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Volume 24 Toronto, June 19, 1913

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The Canadian Engineer

An Engineering Weekly

METHODS OF RAPID SAND FILTRATION

GENERAL DESCRIPTION OF SYSTEM — COAGULATING CHEMICALS FOR CLARIFYING RAW WATER—OPERATING DEVICES—COST OF CONSTRUCTION AND MAINTENANCE*

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RAPID sand filtration first attracted attention as a method for purifying public water supplies in 1885, when a rapid filter plant was built to treat the supply of Somerville, N.J. Since that time this method has come into use in more than 350 cities in different parts of the world and supplies a total daily demand of considerably over 700,000,000 gallons. The largest plant of this type is installed at Cincinnati, Ohio, and has a daily capacity of 112,000,000 gallons. Others are located at Columbus, Ohio, capacity 30,000,000 gallons daily; Hackensack, N.J., capacity 24,000,000 gallons; Harrisburg, Pa., capacity 20,000,000 gallons; Little Falls, N.J., capacity 32,000,000 gallons; Louisville, Ky., capacity 36,000,000 gallons; Toledo, Ohio, capacity 39,000,000 gallons; and New Orleans, La., capacity 40,000,000 gallons. Among the larger rapid filter plants under construction in 1911, were those at Minneapolis, Minn., daily capacity 39,000,000 gallons, and at Grand Rapids, Mich., daily capacity 16,000,000 gallons.

Of the three score rapid filter plants in foreign countries the largest is that at Alexandria, Egypt, capacity 12,000,000 gallons daily. Similar works of even greater capacity are under construction at Kyoto, Japan, and at Cairo, Egypt.

The essential differences between rapid sand filters and slow sand filters are as follows: In the rapid sand filters, the filter units are much smaller; the sand grains comprising the filter bed are much coarser; a coagulant is always used in preparing the raw water for final filtration; the rate of filtration is in round numbers forty times that ordinarily used in slow sand filters; and the whole filter bed, when dirty, is cleaned in the tank itself by forcing water upward through the sand instead of scraping off the surface layers as in slow sand filters.

Up to 1902 rapid sand filters were of more or less uniform design. They were contained in wooden or steel tanks of comparatively small diameter, and the more economical concrete construction had not as yet been attempted. At the commencement of the classic investigations into this process of water purification, conducted at Louisville, Ky., under George W. Fuller, in 1895-1898, even the process itself had not proved its usefulness in the purification of large volumes of water. Provisions for adequate preparatory treatment of the raw water were rarely made, and the whole subject of the suitable design and operation of such works was but little understood.

The need of adjusting the design of rapid filter plants to meet local requirements began to be fully realized when the plant at Little Falls, N.J., was built in 1902 for the East Jersey Water Company. In this plant suitable provision was made for the accurate application of the coagulating chemical (sulphate of aluminum) to the raw water. A basin of adequate size was provided in which coagulation and sedimentation of the raw water could take place. The filter tanks themselves were built of concrete, for the first time, and were rectangular in plan. Improved facilities were installed for agitating the sand layer with compressed air during washing. Neat operating tables, from which all valves could be operated and motors started and stopped by hydraulic power, took the place of the less neat and convenient wheel stands. With the Little Falls plant the modern ideas of proper design for rapid filter plants began to be realized, and its construction marked a most important epoch in municipal water filtration.

Nearly all rapid filter plants are now built of concrete, although wooden and steel tanks are still used for small installations. The filter tanks are ordinarily built monolithic, and embedded in the floor of the tanks is the underdraining system, composed of perforated pipes or strainer cups, designed to permit the filtered water to pass out without allowing sand to escape and to permit an even distribution of water throughout the sand layer when the filter is being washed. Over the strainer system a shallow layer of coarse sand or gravel is placed, and on this rests the sand layer which forms the filter proper.

When the raw water has been sufficiently clarified by coagulation and sedimentation it is passed on to the surface of the filter, over which water ordinarily stands to a depth of several feet, and allowed to pass downward through the bed at a rate of 100,000,000 to 120,000,000 gallons an acre daily, such rates being automatically controlled by special devices. This corresponds to a rate of 2,310 to 2,760 gallons a day on 1 square foot of filtering surface.

The water applied to the filter always contains a considerable amount of coagulated matter, such as mud, vegetable stain, and bacteria, which is retained at or near the surface of the bed. As operation is continued the frictional resistance in the sand layer increases to a point where it is necessary to close the filter for washing. At such times the water standing over the bed is drained down to the level of the overflow gutters, which are located a foot or more above the sand layer, and filtered water is then forced upward through

* Extracted from United States Geological Survey Report, 1913, "The Purification of Public Water Supplies."

the filter, being evenly distributed by means of the strainer system. The material which has accumulated on the top of the sand is thus washed out, and the dirty wash water overflows into the gutters, thence to pass to the sewer. Such a washing operation ordinarily consumes about 10 minutes from the time the filter is closed down until it is again thrown into service.

The rapid filters just described are the type more commonly used; they are known as "gravity" filters and are contained in open tanks.

There is another type, known as "pressure" filters. Such filters are contained in closed steel shells. This type of filter is more extensively employed for household and industrial use, and in some places it is found to be more economical and convenient than the gravity filter. The largest municipal plants of the pressure type are located at Davenport, Iowa, capacity 9,000,000 gallons daily, and at San Diego, Cal., capacity 5,000,000 gallons daily.

Coagulating Chemicals.—The chemicals most commonly used for the coagulation of water are compounds of aluminum and iron, and of these potash alum sulphate of alumina, alumino-ferric, and sulphate of iron are the most extensively employed.

The manufacture of alum is of great antiquity, and for many centuries this chemical has been used in far eastern countries for coagulating water as an aid to clarification. The manufacture of aluminum sulphate from bauxite and alum clay is of more recent origin. The process of making alumino-ferric from bauxite was patented by P. and F. M. Spence in 1875. The sulphate of iron used in water coagulation is for the most part a by-product of iron and steel industries.

The choice between the different coagulating chemicals is properly based on their efficiency as coagulants, and this refers directly to the percentage of available aluminum or iron which they contain. Potash alum, sulphate of aluminum, and alumino-ferric cost about 1 cent a pound; sulphate of iron costs about half a cent a pound. In this country sulphates of aluminum and iron are the most widely employed in water purification, but at the waterworks at Tokyo, Japan, potash alum is used. Sulphate of aluminum is the coagulant in the works at Alexandria, Egypt, and also in practically all rapid filter plants in Europe, India, and Egypt, except at the waterworks at Calcutta, India, where alumino-ferric is used.

