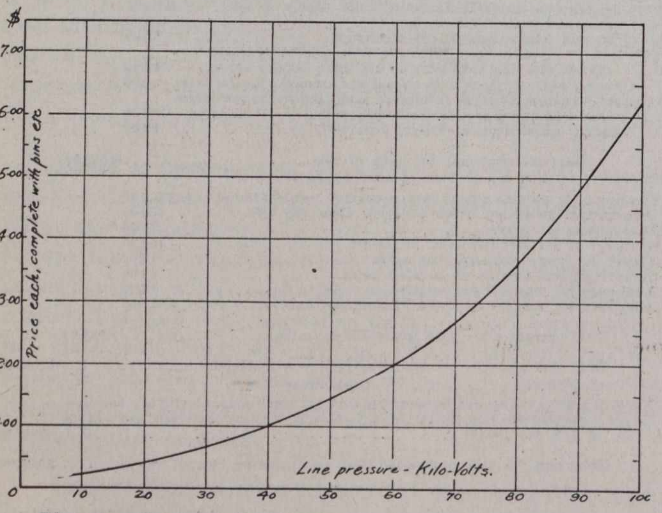


Fig. 1.—Cost of Insulators for Various Voltages.

line for voltages above 44,000 on account of the heavier insulators, wider spacing between conductors, and generally greater height of support, it does not follow that wood poles or wood-pole structures may not prove economical, even for comparatively high voltages, in countries where suitable timber is plentiful and the ready means of transportation and erection of steel towers are wanting.

Steel structures may be either galvanized or painted; the extra cost of galvanizing should be compared with the cost of painting periodically, say every third or fourth year. The cost of concrete poles will usually be between 50 and 80c. per 100 lb. weight. A pole 35 ft. high of square section 6 by 6 in. at top and 12 by 12 in. at bottom would weigh about 2,000 pounds.

The cost of foundations for towers varies greatly. In the case of fairly high steel towers with wide square bases in soil not requiring the use of concrete, the cost of excavating, setting legs, and back filling, not including erection of towers, will generally be between $10 and $20 per tower.

Cost of Conductors.—The capital expenditure on conductors will depend upon the material and the total weight. It is not proposed to discuss, in this article, the relative merits of copper and aluminum as conductor materials, but it may be well to point out that although, at the present market values of these metals, the use of aluminum may lead to some saving on first cost, there are many engineering points to be most carefully considered before definitely adopting either metal. The weight of the conductors necessary to transmit a certain amount of power over a definite distance will obviously depend upon the voltage, but apart from the engineering difficulties encountered at the higher

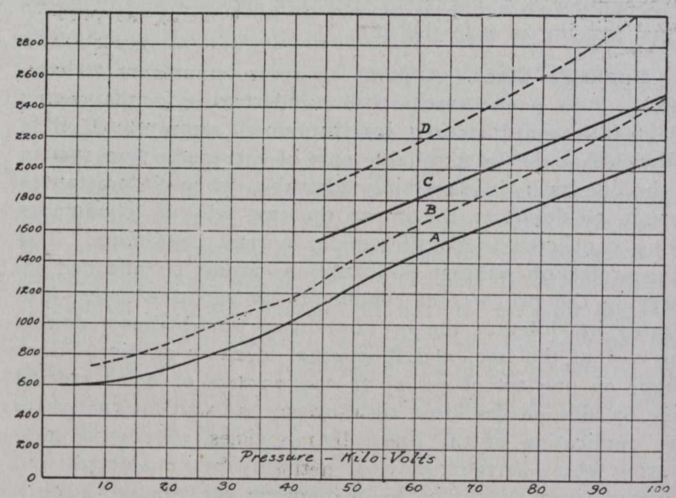


Fig. 2.—Cost in Dollars Per Mile of Transmission Line Complete, Not Including Cost of Conductors, Right-of-Way, and Clearing Ground in Wooded Country.

A—Single 3-phase line without insulators or wires.
B—Ditto, including insulators and stringing but not cost of wires.
C—Same as A, but for double 3-phase line on single set of poles or towers.
D—Ditto, but including insulators and labor stringing wires but not cost of wires.

voltages, there are economic considerations which determine the maximum voltage suitable for any given conditions. Among these may be mentioned a possible increase in the cost of generating plant for the higher pressures, the greater cost of step-up and step-down transformers and of the control apparatus, together with the line insulators, entering bushings, etc. The transmission line poles or towers will also, as previously mentioned, cost more for the higher pressures, because of the wider spacing between conductors. Then again, with the extra high pressures, the increased losses through leakage over insulators and possible corona losses may be quite appreciable.

Given a definite amount of power to be transmitted, and a definite line pressure, the current can be calculated; and the economic conductor cross-section, and therefore the weight and cost of the conductors, will be directly proportional to this current. It is only of recent years that this fact appears to have been generally recognized, and yet, so long ago as 1885, in his Cantor lectures delivered in London, George Forbes said: "The most economical section of conductor is independent of e.m.f. and distance, and is proportional to the current." The determination of the current value to be used in the calculation of conductor sections is a real difficulty. It must not be supposed that even a knowledge of the load factor is sufficient by itself. The load factor being the ratio of average load to maximum load, does not give the relation between the average I^2R loss and the I^2R loss of maximum output. The power lost in the conductors of a constant potential supply is proportional to the square of the power transmitted. On the basis of the average hydro-electric load curve, if the load factor is 50 per cent., the load on which the average transmission line losses should be based, being the square root of the mean of the square of the power, will probably be found to be more nearly 60 per cent. than 50 per cent. of the maximum load.