In composition these chemicals show considerable variation, but they may be bought on a basis of a guaranteed percentage of available alumina or iron oxides. The essential feature is that the chemical shall be basic, that is, shall contain more aluminum or iron than the equivalent of the sulphate radicle present. The approximate composition of these chemicals now on the market is as follows:

Approximate Percentage Composition of Coagulating Chemicals.

Constituent.	Pure potash alum	Sulphate of aluminum	Alumino-ferric	Sulphate of Iron
Matter insoluble in water	.....	0.30	0.06	0.50
Alumina (Al_2O_3)	10.77	17.00	14.26	.....
Iron oxides (Fe_2O_3 and FeO)	.....	.25	.60	57.50
Potash (K_2O)	9.93	.....	.....	.....
Sulphur trioxide (SO_3)	33.76	38.70	35.81	28.80
Water (H_2O)	45.54	43.75	49.27	13.20

When potash alum, sulphate of aluminum, or alumino-ferric are applied to a turbid water the chemical is rapidly decomposed. The strong sulphate radicle of the chemical displaces the weak carbonate or bicarbonate radicle in the water, and an equivalent amount of carbon dioxide is liberated. The white, insoluble, and gelatinous aluminum hydrate that is formed absorbs the dissolved color and envelops and brings together into comparatively large aggregates the mud and the bacteria in the water. These flocks of coagulated matter are removed with comparative speed by subsidence.

Generally speaking, the application of these coagulating chemicals to a water will bring about a slight increase in the amount of incrustants in the water and a decrease in temporary hardness. The total hardness of the water—that is, the sum of the temporary hardness and the incrustants expressed in terms chemically equivalent—will remain unchanged. The increase in incrustants has some significance as regards corrosion of uncoated iron and incrustation in boilers; but, practically speaking, these are factors of comparatively little importance in view of the relatively small amounts of the coagulating chemical ordinarily employed.

Most surface waters naturally contain more than sufficient carbonate and bicarbonate radicles to make possible complete decomposition of the chemical which is applied for coagulation. In some waters, however, the natural alkalinity is so low, particularly at times of floods, that this is not true, and for such waters it is necessary to make up the deficiency by applying soda ash or lime water before the coagulant is added.

Sulphate of iron, known commercially as copperas, is obtained in two grades, namely, the ordinary commercial by-product from iron and steel manufacturing, and the higher-grade sugar copperas manufactured by a vacuum crystallizing process.

The use of copperas in water purification introduces more complicated features than alum compounds, chiefly for the reason that lime is required for the precipitation of the iron. When added to a natural water the copperas is decomposed somewhat like alum except that the formation of the hydrate of iron takes place very slowly. By adding lime in the form of limewater or milk of lime rapid formation of insoluble iron hydrates is induced. In general terms it may be stated that to obtain satisfactory results from the use of lime and iron as coagulants it is necessary to make use of sufficient lime to neutralize and precipitate the iron. The use of too little lime results in poor coagulation, caused by the incomplete precipitation of the iron, some of which is usually left in solution and appears in the effluent of the filters. The use of too much lime results in the formation of lime incrustants, which deposit in the air and strainer systems and cause much trouble through clogging.

Water treated with lime and iron will show an increase in permanent hardness, as compared with the effect of the use of compounds of aluminum. In general the aluminum salts are considered more satisfactory as coagulants; they remove color from water more rapidly and completely and make it possible to obtain by filtration a more brilliant water than do iron rails.

Devices for Application of Coagulants.—No department in a filtration plant is more important than that wherein the coagulating chemicals are applied to the water. To obtain satisfactory results from the plant as a whole and the filters in particular, it is necessary that the application of the coagulating chemicals be at all times under strict and accurate control and be adapted to the quality of the water to be filtered. Material variation in the dose of the chemical applied to the water or in the quality of the water means overdosing or underdosing. The former results in a waste of the chemical and sometimes in undecomposed coagulant in the filtered water, and the latter results in incomplete coagulation and impaired efficiency. Owing to the high rates of filtration used in rapid filters undercoagulated water will leave the filter in a less purified state and will possess an undesirable turbidity. The filter will run longer without washing because of the slower accumulation of coagulated material, but the efficiency will be poor.

The different types of device for the control of the application of chemicals are very numerous and are all designed to be as nearly automatic as possible. The appliances which have given the best results are those wherein provision is made for the application of the solution under a practically constant head through an orifice which can be adjusted at will. The depth of solution over this orifice should not be less than 6 inches, and this depth may be maintained by allowing slightly more of the solution to be delivered into the orifice tank than is allowed to escape through the orifice, the excess being discharged back into the main solution tank through an overflow, or by means of a float valve. The overflow is by all odds the more reliable.

The sulphates of iron and aluminum have a corrosive action on almost all metals, and it has been found advisable to make all of the metal parts which come in contact with the solutions of lead, copper, or special bronze. It is sometimes found advantageous to use hard rubber piping, valves, and orifices, but the cost may preclude the use of such material. Rubber piping and valves are easily broken, and the cost of replacement may prove no inconsiderable item. Generally speaking, however, the decision as to the kind of metal to use depends on the relative cost of the cheaper iron and its correspondingly higher cost for repairs and replacements and the ease with which repairs can be made, and the higher first cost of more expensive materials and the lower cost for upkeep.

Improved Devices for Filter Operations.—As already pointed out, it was not until 1902 that marked improvement was made in the direction of making easier the manipulation of valves and other apparatus, which has so much to do with the successful and economical operation of a rapid-filter plant. Until that time all valves, without exception, were opened and closed by hand. When a filter required washing, it was necessary to close the influent and the effluent valves, and to warm up the steam wash-water pump preparatory to supplying wash water to the filter. Now the operator moves a lever at an operating table, and by means of hydraulic cylinders valves are opened or closed with practically no manual effort or loss of time. Electrically driven wash-water pumps have largely supplanted the steam pumps, and the operator starts and stops this pump merely by pressing a button at the same operating table. Air compressors, which supply air to the filters during washing for the purpose of agitating the sand layer, have in most large plants taken the place of the steam-driven rotary agitators, and these compressors are also started and stopped by pressing a button on the operating table.