Economic Voltage.—Clearly, the choice of the transmission voltage is a very important matter; but as it is possible to determine the proper voltage on purely economic grounds, the use of exceptionally high pressures merely because of their interest from an engineering point of view, should be discouraged. On the other hand, it would appear that most transmission line troubles occur on lines working at pressures between 30,000 and 80,000 volts; and an important consideration to bear in mind is that more trouble may be experienced with heavy currents than with high voltages, owing to the more serious effects of interruptions or transient disturbances when the current is large, so that greater security may sometimes be obtained by increasing the voltage with a view to reducing maintenance and operating costs. A remarkable instance of high pressure being used for short-distance transmission occurs in Germany at Lauchammer. This is the first 110,000-volt installation in Europe. The line is only 35 miles long, but the power to be transmitted is considerable, being 20,000 kw. The engineers claim that, owing to large fluctuations expected through rolling-mill load, low voltages would be uneconomical. Under ordinary circumstances, the trend of modern practice would indicate something above 60,000 volts as the best pressure in this case; but when there is little difference between the cost of a 60,000-volt and an 80,000-volt scheme, it is wise to adopt the higher pressure.

When figuring on the best voltage for any particular scheme, the capital cost of all works, buildings, or apparatus which is liable to be influenced by the transmission-line pressure, together with all operating and maintenance charges which may be similarly influenced, must be taken into account. It will usually be found convenient to reduce all such costs or differences of cost to the basis of annual charges.

Costs Other Than Transmission Line, Liable to be Influenced by Voltage Variations.—The cost of a generating station complete with all plant and machinery, but not including transmission line, may be anything from $20 to $200 per horsepower installed. It will depend on total output, that is, on the size of the station, on location, and transport and labor facilities. The cost of a hydro-electric station will depend on the head of water, the amount of rock excavation, the size of dam, etc.

Approximate costs per kilowatt of medium head hydro-electric power station and sub-station (not including transmission line) for total output of about 10,000 kilowatt appear below.

The figures given in the accompanying table are approximate costs for a medium head hydro-electric development suitable for a total output in the neighborhood of 10,000 kw., to be transmitted over two outgoing 3-phase feeders. The usefulness of these figures lies mainly in the indication they give of the probable differences in cost with the variation of transmission-line pressure.

	Transmission-Line Voltage:		
	30,000	60,000	100,000
Hydraulic works outside power-station buildings	$15.00	$15.00	$15.00
Power-station building, including excavations	5.00	5.06	5.10
Receiving-station building	1.00	1.03	1.05
Switch-gear (both ends)	1.20	1.35	1.70
Electrolytic lightning arresters	0.34	0.66	1.20
Transformers (both ends)	2.50	2.90	3.50
Generaters and exciters	8.00	8.00	8.00
Cables in buildings, entering, bushings, etc.	0.40	0.40	0.50
Crane, sundries, and accessories, including preliminary work	2.00	2.10	2.20
Turbines and hydraulic equipment	10.00	10.00	10.00
Total cost per kilowatt	$45.44	$46.50	$48.25

Annual Charges Depending on Voltage.—These charges may be summarized as follows:

1. A percentage on all capital expenditure, whether for generating station, transmission line, or receiving stations, which is not constant irrespective of voltage.

2. The yearly cost of the power lost in the transmission line.

3. The yearly cost of power lost in generators and transformers (the efficiency of the electrical plant will not necessarily be the same for all voltages).

4. The yearly cost of maintenance and operation. This may depend upon length of spans in transmission line, and on the necessary plant, switch-gear, etc., to be attended to, and kept in working order.

The percentages referred to under item (1) must include interest on capital invested, and depreciation. The accompanying table gives the percentage to allow for depreciation for various terms of years. Depreciation, which may include what is sometimes referred to as obsolescence,

Depreciation Table.

(On basis of 5 per cent. compound interest earned by money put aside annually.)

Life. (yr.)	Depreciation. (%)	Life. (yr.)	Depreciation. (%)
2	48.70	28	1.710
4	23.20	30	1.505
6	14.70	32	1.325
8	10.50	34	1.175
10	7.95	36	1.045
12	6.28	38	0.928
14	5.10	40	0.828
16	4.23	42	0.740
18	3.55	44	0.662
20	3.03	46	0.593
22	2.60	48	0.532
24	2.25	50	0.477
26	1.96		

is the amount to be set aside annually in order to reproduce, at the end of a term of years, the capital originally invested. This term of years in the "life" of the works or materials on which the percentage depreciation is to be calculated. It is assumed that, at the end of this term of years, the value of such works or materials is nil. It is also assumed that the amount put aside annually earns interest at the rate of 5 per cent. compound.

Method of Determining Most Economical Voltage.—Consider the case of a typical medium head hydro-electric power station:

Distance of transmission = 50 miles.

Duplicate three-phase line with copper conductors.

Cost of conductors = $15 per 100 pounds.

Power demanded = 15,000 h.p. or 11,200 kw. (It is assumed that this power will be required continuously day and night for industrial purposes, and that it is the probable limit of the water-power available).

Power factor = 0.8.

Selling price of power = $21 per horse-power-year.

Interest on capital invested, allow 6 per cent.

The economic drop of voltage per mile of single conductor is given by the formula:[1]

$$e_r = 8.1\sqrt{\frac{a \times p}{p_1}}$$

Where p is the price in dollars of 100 lb. weight of conductor (in this example $p = 15$), a is the percentage to cover annual depreciation and interest on cost of conductors, and p_1 is the cost per horse-power-year of the wasted power. The proper value for a may be arrived at by estimating the term of years corresponding to the life of the conductors, at the end of which they are supposed to be of no value. Taking 20 years as the life of the conductors the depreciation to be allowed according to the table herewith is 3.03, which makes $a = 6 + 3.03$, or, say, 9 per cent.

With regard to p_1, if the demand for power were equal to the available supply from the time of the power-plant being put into operation, the works cost of waste power would be the same as the selling price; but, on the assumption that the supply exceeds the demand during the first five years of operation, and that the cost of waste power during this period is only \$7 per horse-power-year.[2]

The average cost of wasted power during the 20 years life of the conductors is:

$$p_1 = \frac{(5 \times 7) + (15 \times 21)}{20} = \$17.50$$

The economic voltage drop is therefore:

$$e_r = 8.1 \times \sqrt{\frac{9 \times 15}{17.5}} = 22.5 \text{ volts per mile.}$$

A first approximation to the required line voltage may be obtained by the formula

$$V_k = 5.5\sqrt{\text{distance} + \frac{\text{horsepower}}{200}}$$

$$= 5.5\sqrt{50 + \frac{15.000}{200}}$$

$$= 61.5, \text{ or say } 60,000 \text{ volts.}$$

In order to calculate the cost of the line losses, it will be necessary to adopt a figure for the horse-power transmitted, which, when squared, will give the average square of the power during the estimated life of the conductors.

Assuming an average figure for the output during 12 months, a table showing probable demand for power can be constructed as follows:

Period.	Hp. Demanded.	Hp. Squared by Years.
First year of working	5 by 1000	25 by 10^6 by 1 = 25 by 10^6
Second year of working	6 by 1000	36 by 10^6 by 1 = 36 by 10^6
Third year of working	7 by 1000	49 by 10^6 by 1 = 49 by 10^6
Fourth year of working	9 by 1000	81 by 10^6 by 1 = 81 by 10^6
Fifth year of working	12 by 1000	144 by 10^6 by 1 = 144 by 10^6
Remaining 15 years of estimated life of conductors	15 by 1000	225 by 10^6 by 15 = 3375 by 10^6

Total of last column, 3710 by 10^6.

Average, 185.5 by 10^6.

Average hp. for purpose of calculating cost of waste power = $\sqrt{185.5 \text{ by } 10^6}$ = 13,600 approximately.

When the section of the conductors is such as to satisfy Kelvin's law of economy, the yearly cost of the I^2R losses is equal to the amount representing annual depreciation and interest on first cost of conductors; and the total annual charges on active line material will therefore be:

$$2 \times \frac{I^2R \times p_1}{746} \times 3 \times 1$$

where R is the resistance per mile of conductor. But

$$I = \frac{P \times 746}{\sqrt{3} \times E \times \cos\theta}$$

where P stands for the horse-power transmitted.

Also: IR = voltage loss per mile = e_r. So that the formula for the total yearly charges on conductors can be written

$$\frac{2 \times \sqrt{3} \times e_r \times P \times p_1 \times 1}{E \times \cos\theta}$$

which in this example becomes:

$$\frac{2 \times \sqrt{3} \times 22.5 \times 13,600 \times 17.5 \times 50}{60,000 \times 0.8} = \$19,300$$

Closer Estimate of Economic Voltage.—In order to take into account first cost, life, annual maintenance, and operating charges of every portion of the complete undertaking which may be affected by a change in the transmission voltage, the costs, worked out on an annual basis, may be arranged in tabular form as here shown, where the total charges for the 60,000-volt scheme are compared with the estimated charges for an 80,000-volt transmission. In this particular example, the figures are favorable to the higher voltage; but the difference is small. It would be useless to repeat the process for a voltage lower than 60,000, because the cost would certainly be higher.

Comparison of Costs at Different Voltages.

Portion of Complete Undertaking Affected by Change of Voltage:	Estimated life (yr.)	Depreciation (from tables)	Depreciation plus 6 per cent. int.	Total Cost. Voltage 60,000	Total Cost. Voltage 80,000	Annual Charges. Voltage 60,000	Annual Charges. Voltage 80,000
Line conductors (copper) of most economic section (annual cost varies as $\frac{1}{\text{voltage}}$)	20	...		......	......	\$19,300	\$14,475
Steel tower transmission-line, without conductors, but otherwise complete (from curves, Fig. 2)	18	3.55	9.55	\$108,000	\$130,000	10,310	12,410
Generating-station buildings	40	0.828	6.828	56,600	57,000	3,870	3,895
Sub-station buildings	30	1.505	7.505	11,500	11,900	863	893
Transformers	18	3.55	9.55	32,500	35,200	3,100	3,360
Switch-gear, including lightning arresters, cables in buildings, and entering bushings	14	5.10	11.10	27,000	34,000	3,000	3,775
Assume unaltered: Yearly cost of power lost in generators and transformers. Yearly cost of operation and maintenance. Right-of-way and clearing.						\$40,443	\$38,808

Difference in favor 80,000 volts = \$1635.

It will be understood that the accompanying estimate of total annual charges of the two selected voltages does not include any items other than those that are liable to vary with changes in the line voltage. An estimate covering the complete undertaking would, in addition to the items named, have to take account of riparian rights for dam, reservoir, etc., preliminary legal and other expenses; cost of providing proper access for materials to site of works; dam and hydraulic works outside station building; turbines; electric generators and exciters; auxiliary plant; sundries and contingencies.

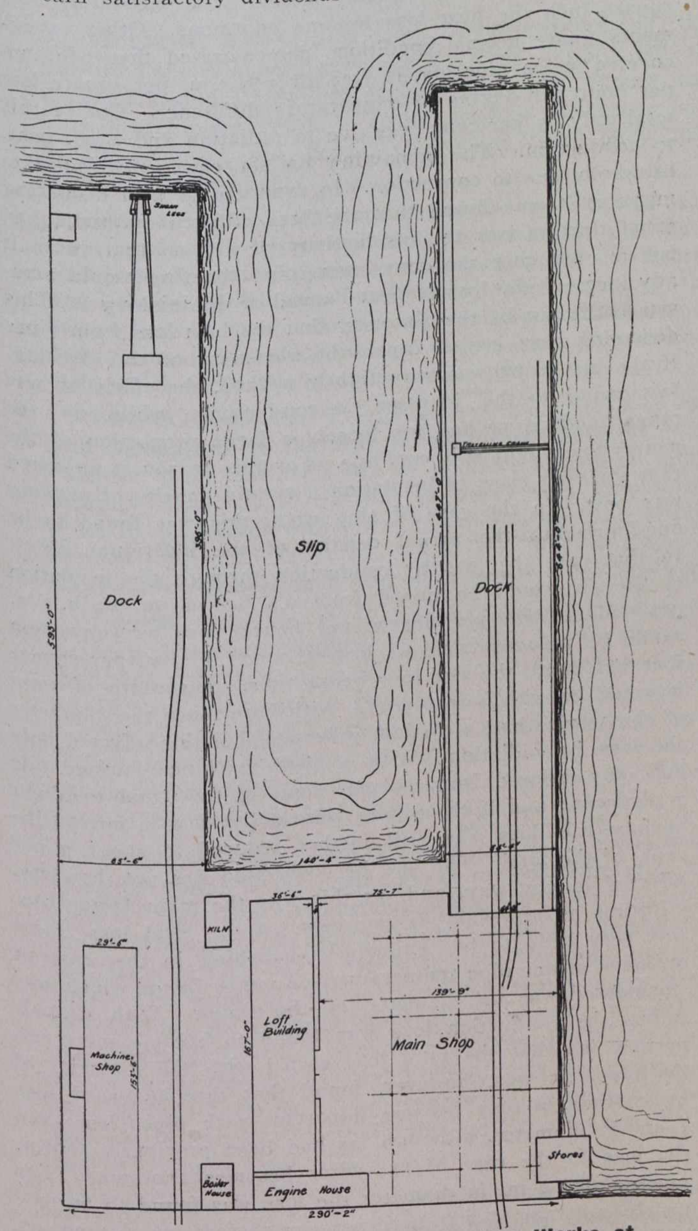
In the case of a short distance transmission with a line pressure not exceeding 11,000 volts, and the possibility of winding the generators for the full pressure, the relative costs and efficiencies of generators wound for different voltages should be taken into account.