As time savers these various improvements more than pay for themselves, and the neat appearance of the newer plants is a vast improvement over the older plants with their multitude of wheel stands.

Filter Washing.—When a rapid filter has become so clogged with coagulated matter that the normal rate of filtration can no longer be maintained, the influent valve is closed and the water standing over the sand layer is drawn down to the top of the wash-water gutters. The effluent valve is then closed and the wash-water pump is started. This pump forces filtered water up through the sand layer until it is freed of practically all of the accumulated matter. The pump is then stopped, the influent and the effluent valves are opened, and filtration is resumed. In some places the filters are washed by water delivered under the requisite pressure from an elevated tank.

During the process of washing a filter it is the practice in the majority of the newer rapid-filter plants to break up the sand layer with compressed air before turning in the wash water in order to facilitate and accelerate the cleaning of the sand grains. In some places, as at Cincinnati, Ohio, and New Orleans, La., no provision is made for agitating the sand layer during washing other than such agitation as induced by the upward flow of wash water. In the older plants, and in some of those recently built, wherein the filter tanks are circular in plan, the sand is agitated during washing by means of rake teeth attached to arms which revolve, driving the teeth through the sand.

When washing a filter the rate of application of wash water must not be too low, and on the other hand it must not be too high, or sand will be carried from the bed with the wash water. Ordinarily the best rate of application of wash water is about 6 to 8 gallons to the square foot a minute, which corresponds to a vertical rise of about 1 foot a minute.

This is equivalent to three to four times the rate of filtration. When wash water is driven upward through a filter bed of normal construction at these rates, the sand layer will rise from 3 to 5 inches, but practically no sand will escape from the bed except during the early stages of operation of a new filter.

Before the modern appliances for facilitating the labor of operation were installed it was not unusual for periods out of service for washing as great as 30 minutes to be recorded, and frequently the time consumed was even longer. In the more recent filters this period rarely exceeds 10 minutes from the time the effluent valve is closed until it is again opened.

Control of Rate of Filtration.—If uniform rates of filtration are required for the successful operation of slow sand filters, then uniform rates are of even greater importance in rapid sand filters. The reason for this is plain. Slow sand filters are operated at actual rates of about 3,000,000 gallons an acre daily; rapid filters are operated at rates from 30 to 40 times as high as this. A sudden fluctuation in these higher rates means a correspondingly greater shock, and impaired efficiency naturally follows.

Although within certain limits there is no particular objection to the rate of filtration in a rapid filter gradually diminishing, a sudden increase in rate will cause an almost immediate deterioration in the appearance and hygienic quality of the effluent. If the rate increases or decreases slowly and steadily no harm may result, but should the rate increase abruptly, even as much as 20 per cent., the effect of the change will usually be apparent from the inferior appearance of the filtered water.

Therefore, to maintain a constant rate of filtration in the rapid filter, automatic controllers are always used. There are many such devices, but the object of all it to maintain a uniform rate of discharge from the filter independent of the head on the outlet pipe on which the controller is located. Although many improvements in these devices have been made in recent years, the best of them subject the filter to fluctuations in rate of at least 10 per cent. Furthermore, on account of the tendency of floats and butterfly valves in these controllers to stick, such fluctuations may occur within a very few seconds. In drawing up specifications for controllers it is frequently stated that such variations from the normal rate shall not exceed 2 per cent., but this requirement is rarely if ever met. Nevertheless the controllers do practically the work required of them, and without them a rapid filter would be unable to maintain a high standard of efficiency.

Cost of Construction of Rapid Sand Filters.—It is almost as difficult to state the comparative cost of construction of rapid sand filters as of slow sand filters. Local conditions largely govern, and it is possible and feasible to build some plants much more cheaply than others, and at the same time obtain plants which will prove as efficient as those which are more complete and ornate. A summary of the more prominent installations and their cost indicates that unless some unusual features are encountered, as in the filters at Little Falls, N.J., where the flow throughout is entirely by gravity, compelling the use of relatively expensive deep structures, or the abnormally large preliminary settling basins at Cincinnati, the cost of a rapid-filter plant, exclusive of high-lift and low-lift pumping equipment, will be about $12,000 for each million gallons daily capacity. On the basis that the water consumption is 125 gallons per capita daily, the first cost to each consumer of such a plant would be about $1.50. At 6 per cent., the interest charges on such an investment would be 9 cents per capita annually.

The above-mentioned fixed charge on the cost of construction of rapid-filter plants is materially lower than that of slow sand filter plants, as would be expected. As a general proposition, it is not usually thought necessary to build large sedimentation reservoirs in which the raw water may be first settled before the coagulating chemical is applied and the water is allowed to flow into relatively small coagulating basins. Where turbid waters are to be purified by slow sand filter plants, large sedimentation reservoirs must be provided or preliminary filters made a part of the system in order to remove the bulk of suspended matter, which would speedily clog the slow sand filters and make the cost of operation of such filters unnecessarily high. The preliminary treatment factor has a great deal to do with increasing the first cost of construction of slow sand filter plants, and, furthermore, the much greater area of filtering surface required for these filters also explains why it costs so much more to build them. It must be borne in mind, however, that all figures of cost herein given are not to be considered as strictly comparable, but only as examples of what has actually been obtained in the construction in this country of filters of the slow sand and the rapid types.

Cost of Operation and Maintenance of Rapid Sand Filters.

Range of Cost.—In the cost of operation of rapid sand filter plants the size of the plant and the quality of the raw water are the main controlling features. Privately owned works are usually operated at lower cost than are those owned by municipalities. As a general proposition, however, the total cost of operation and maintenance of rapid sand filter plants, exclusive of the interest on investment and pumping charges, ranges in this country from about $3 to $5 for each million gallons of filtered water. For some plants the cost is even less than $3, and for others it is in excess of $5 for each million gallons. The following examples will show the cost of operation of several plants in this country.

The Little Falls plant is filtering about 30,000,000 gallons daily. The charge for superintendent and labor includes the salaries of the superintendent, one filter foreman, four filter attendants, an analyst, and a boy. On a basis of a yield of 30,000,000 gallons daily, the cost of operation for each million gallons of water filtered is as follows:

Cost per Million Gallons of Water Filtered at Little Falls, N.J.

Labor	$0.80
Coagulant	1.43
Heat	.35
Power	.22
	$2.80

No itemized costs of operation of the plant at Binghamton, N.Y., are available, but it is understood that the total cost is about $6 for each million gallons of water filtered.

During 1910 the Harrisburg filters were operated at an average rate of slightly over 9,000,000 gallons a day. The cost of operation for each million gallons during 1910 was $5.31 and was divided up as follows.

Cost per Million Gallons of Water Filtered at Harrisburg, Pa., in 1910.

Labor	$2.52
Coagulant	1.06
Supplies	.28
Repairs	.38
Coal	.63
Oil and waste	.07
Laboratory	.37
	$5.31

During the year 1910, which was a representative year, the average yield of the Cincinnati rapid-filter plant was 49,000,000 gallons daily. The total cost of operation and maintenance was $4.19 for each million gallons of water filtered, the charge being made up as follows:

Cost per Million Gallons of Water Filtered at Cincinnati, Ohio, in 1910.

Supervision and attendance	$1.98
Coagulant	1.93
Repairs	.28
	$4.19

Total Cost of Rapid Sand Filtration.—It has been stated above that the average cost of rapid sand filter plants is about $12,000 for each million gallons daily capacity, which cost will include the necessary filter building, the filters, and the coagulating and filtered-water basins. At 6 per cent. this cost corresponds to a fixed charge of about $2 for each million gallons. The addition to this charge of a fairly average figure for operation and maintenance makes the total cost of filtered water by the rapid sand filter system, exclusive of pumping charges, about $6 for each million gallons. On the basis of 125 gallons per capita daily consumption, the total cost of water filtration will be, according to these figures, about 27 cents per capita per annum. This estimate is approximate and is subject to considerable variation according to the conditions in various places. It is obvious that the larger the filter plant the lower will be the cost of operation per million gallons; and also that where waters require a great deal of coagulating chemical the cost of operation will necessarily be increased in proportion.

Efficiency of Filtration.—Slow sand filters will render water clear and practically free from turbidity and will remove a material percentage, probably from 20 to 30 per cent., of the dissolved color in waters stained by decaying vegetable matter. They are not able to treat successfully and economically the very muddy waters of the central western and the southern portions of this country unless such waters are first subjected to long periods of plain sedimentation or to shorter periods if coagulants are used. Rapid sand filters are capable of treating successfully practically all kinds of water, but are particularly applicable to the treatment of waters heavily charged with suspended matter or which are highly colored. The final effluent from such filters will contain practically no residual color or turbidity. Both types of filters will ordinarily remove all but about 1 or 2 per cent. of the bacteria originally present in the raw water.

In the following table are given a few representative samples of the efficiency of slow and rapid sand filters in cutting down the typhoid fever rate in communities where they are used. This is one of the best indices to the bacterial efficiency of filters. In addition to the reduction of typhoid fever effected by filters, it appears to be a fact that the death rate of a community is materially reduced by the substitution of a pure for a polluted water supply. At the International Engineering Congress, held at St. Louis in 1904, Allen Hazen made the following statement:[1]

* * * Where one death from typhoid fever has been avoided by the use of better water, a certain number of deaths, probably two or three, from other causes have been avoided. This seems the clear and logical conclusion from the statistics. It is not easy to explain how the water is connected with the deaths other than those from typhoid fever. It may be that a good water supply, used freely and with confidence, results in a better general tone in the system of the population, and so indirectly to a lower death rate, and that a part of the reduction is represented by diseases having no recognized connection with the quality of the water supply.

Death Rate From Typhoid Fever per 100,000 Population in Cities Using Filters.

City	Kind of filter	Plant completed	Years, in average— Before filtration.	After filtration.	Typhoid fever death-rate— Before filtration.	After filtration.
Albany, N.Y.	Slow	1899	10	10	90	21
Binghamton, N.Y.	Rapid	1902	5	5	47	15
Cincinnati, Ohio .	Rapid	1908	4	2	50	13
Columbus, Ohio ..	Rapid	1908	11	2	78	15
Lawrence, Mass. .	Slow	1893	7	15	114	25
Paterson, N.J. ...	Rapid	1902	5	8	32	10
Pittsburgh, Pa. ..	Slow	1907	8	3	133	*26
Watertown, N.Y...	Rapid	1904	5	5	100	38
York, Pa.	Rapid	1899	2	8	76	22

*Filtered-water section. Allegheny not included.

[1]Trans. Am. Soc. Civil Eng., vol. 54 D, p. 153.

A SILICIOUS WOOD PRESERVATIVE.

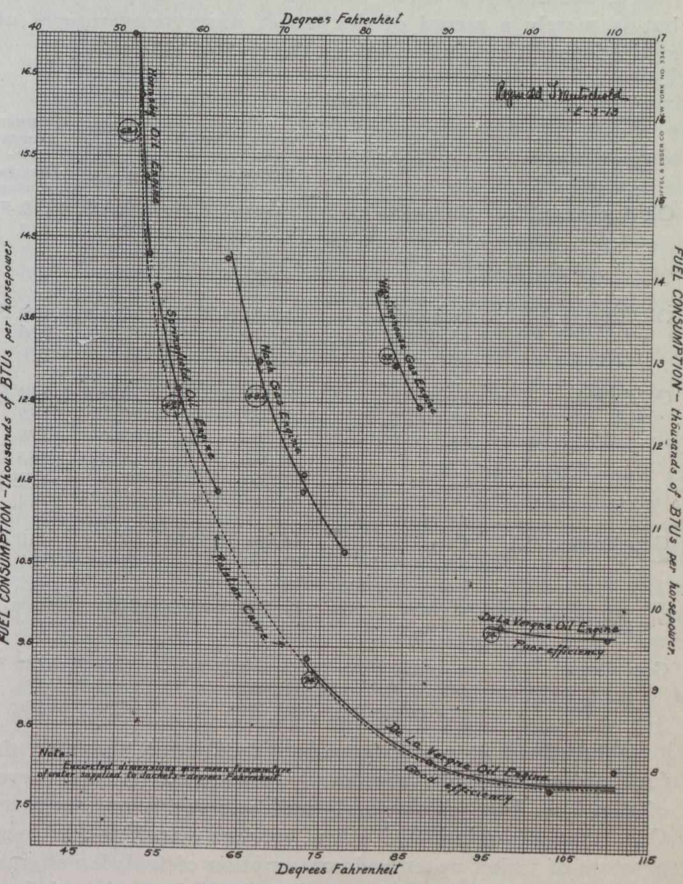
In a new process for the impregnation of timbers with melted paraffin and naphthalene, diatomaceous earth, a silicious material, is ground so fine that ninety-two per cent. passes a two-hundred-mesh screen. This is mixed with the melted paraffin and the naphthalene and timbers immersed in the mixture for four hours. As compared with the twelve to twenty-four hours required in creosoting, this is noteworthy. Furthermore, it is an open vat process. The wood is permeated to the centre and resists the attack of marine borers and decay, besides gaining the resilience. Nails hold better and do not rust, nor does the wood become waterlogged. Hardwoods, like white oak, which resist other treatment, yield to this preservative. The expense is small, for the mixture costs only three cents per pound, and less than two pounds of solution are required for each cubic foot of timber.