[1] This and the one or two subsequent formulas are either taken from, or suggested by, an article by me which appeared in the Electrical World of September 23, 1911, and in which their derivation is explained.

[2] The actual works costs of the wasted power is always difficult to determine exactly. It must, however, be remembered that even with unlimited power, and no appreciable increase in maintenance and operating charges with increase of losses, the greater capital cost of the plant installed to provide this waste power has to be taken into account and expressed in the form of an annual charge per horsepower wasted, whether this waste occurs in the generating and transforming plant or the line itself.

THE PLANT OF THOR IRON WORKS, LIMITED.

The Thor Iron Works, Limited, of Toronto, has been incorporated with an Ontario charter with the object of manufacturing steel plate work of all descriptions, structural steel for buildings and bridges, to execute marine repairs, and to conduct a general iron and steel manufacturing business. The company has bought the plant and equipment, excepting the land, which is leasehold, and the property of the Grand Trunk Railway, of the Toronto Shipyards Company, successors to the Canadian Shipbuilding Company. The experience of these companies, and of others, led the directors of the new company to the conclusion that a shipbuilding proposition can hardly be made to earn satisfactory dividends here.



General Layout of Plant of Thor Iron Works at Toronto.

The sketch shows the general layout of the plant. The shops are located at the foot of Bathurst Street, Toronto, along the waterfront, and the slips where the docks are located are, therefore, in the protected harbor of Toronto Bay.

Although the plant was originally designed for shipbuilding, and is capable of constructing as large vessels as are in use in Canadian inland waters, it is not the intention of the company to engage in this work. The old layout of the plant will be slightly altered to the conditions shown in the drawing, and the company will manufacture tanks, etc.

The machinery is modern throughout, and is operated by individual electric motors. The plant consists of two large docks, on one of which is a travelling crane, and at the extreme end of the other is a set of shear-legs of 65 tons lifting capacity. The shear-legs will be used for lifting boilers and machinery out of vessels and for raising small vessels out of the water for repairs.

As has been noted, the shops are situated at the foot of Bathurst Street, and are served by a branch of the Grand Trunk Railway. The shops consist of punch-shop, boiler, and engine-house, woodworking shop, machine shop, storehouse and general offices. In the punch-shop is a complete equipment of punches and shears, rolls, planers, steam hammers, etc., with an admirably designed system of cranes to serve them. These machines are all operated by individual electric motors. The main plate rolls have as great a capacity as any in Canada, and the punches and shears have all the attachments for making special cuts that are likely to be called for.

The machine shop contains several lathes, a large planer, a shaper, pipe-cutting and threading machines, and a complete outfit of small tools, while the storeroom is equipped with a large stock of valves, pipe fittings, bolts, etc.

The plant is well adapted to the fabrication of steel plate work for tanks, water-towers, standpipes, etc. No additional machinery or equipment is required. For marine repair work, also, the plant is well laid out. The actual capacity of the equipment now installed is estimated at about 3,000 tons per annum. The company expect that at the outset the principal business done will be in the line of steel plate work, construction of tanks, water-towers, flumes, penstocks, blast furnaces, etc.

The unusual dimensions and capacities of many of the machines have in the past brought special work from many outside plants. The new owners will maintain the policy of placing the equipment at the services of any firm requiring assistance. Plates 19 feet wide may be rolled in the plate rolls and, by means of a special device, the rolls may be used for flanging. The steam hammer and large forges combine with heating furnaces of unusual length and capacity and bending slabs of ample area to make possible the handling of blacksmith work on a large scale. Although originally planned and used as shipyard equipment, this part of the plant is easily adaptable to other work of a similar nature.

The stores contain a great variety of special as well as much stock material. This is being disposed of to a very considerable extent to make room for materials used in connection with the work to be undertaken. Much of the special wood-working machinery will also be eliminated—only sufficient being retained to equip pattern and template shops.

The company have already started work, although it will be a few weeks before they can secure delivery of steel. The plant is being overhauled and put in shape in the meantime.

The company's authorized capital stock is $100,000. The officers and directors are Messrs. J. H. Malone, J. E. Russell, W. Snaith, C. H. Cunningham and W. L. Carr, all of Toronto.

KING EDWARD HIGHWAY.

A portion of the King Edward Highway is to be built of concrete, the contract having been let on September 11th, by the Honorable J. E. Caron, Minister of Agriculture and Highways of the Province of Quebec. The King Edward Highway is the Canadian section of the International Highway connecting Montreal with several large cities of the United States. Ultimately, it is expected that this road will continue as far south as Miami, Florida.

NEW RESEARCH LABORATORY IN CONNECTION WITH SCHOOL OF MINES, KINGSTON.

Under the directorship of H. T. Kalmus, S.B., Ph.D., there has been recently opened in the city of Kingston, Ont., a new research laboratory to be devoted to researches along the lines of the practical application of electrochemistry and electro-metallurgy. This laboratory is the property of the mines branch of the Canadian Department of Mines.