When completed, New York's skyscraper, the mammoth fifty-five-story Woolworth Building, will have cost approximately $13,500,000, of which amount $4,500,000 represents the cost of the land, $1,000,000 of foundation excavation, and $8,000,000 for construction.

JACKET WATER TEMPERATURES AND FUEL CONSUMPTION IN INTERNAL COMBUSTION ENGINES.

By Reginald Trautschold, M.E.

The thermal efficiency of internal combustion engines, the proportion of the heat units supplied that are converted into available or useful kinetic energy at the fly wheel—is, and has been, high as compared with that of even the most efficient types of reciprocating steam engines. And one of the main reasons of the recent wide adoption of the former type of engine to service of all kinds lies in the fact that its average efficiency, as the engine is to-day manufactured, shows considerable improvement over that of similar engines built but ten or fifteen years ago. This increased efficiency has been obtained through the use of more suitable mixtures in the combustion chamber, better regulation, improved design, and proportions, etc., etc., until at the present time



TEMPERATURE RANGE OF JACKET WATER

CHART I.

internal combustion engines operating on crude and the heavier oils have occasionally developed a thermal efficiency of about 35 per cent. Such progress is very gratifying and has helped in the wide introduction of internal combustion engines, but even now many such engines are being operated below their best efficiency from lack of general and proper knowledge of the requirements and conditions governing efficiency. Particularly is this so in the question of jacket water temperatures—water jacketing being generally resorted to in stationary engine practice—and a study of this question is, therefore, of particular interest.

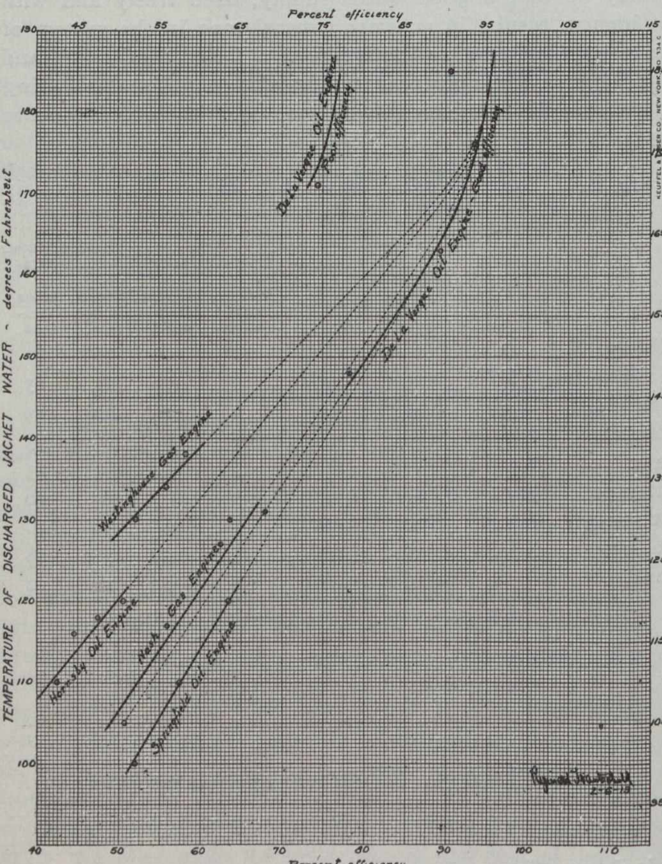
In considering the effect of jacket water temperatures upon fuel consumption, two main points naturally present themselves, 1st, the amount of heat that the jacket water should absorb—i.e., its temperature range, for most satisfactory operation; and 2nd, the temperature at which the water should be discharged from the jackets. The first consideration governs the amount of jacket water that should be used, as the available temperature range of jacket water supply is inconsequential, when the intense heat of the gases at the moment of ignition is taken into consideration—a point of importance when the jacket water is cooled on discharge from the jackets and used over again, a practice that is nearly universal. The second consideration is but a logical deduction from the first, but it is, nevertheless, upon this point that the economic consumption of fuel or thermal efficiency of the engine largely depends.

Engines operating under all degrees of efficiency must be considered before any conservative and reliable rule can be advanced to govern the supply and temperature of the jacket water that will assure the converting of the greatest proportion of the heat units supplied by the fuel into useful energy. Hence, the data given in Table I does not do justice to the possibilities of the various types of engines mentioned, nor does it properly indicate their relative efficiencies, but is merely a record of the jacket water temperatures of engines operating under various degrees of efficiency.

Table I.

Type of Engine	Fuel and Heating Value	Consumption of Fuel per Horsepower	Jacket Water Increase Range	Temperatures Discharged Water
Oil Engine "A"	Kerosene	17,000 B.T.U.	52.0 F.	110 F.
	20,000 B.T.U.	16,250	53.0	116
	per pound	15,250	53.5	118
		14,300	54 0	120
Oil Engine "B"	Gasoline	13,900 B.T.U.	55.0 F.	100 F.
	18,000 B.T.U.	12,650	57.5	110
	per pound	11,400	62.5	120
Oil Engine "C"	Fuel Oil	9,250 B.T.U.	73.5 F.	148 F.
	19,000 B.T.U.	8,100	88.5	163
	per pound	7,750	103.0	176
		8,000	111.0	185
		9,750	97.0	171
		9,600	110.0	184
Gas Engine "A"	City Gas	14,250 B.T.U.	63.5 F.	110 F.
	560 B.T.U.	13,000	67.5	117
	per cubic foot	11,600	73.0	127
		11,400	73.0	130
		10,650	78.0	131
Gas Engine "B"	City Gas	13,850 B.T.U.	82.0 F.	130 F.
	560 B.T.U.	12,950	84.0	134
	per cubic foot	12,450	87.0	138

The effects of temperature range of jacket water on the fuel consumption are graphically illustrated by the curves of Fig. I, a chart which clearly indicates two important facts. One, that the relation existing between the range of temperature of jacket water and consumption of fuel, for engines operating on fuels of about the same heating value, follows closely the relationship illustrated by the smooth curve designated "Relation Curve" and that about the same relation exists for engines operating on fuels of any specific heating value. Two, that the temperature of the water supplied to the jackets, within usual limits, has little effect upon the efficiency of the engine as far as fuel consumption is concerned. Considering only the engines operating on fuels of about the same richness or heating value, it is seen that the fuel consumption decreases rapidly with any increase in the temperature range of the jacket water for relatively small values of heat absorption by the jackets and that the rate of fuel consumption continues to decrease with increasing temperature range of jacket water, with gradual retardation, until a temperature range of about 105 degrees Fahrenheit is reached, after which the fuel consumption of the engine remains about constant. During this period of minimum fuel consumption, little or no gain in efficiency is obtained by increasing the temperature of the range of the jacket water, and if increased to such a point that the discharge temperature is too high, a point that will be referred to again, serious generation of steam in the jacket will occur, reducing the efficiency of the jacket and upsetting the rule that increased temperature range of jacket water is conducive to reduced fuel requirements. With unusually cold water supply it is possible, of course, to retain the water in the jackets until a considerable range of temperature takes place, but as previously stated the possible temperature range of the jacket water supply is limited and the possible gain in fuel consumption due to increased temperature range of jacket water is hardly sufficient to warrant running the risk of an interference with the water supply that may counteract the small gain in economy of fuel consumption through increased temperature range of jacket water by a too great increase in the



COMPARISON WITH ENGINE OF 35% THERMAL EFFICIENCY

CHART II.

temperature range of the jacket water to from 100 to 130 degrees Fahrenheit, depending upon the temperature of the water supplied to the jackets, in ordinary installations of internal combustion engines. Engines operating on fuels of lesser heating value, require a greater range of jacket water temperatures to give the same fuel economy as those operating on fuels running about 18,000 or 20,000 B.T.U. per pound but, as in all cases, the temperature range of the jacket water is limited by the temperature at which it is discharged from the jackets, and this is governed by the generation of steam in the jackets.

About the best thermal efficiency for an internal combustion engine that has yet been attained is 35 per cent., or the delivery of one brake horsepower per 7,250 B.T.U. supplied, and for sake of convenient comparison, such efficiency will be considered as 100 per cent. A comparison of the thermal efficiencies of various engines, as represented by the data of Table I, with that of an engine delivering a horse-power of useful energy per 7,250 B.T.U. supplied, shows that the temperature at which the jacket water is discharged, has a marked effect upon the efficiency of the engine. This is graphically illustrated in Fig. 2 and, though there appears to be considerable variation in the efficiencies of the various engines when the jacket water is discharged at a relatively low temperature, the curves for the various engines all point to a maximum engine efficiency when the jacket water is discharged at a temperature at 180 degrees to 190 degrees Fahrenheit. Above 180 degrees the improvement in efficiency is very gradual, as it is at this temperature that the generation of steam in the jackets usually begins to become serious. With well designed and proportioned jackets, however, the jacket water may be safely retained in the jackets until a temperature of 190 degrees Fahrenheit is reached, but beyond such temperature it is very questionable whether any appreciable increase in efficiency is attainable.

The temperature of the jacket water supply is of secondary importance, as its only effect upon the efficiency of the engine is that the cooler it is the less jacket water is required—that is, the greater the possible temperature range—but as a temperature range of from 105 to 115 degrees Fahrenheit furnishes the maximum economy in fuel consumption under ordinary conditions, no material benefit is derived by having the jacket water supply cooler than 70 or 75 degrees Fahrenheit, other than reducing the mean velocity of the supply through the jackets. This, in the average case were the water is used over and over, is conducive to additional expense rather than to economy, as cooling facilities have to be greater than when the water is returned to the jackets at a higher temperature.

The operating engineer has discovered that certain benefits are to be derived by discharging the jacket water at higher temperature than was formerly considered good practice for the engine tests from which the data of Table I was collected, cover a period of some ten or fifteen years, the tests in which the jacket water was discharged at a relatively cool temperature, having been made in the late nineties while those tests in which the jacket water was discharged at the higher temperatures being of comparatively recent date—all tests having been made according to good practice at the time they were made, and to ascertain the best efficiencies of the engines rather than as studies of the effect of jacket water temperatures.

MEXICAN PETROLEUM OUTPUT.

The development of Mexico's petroleum industry is shown by the following statistics of output of crude oil in the past six years: 1907, 1,000,000; 1908, 3,481,410; 1909, 2,488,742; 1910, 3,332,807; 1911, 14,051,643; and 1912, 16,500,000 barrels.

The Canadian Pacific Railway Company, who have invited tenders for two 600 ft. high-speed Atlantic liners, have placed an order with Denny, Dumbarton, Scotland, for two auxiliary steamers of 375 ft. length.

The International Road Congress, which will be held this year in London, England, June 23rd to 28th, will bring together the leading men from practically every country identified with highway construction and maintenance. This is the third Congress of the kind to be held, and is the first to be held in an English-speaking country. The first Congress was held in Paris, France, and the second in Brussels, Belgium. These Congresses are held every three years.

PRESERVATION OF RAILROAD CROSS TIES.

In rather extensive experiments carried on by the United States Forest Service in the preservation and use of cross ties, the following results were secured and deductions drawn:—

Zinc chloride is an effective preservative for ties subjected to the severe conditions under which the experimental ties were laid, as a result of which 87 and 92 per cent. respectively of these ties were serviceable after seven and one-half years. A fairly heavy impregnation of zinc chloride is advantageous. Treatments by the Burnett and Wellhouse processes, made at Somerville, with two per cent. zinc chloride solutions and average absorptions of 0.35 and 0.33 pounds of dry salt per cubic foot of wood, resulted in only 45 and 47 per cent. respectively of serviceable ties after seven and one-half years' service. Similar treatments made at Chicago with a 4 per cent. solution and average absorptions of 0.42 and 0.57 pounds of dry salt per cubic foot resulted in 87 and 92 per cent. respectively of serviceable ties after the same length of service.