The first investigation, which is now well under way in this department, and which is being done for the mines branch, Department of Mines, Ottawa, has to do with the utilization of the element cobalt. (Canada has produced and is producing millions of dollars worth of cobalt, estimating it at a fair market value, of which only about one-third finds its way into the industries). Although this metal is in many respects similar to nickel, yet, no important alloys of it with other metals are in use. An exhaustive series of researches is therefore being undertaken on "The Metal Cobalt and Its Alloys," for the purpose of increasing its usefulness in the industries.

This research, among others which this new department is conducting, requires an electrical equipment of the most modern type. The laboratory is supplied with electrical power from the power plant of the School of Mining, which is being enlarged for the purpose, and has suitable transformers, bus-bars, switch-boards, etc., to operate its furnaces at any current up to 3,000 amperes, and at varying voltages up to 120 volts. This power equipment, situated as it is in the splendid new Nicol Hall, and with the most modern auxiliary apparatus is probably the most complete electro-metallurgical laboratory in the world.

A 28,000 H.P. ZOELLY STEAM TURBINE.

The firm of Escher Wyss & Co., in Zurich, Switzerland, Canadian office in Montreal, has recently delivered to the Rheinisch-Westfelischen Electric Generating Station In Essen the most powerful steam turbine ever built. When running at a speed of 1,000 revolutions per minute it develops 22,500 h.p. eff. under normal continuous working, with a pressure of 150 lbs. per square inch gauge and a steam temperature of 572 deg. Fahr. at the stop valve and a vacuum of 27.5 inch. (A higher vacuum cannot be obtained owing to the fact that only re-cooled water is available for the condenser). The turbine is also capable of developing 28,000 h.p. continuously and 30,000 h.p. for short periods.

This turbine is of the well-known standard "Zoelly" type, of which the Escher Wyss Company have turned out over 225 in number up to the present, aggregating a total output of about 500,000 h.p. The machine has 14 runner wheels, mounted on a strong steel shaft, the total weight of the rotor being 26 tons. The total weight of the generator rotor (Siemens Company's make) approximates 60 tons.

The two rotors coupled together are supported by four bearings being supplied with about 130 gallons per minute of oil for lubrication. This oil is under pressure produced by a pump driven from the main shaft. During the period of starting the main unit the pressure oil is produced by a small centrifugal pump connected directly to a separate tiny steam turbine. When the main unit has attained full speed, this auxiliary turbine is shut down. The oil is conducted from the bearings to an oil tank, where it is cooled down in solenoids of copper, and is then pumped back to the bearings. The oil is consequently used over and over again, and only from time to time a small quantity is needed to replenish the supply.

The exhaust steam is led through a branch of 8 feet diameter to the surface condensing plant, located beneath the turbine, the cooling water being supplied from a cooling tower. A separate turbo-pump then delivers the condensed steam into a hot well, from which the water is in turn delivered to the boiler feed pump.

The attendance of this gigantic turbine-driven alternating unit with its condensing plant is overcome with ease by only three men on each shaft.

LOSSES OF EXPOSED STEAM PIPES.

In a paper read before the British Association it was stated that the effect of the density of the surrounding air greatly enhanced the loss of heat from exposed steam pipes, and that under experimetal pressures of 2,000 lbs. per square inch the heat loss became enormous. Other experiments under normal conditions demonstrated that 1-in. uncovered steam pipe lost in free air 3 b. t. u. per square foot per hour per degree of temperature difference. Out of this total only 15 per cent. was due to radiation and 4 per cent. to conduction. The remaining 81 per cent. was found to be wholly due to convection. In experiments with insulating material it was found that the best of such materials had some thirty times the conductivity of air, so that, were it not for reducing the convection, pipe covering would actually increase the loss of heat instead of diminishing it. This was borne out by the discovery that the heat loss from pipes depended very largely upon the closeness of the packing. If the insulation was very tightly packed, the efficiency was low owing to the increase in conductivity, while, on the other hand, if packed too loosely a large proportion of the convection would still continue. For this reason it appeared that for each class of insulation a certain density of packing was best. In the case of slag wool, this was found to be one-fourteenth the actual density of the individual fibres. In that case the loss by conduction through the insulation to the air would be raised from 0.1 b. t. u. to 0.4 b. t. u. per square foot per degree per hour; loss by convection would be reduced from 3.2 b. t. u. to 0.1 b. t. u. per square foot per hour, the net loss being thus one-seventh of what it would be with bare piping. With bare pipes the character of the service had a distinct influence, but this affected only the loss by radiation. With a good machined surface this loss was reduced from 15 per cent. of the total to about 7 per cent., and if the piping were polished to a mirror-like surface this loss was still further reduced to about 3 per cent. of the total. The loss by convection was not, however, affected in any way, and, as this was the main factor constituting as aforesaid 81 per cent. of the total loss, there was very little to be gained by polishing in the case of ordinary steam pipe temperature. Another factor which was considered was the diameter of the piping. With a small radius the conduction loss was found to become more important, so that the total loss varied with the diameter of the pipe. It was, however, found that this increased loss by conduction only became important with pipes less than ½-in. in diameter, although, as had been previously shown, the loss in the case of fire wires becomes enormous. For pipes above 4 in. in diameter the loss was found to become nearly constant at 2 b. t. u. per square foot per degree per hour irrespective of the diameter.

In connection with the extension of the waterworks of Glasgow, the tunnel which is being made in Rob Roy's country at Inversnaid to connect Loch Arklet with Loch Katrine has just been bored through. The length of the tunnel is 3,900 ft., and the inside dimensions are 12 ft. by 10 ft. The boring operations were commenced over two years ago, but owing to the hardness of the rock the progress has been slow. At each end of the tunnel large basins are to be built.

COAST TO COAST.

Calgary, Alta.—Mayor Mitchell was accorded the honor of turning the first sod in connection with the construction of the Canadian Northern Railway subway entrance to this city.

Province of British Columbia.—It is estimated that the cost of double tracking the lines of the Canadian Pacific Railway traversing the Rocky Mountains will be about $30,000,000.