A light injection of creosote apparently adds to the effectiveness of zinc chloride treatments. The Allardyce treatments, made at Somerville, show 81 per cent. of serviceable ties, while treatments made at the same plant with zinc chloride alone show only 45 per cent. of serviceable ties after seven and one-half years. Beaumont oil in combination with zinc chloride also produced an effective treatment.

Treatment with preservatives will not yield good results unless the ties are sound in the first place and the treating is properly done. This is strikingly shown by the treatments of zinc chloride and English creosote. These ties were probably injured by over-steaming during the treatment.

The experiments seemed to indicate that ties treated with zinc chloride suffered more mechanical wear than untreated ties, and from this it would appear that the zinc chloride treatment weakens the wood. This result was also noticed on the creosoted ties, in one experiment, but in another, on ties which had been treated with about fourteen pounds of creosote per cubic foot, examined two years after placement in track, approximately two per cent. were slightly affected with decay, and about twelve per cent. of those treated with zinc chloride, but on inspection of a number of ties which were more or less split, it was found that the exposed portions of the ties appeared thoroughly sound and well treated, and it seems probable that the greater part of them were slightly affected with decay at time of treatment, and only two ties could be found showing any rail wear, and this was so slight as to be negligible.

In general, however, these experiments, carried on with seven different railroad organizations, show that in many cases the life of ties can be doubled or even trebled by proper treatment, but to secure this result, the ties must receive a first-class treatment of a good preservative and must receive a liberal and not a skimping treatment.

Ties with low decay resistance, such as loblolly pine, hemlock, tamarack and beech, if laid untreated, should not be tie-plated, as they will decay before they will wear out, even without the tie plates, and, this being the case, the tie plates are a useless expense and do not prolong the life of the tie. However, the increased resistance to decay caused by proper treatment makes it highly desirable to protect the ties from deterioration from mechanical sources, and this is particularly true of ties with low crushing strength.

Practically all radium-bearing ores mined in Canada and the United States are sent to Europe for the extraction of the radium.

FOUNDATIONS FOR PITT RIVER BRIDGE.

Features of the Location and Requirements—Special Interim Construction for Continuous Use—Progress to Date.

While Canada seems to be experiencing great prosperity throughout the entire country, nowhere does this development seem to be making such rapid strides as on the Pacific Coast. This is apparent to everyone who will glance at the enormous outlays by the older railroads for betterments and easements, and also by the strenuous efforts of several new roads to complete their lines across the continent in order to participate in this prosperity and development.

The Canadian Pacific Railway is spending enormous sums in double-tracking, flattening out curves, cutting down heavy grades, and building many new bridges of a type sufficient to accommodate its rapidly increasing traffic. One of the biggest, and perhaps the most difficult, pieces of work between the coast and the summit of the Rockies, is the foundation for the Pitt River bridge.

The present bridge, which is a single-track structure, has been in use only approximately six years, and already it is incapable of handling the traffic passing over it. In addition to this, there lies between the western end of this bridge and Westminster Junction the new terminal yards of the Canadian Pacific Railway, upwards of half a mile wide and two and a half miles long. These conditions made it doubly imperative, on the part of the railroad, to construct a new bridge capable of handling the increased traffic.

The Pitt River is tributary to the Fraser, and is subject to the rise and fall of the tide, although no salt water reaches this point. The river itself, which joins the Fraser opposite Port Mann, and about six miles above New Westminster, has a depth of water reaching almost seventy feet in many points. It is about ten miles long and drains a large body of water known as Pitt Lake. The maximum current is approximately three miles an hour, and this is upstream. One peculiarity of the river is that, while the current is still setting upstream, the level of the water in the river begins to fall, the outward flow not taking place until the water level at the bridge site has fallen approximately six inches.

The new bridge, which is to be a double-track one, spans the river at a point about two miles above its confluence with the Fraser, and is approximately 1,750 feet in length between the backs of ballast walls of the east and west abutments.

The work divides itself naturally into two distinct classes: One comprising pier No. 1 and piers No. 6 to 13 inclusive, together with the two abutments, which are being constructed by the use of sheet piling cofferdams; while piers No. 2, 3, 4 and 5 are to be put in by means of large caissons, which will be built on land, launched, floated into exact position and there sunk to the river bottom. Through wells, the sand, which comprises the river bottom at these points, will be excavated; and the caisson will be weighted to force it downward. When a sufficient penetration has been obtained and the soil at this point, as indicated by borings and by the actual excavation, is satisfactory, the bottom of these dredging wells will be sealed under water, and concrete allowed to set, when the caissons will be pumped out and the rest of the pier constructed in the manner similar to the methods obtaining on land.

The depth of water at the site of pier No. 2 is approximately 45 feet; the depth at piers No. 3 and 4, approximately 65 feet; while the depth at pier No. 5 is about 35 feet. The depth of water at the other piers gradually diminishes until reaching the abutments, the sites of which are above ordinary