Ottawa, Ont.—The municipal council have been named defendants in a large number of damage claims arising out of death and disablement following the recent outbreak of typhoid fever.

Vancouver, B.C.—Up to date the expenditure on the Burrard Peninsula joint sewerage has been $21,280, out of the total amount of $35,000 agreed to be spent during the year in preliminary work. To this amount Vancouver contributes $14,000, and South Vancouver, Point Grey and Burnaby, $7,000 each.

Ottawa, Ont.—Twenty-one out of the one hundred and eight joints of the river section of the new intake pipe have already been repaired by divers employed by Messrs. Laurin and Leitch, the Montreal contractors, as far as fixing the bolts or putting on clamps is concerned. To make assurance doubly sure it is the intention to encase each joint in concrete which work will take some time still.

Toronto, Ont.—The Provincial Board of Heath of Ontario contemplate in the near future the oppointment of an engineer to the staff, who will be available to give all municipalities advice as to the sort of works they should construct in connection with plans for waterworks and sewage disposal systems. This will allow the municipalities to engage any engineer they may wish to carry out the work.

London, Ont.—Mr. H. J. Glaubitz, general manager of the hydro-electric department in this city, has presented a good report showing the result of the operation of the utility for the past few months. The statement shows that for the first ten months the department has a gross surplus of $31,-784.61, and a net surplus of $15,046.73. This is looked upon as exceptional in view of the fact that $7,000 for the solicitation of business has been charged against revenue.

British Columbia.—The fact that the coal deposits found along the shores of the Pacific are of pre-tertiary origin, and yield no coke, is a circumstance which so greatly hampers the development of the iron industry in British Columbia that the latter, in fact, has to fall back upon suitable imported coke. This being so, Russian enterprise is now being urged to commence the exploitation of the rich deposits of coal in the Island of Saghalien, which are supposed to be the best in the Pacific Ocean, but which hitherto for some reason have been entirely neglected. The geographical position of these deposits is favorable for the export to British Columbia of coal or, perhaps, coke.

Vancouver, B.C.—The city council passed an agreement between the municipality and the Canadian Northern Railway by which the city is prepared to deed over to the railway company 110 acres of tide flat property. The agreement will go before the ratepayers in November. The company will spend $4,000,000 in terminal facilities and $4,000,000 in a tunnel entrance to the city, four miles in length. The proposed depot will cost $1,500,000, and a first-class hotel will be built.

Marlboro, Alta.—Three rotary kilns, each 140 feet in length, eight feet in diameter, made of steel ranging from three-quarters to fifteen-sixteenths of an inch in thickness and weighing 150,000 pounds, exclusive of base and gear, arrived in the Grand Trunk Pacific Railway Company's north yards from Alliance, Ohio, consigned to the Edmonton Portland Cement Company at Marlboro, Alta., 144 miles west of Edmonton. Twelve flat cars, six of which carried the ends of the kilns on swivel blocks, were required to convey the machinery, which weighed 450,000 pounds.

Coquitlam, B.C.—An old proposal to construct a dam across the Second Narrows and thus convert the eastern end of Burrard Inlet into a fresh water lake has now been revived by the municipal council of Coquitlam. This body has forwarded a request to Hon. Frank Cochrane, minister of railways and canals, to withhold sanction to the Second Narrows bridge project until the municipality has had an opportunity to prepare plans for a causeway and locks, and forward them to the department. The application has a connection with a scheme to connect the headwaters of the Pitt River with the Inlet by means of a canal.

Victoria, B.C.—Following the recent educational campaign of the university authorities and parliamentary officials regarding forestry and lumbering methods, the management of the Victoria Lumbering and Manufacturing Company have made a practical application of these teachings and have, after installing a logging railroad, given instructions that all underbrush, snags, down logs, or whatever else might help to spread a fire must be cleared away for at least a hundred feet on each side of the track. This is probably the first time that adequate precautions of this kind have been taken by any lumbering company in this province.

Ottawa, Ont.—The Secretary of the Dominion Railway Board has sent out a circular to the railroads informing them that in all cases of bridge work over water in which there might be the slightest doubt as to it being navigable or not, the railway companies must, in addition to the papers now forwarded in support of their applications, furnish the Railway Board with evidence showing that the question of the navigability of the water has been, in the first instance, taken up with the Department of Public Works; and, secondly, that if the department deems the waters to be navigable, the structure is satisfactory to that department.

Province of Ontario.—The Great Lakes International Pure Water Association and the National Association for Preventing the Pollution of Rivers and Streams will meet in Cleveland on the 23rd and 24th of this month. Dr. Chas. E. Hodgetts of the Conservation Commission, Dr. J. W. S. McCullough of the Provincial Board of Health, Prof. Amyot, provincial bacteriologist, and Dr. Charles Hastings, Toronto, will represent the Canadian interests. The whole range of subjects dealing with water contamination will be discussed, and the conclusions of the conference will be forwarded to the International Joint Commission, which meets to deal with the question next month.

Detroit, Mich.—The Livingstone Channel in the Detroit River, one of the two most important engineering feats on the great lakes, which has cost the United States Government fully $10,000,000, has just been formally opened for navigation. The plans for the initial opening were in the hands of Lieut.-Col. M. M. Patrick, chief the of the United States engineers in charge of the Detroit district, representing the War Department; George A. Marr, Cleveland, secretary of the Lake Carriers' Association; and Homer R. Warren, president of the Detroit Board of Commerce. The length of the channel is eleven miles; its width 300 to 800 feet, and its depth 23 feet, and it has been under construction for the past four and a half years.

Midland, Ont.—At a meeting of the citizens of Midland held recently the construction of the Central Canadian Railway from Midland to Montreal was approved. This company have had a charter for some years and are entitled to a very large land grant under a charter granted before confederation. The company have recently floated their bonds in England and have let a contract to a large English contracting corporation for the construction of the railway from Montreal to Midland. An offer has been made to the Dominion Government to grant running rights to the Intercolonial Railway from Montreal to Midland, thus giving the government road a much needed outlet to the lakes and providing them with the means of securing western freight.

Vancouver, B.C.—Mr. E. H. Heaps and Mr. H. Schaake, of the Heaps Engineering Co., successors to the Schaake Machine Works, met the finance committee of the city council of Vancouver and discussed the details of the agreement, whereby the engineering company will lease from the city 697 feet of land on Lulu Island at a yearly rental of $1,742.25, provision being made so that the company can purchase the land at the end of five years for $69,700, or $104,550 if purchased within seven and a half years, and the price to increase to $139,400 if purchased after that time and up to ten years. The company agrees to employ not less than 100 employees and during the term of the lease shall employ white men only. A by-law will be submitted to the ratepayers to ratify the agreement.

Toronto, Ont.—Commissioner of Works Harris states that in his opinion it will not be possible to secure the requisite equipment in sufficient time to operate the civic car lines this winter. To do so, he states, it will be necessary to erect transformer houses, design and build machinery, and erect feed wires, as well as to secure snow sweepers, etc. A gasoline motor or storage battery car might be operated, but sufficient experience has not been gained with these types of unit to justify him in recommending their use. Again, the line has been built with the overhead structure required for trolley operation. Respecting this, the Board of Control recommend that the Commissioner of Works be given full authority to establish an electric service on the above branch of the civic car line system.

Gretna, Man.—The Savoie-Guay Company, of Plessville, P.Q., have been experimenting in this province with a new auto plow of their own manufacture. The machine is of 45 horse-power, and it is claimed to be an entirely new idea in auto plows, as the engine is all in front of the plow, and the weight is all carried on the two main wheels, on which the motor chains are attached, which drive the machine. The machine is steered by a wheel in front of the driver, similar to an auto, and the steering is controlled by a small wheel at the rear. This auto plow plows an acre and a half an hour. Another feature about the machine is that it can be used for other purposes, such as drawing grain to the elevator, and can also be used to draw a binder, in fact anything that a tractor can be used for, for driving all classes of machinery on the farm, an outstanding feature being the fact that it total weight is only 5,000 lbs.

The Canadian Pacific Railway.—The ratio of the working expenses to the traffic receipts of the Canadian Pacific Railway was as follows during the years ending with 1911-12 inclusive:—

Year.	Ratio. Per Cent.	Year.	Ratio. Per Cent.
1902-3	63.97	1907-8	69.47
1903-4	69.42	1908-9	69.72
1904-5	69.35	1909-10	64.38
1905-6	62.75	1910-11	64.87
1906-7	64.96	1911-12	65.06

The ratio was thus at its lowest in 1905-6, while it attained its maximum in 1908-9. The Canadian Pacific Railway is made up of a great number of new lines, most of which have not yet fully developed the local traffic which they are capable of carrying. The length of line in operation upon the system in 1902-3 was 7,748 miles; in 1911-12 the corresponding total was 10,990 miles. The receipts in 1902-3 were $43,957,000; in 1911-12 they had expanded to $123,319,000. But while the Canadian Pacific Railway has yet to develop its full carrying powers and productibility as regards local traffic, one important reason for the high ratio of its working expenses is the high cost of labor. The growth of population will probably moderate this difficulty, and it will certainly add year by year to the local business of the system.

Regina, Sask.—We are informed through Mr. A. J. McPherson, chairman of the Board of Highway Commissioners of Saskatchewan, that Dr. W. W. Andrews, of the Highway Board, has been engaged for some time past in investigating the practicability of treating the gumbo clays, which are spread so extensively over the Province of Saskatchewan, so as to make them more suitable for road purposes. Quite a large section of the Province lying from Weyburn north-west to the Elbow, on the South Saskatchewan River and north of the South Saskatchewan to the Alberta line, consists of a gumbo clay which does not lend itself to making satisfactory roads. Even an application of gravel or broken stone is not a success, as the clay is of such a nature that when dry it is exceedingly hard, and it is almost impossible to prevent hummocks or lumps forming on the road, and when wet it will turn into a liquid, and in a very short time any porous material that is put on the road will be impregnated with this liquid and lost. Dr. Andrews made experiments with tannic acid, which when applied to this clay will take away some of these qualities, the tannic acid being obtained from ordinary straw or hay by means of a certain process. This method has not proved itself up to the present to have a likelihood of success. He has also devised a method of calcining clay by means of burning lignite or straw in a form of kiln on the road. The result from this seems to show that there is some hope of success. When the clay is calcined in this way it does not form a mud, as it will in its natural state, and an experimental piece of road is now being tried on a practical scale with the object of seeing how the objects from the calcination process will stand the traffic; also to find out what it will cost to do a unit length of road by this method.

Toronto, Ont.—The local Board of Health states that during the month of September, water samples have been taken all over the city, including all the pumping stations, the reservoir, and the various districts of the city, in order to detect any other possible source of contamination. The taste which developed in the water at Exhibition time began at the same time that the filters were put in operation, and was undoubtedly due to a combination of the tar from the sand boxes in the filters, the hypochlorite, and probably to an organic material from growth in the underdrains of the filters while standing idle for two months. The same amount of chlorine was being used as has been in use for several weeks before, and the taste was not due to free chlorine, but to a combination that could not have been foreseen. Experiments carried on in the laboratory proved the correctness of this fact, though the filtered water itself had no taste of creosote or tar. The reason why the taste always developed in the early morning hours was only detected by two of us spending two nights at the main pumping station, when we found that the water pumped dropped from approximately 45-48 million gallons down to 40 millions or lower. This simply meant that in the early morning it was practically only filtered water which was being pumped and the taste would then develop with the filtered water and chlorine where it would not develop when 8-10 million gallons of unfiltered water was mixed with the filtered water. We had, therefore, to reduce the amount of free chlorine from over .3 parts per million down to .1 part per million, before we could eliminate the taste, and as it was then dangerous to have from 8-10 million gallons of unfiltered water and almost unchlorinated water coming into the city, all of the water was put through the filters. Now that the filters have been washed free from the material responsible for the taste, we have been able to increase the amount of chlorine to .25 parts per million without producing taste. Tests for B. Coli while the sand is being stirred up by the pump at the John Street well will be without significance, and in general terms it may be said that Toronto water, as long as it is filtered and chlorinated, is safe drinking water. The water used at West Toronto and East Toronto, however, is not safe, because at times the water is muddy and the chlorine does not work so efficiently. When the sewage is transferred to Morley Avenue and put into the lake, it will make the West Toronto supply very much safer, and the East Toronto supply less so. At present it is only the chlorine that stands between the people and the possibility of sewage infection, and though this has proved satisfactory most of the time, it must be recognized that at the time when the water is muddy and at the worst, the chlorine is not so efficient.

AMERICAN SHIPBUILDING COMPANY'S CANADIAN PLANT.

The company's plant at Port Arthur is referred to in the annual report of the American Shipbuilding Company for the year ended June 30th, 1912. That plant is stated to be in full operation, with contracts for steamers that will keep it busy for the next six to eight months, with additional negotiations pending. It is also well employed in dry dock and repair work. A considerable part of its equipment has been completed and is in operation, and its permanent machine shop, joiner shop and power plant are well under way toward completion.

The surplus of the company for the fiscal year was 0.36 per cent. on the common stock as against 1.1 per cent. in 1911. There was a balance of $580,699 as compared with $637,228 in the previous year. During the year up to the close of navigation, in 1911, marine business continued very dull and discouraging to the vessel interests; but the opening of navigation this year was more encouraging, and at the end of the company's fiscal year there was a fair revival in business.

The company has built and completed twelve vessels and has now under construction nineteen, among them a side wheel passenger steamer, larger than the one built last year, and which, when completed, will be the equal in type, construction and finish to anything afloat on inland waters.

RAILROAD RATES ON PULPWOOD.

Argument was heard before the Dominion Railway Commissioners recently in the application of the International Paper Company, of New York, and a large number of Canadian firms to have the railways justify their recent increase of approximately 1½c. from Ontario, Quebec and New Brunswick points to New York State on pulpwood. The Canadian Pacific Railway, Grand Trunk and Canadian Northern were represented and urged that the new rate was a substitution for a blanket rate which had originally covered a very large territory. On account of the extra haul a line through Richmond, Quebec, had been taken as a dividing point and rates increased beyond that, the advance chiefly affecting American mills. Warning has been given shippers so as to allow them to take the increase into their contracts. The pulpwood interests, on the other hand, urged that the present rates are high enough.

BRANCH OFFICE IN WINNIPEG.

The Canadian Domestic Engineering Company, Limited, have opened a branch office in Winnipeg, to handle its Western business. This company has a very large contract in hand for the new Parliament Buildings at Winnipeg, Manitoba.

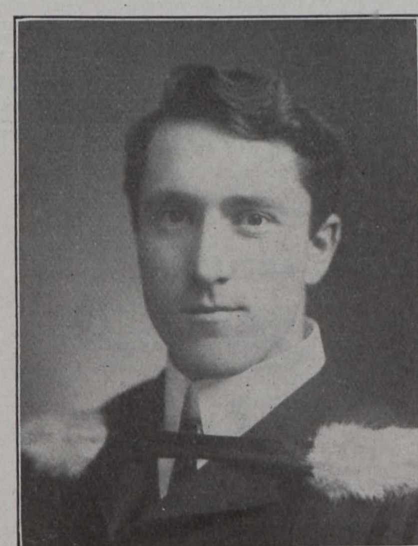
PERSONAL.

MR. C. O. MAILLOUX has been appointed assistant to the president of the Granby Consolidated Mining Co., of Canada. This is a new position.

MR. A. W. DAVIS, mining engineer for the Consolidated Mining and Smelting Co., of Canada, has returned to Trail, B.C., after examining prospects in the Skeena district.

MR. WILLIAM H. NICHOLS has been chosen president of the Granby Consolidated Mining, Smelting and Power Co., in place of G. M. Luther, who retires on account of ill-health.

MR. WILLIAM R. WORTHINGTON, B.A.Sc., who has been recently appointed chief sewer engineer for the city of Toronto, was born and educated in Toronto. He is a graduate in civil engineering of the Faculty of Applied Science and Engineering of the University of Toronto, in the class of 1904, and since that time has been chief assistant in the sewers department. During this time he has had charge of the design and construction of some of the largest sewer systems in Toronto, and indeed, in the Dominion. These systems required expert technical knowledge and foresight to meet the extraordinary growth of that city.



Mr. Wm. R. Worthington.

MR. J. M. TURNBULL, mining engineer for the Consolidated Mining and Smelting Co., of Canada, has been chosen a member of the first senate of the newly organized University of British Columbia.

MR. C. N. CLARKE, of New York, president of the Minnehaha Mining Co., recently visited the mine, situated in the Manitou Lake mining district of Ontario, in connection with negotiations for its sale.

MR. F. H. SYKES, O.L.S., D.L.S., until recently Assistant Structural Engineer in the Toronto City Architect's Department, has been appointed Chief Examiner of Plans for the same Department. Mr. Sykes is an honor graduate of the School of Practical Science of the class of 1905.

MR. H. G. SALISBURY, Chief Examiner of Plans of the City Architect's Department, Toronto, has tendered his resignation to the Board of Control. In accepting the resignation, the Board have recommended that his salary be paid until the end of the year in view of his past satisfactory services.

MEETINGS.

Dr. Chas. Hodgetts, of the Conservation Commission; Dr. J. W. S. McCullough, of the Ontario Health Department; Prof. Amyot, Provincial Bacteriologist, and Dr. Charles Hastings, M.O.H. for Toronto, represented Canada at the meeting of the National Association for the Prevention of the Pollution of Water, which was held in the city of Cleveland, Ohio, October 23rd and 24th last.

COMING MEETINGS.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Monthly Meeting will be held in the Rooms of the Society, 413 Dorchester Street West, Montreal, November 7th. Chairman, Henry Holgate.

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

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

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

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

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

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

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

ENGINEERING SOCIETIES.

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

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

OTTAWA BRANCH—
177 Sparks St. Ottawa. Chairman, 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, 911 Rogers Building, Vancouver, B.C. Headquarters: McGill University College, Vancouver.

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

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

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