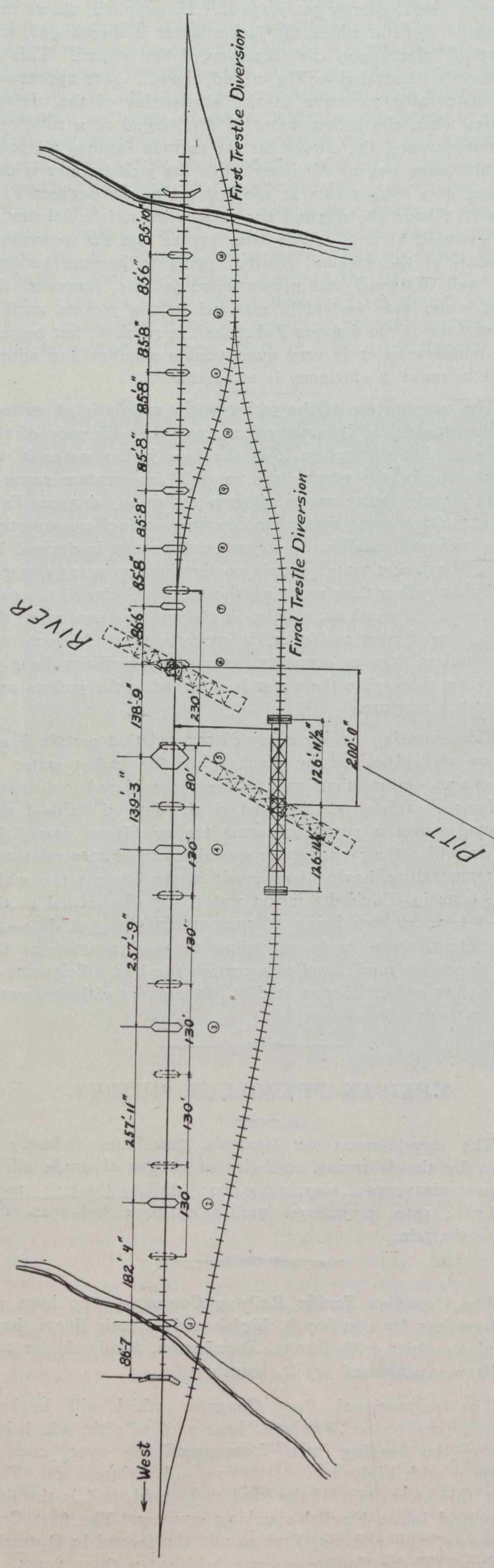


Fig 1.—Layout of C.P.R. Pitt River Bridge, Coquitlam, B.C.

high tide. The river is subject to the annual floods which inundate the banks of the Fraser. At this point on the Pitt, the shores are protected by dykes or levees about 18 feet in height, which is approximating the height of the base of rail of the railway. These annual floods are very irregular in time and occurrence, and also in the elevation to which they rise. There seems to be no possibility of foretelling what the conditions may be, as the snows on the mountains are always sufficient to supply enough water, provided the rise in temperature is sudden and of sufficient duration.

The Foundation Company, Limited, of Montreal, Canada, was called in to do this work, on account of the recognition of the many difficulties anticipated here, and also because this company had successfully handled difficult work of a similar nature in the east for the railway company.

Recognizing the desire for the completion of this work at the earliest possible point of time, operations were begun immediately, no delay for the removal of traffic from the old bridge taking place. The construction of the two abutments and several of the piers was prosecuted while traffic was still operated over the old bridge. At the same time, the railroad company began to construct trestle work across the river, for the purpose of diverting this traffic. The diversion was

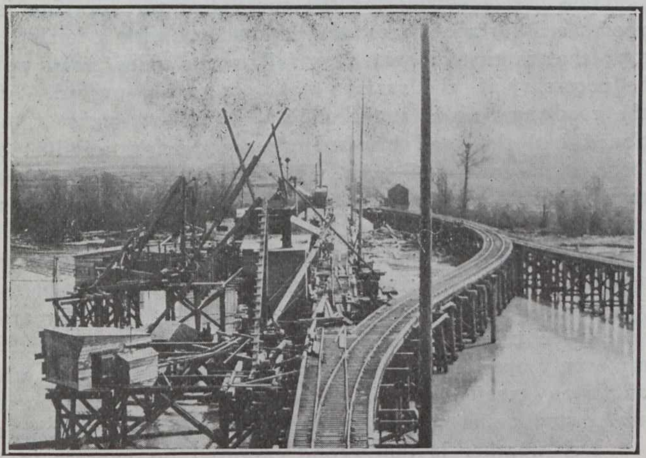


Fig. 2.—C.P.R. Pitt River Bridge, Showing Trestle and Work on Eastern Portion.

a necessity, owing to the fact that two of the old piers had to be demolished, in order to accommodate piers for the new bridge, as well as to shorten the time of construction. This pile trestle is expected to be completed by the end of June. The railroad company is now erecting the truss of the swing span, which was formerly used in the old Red River bridge, where the foundations for a new bridge had been built by The Foundation Company. This swing span for the trestle is being erected on the guard pier, and at right angles to the line of traffic. When this is in operation, the swing span of the old bridge will be floated out of position, and the old pivot pier removed, so that the east rest pier for the new swing may be erected at this point. The west rest pier of the old swing must also be taken out, as the pivot pier of the new bridge will be constructed on its location.

By reference to the accompanying plan, the reader may note the pile trestles built by the railway company to accommodate the diverted traffic, as well as the old piers which had to be removed, and the location of the new piers, with the lengths or dimensions, centre to centre, of the various plate girders and trusses of the new bridge. The work on the new bridge has been pushed forward with all possible despatch; the two abutments and piers No. 12 and 13 having been completed, while piers No. 1, 9, 10 and 11 will be completed early in the month of June. The soil on the west side of the river, where pier No. 1 was constructed, under the old bridge, while traffic was maintained at this point, consists of very compact, rather finely grained sand, rather difficult to

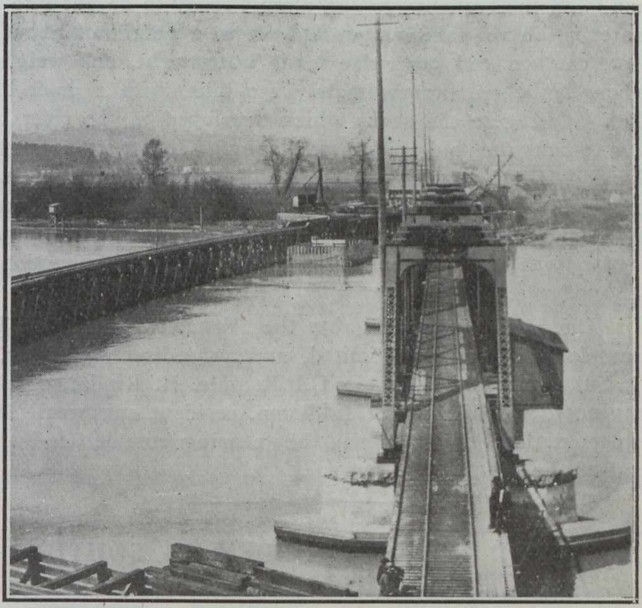


Fig. 3.—C.P.R. Pitt River Bridge, Showing Western Portion of Main Trestle.

handle; while on the eastern bank of the river the soil, which was largely of a clayey silt, contained many pockets of fine, white sand, along with stumps, driftwood, roots and branches of trees, and also layers of dead vegetation, making it, on the whole, a most treacherous class of material. The removal of the stumps loosened up the soil to a considerable depth; the dead wood, which could not be reached by ordinary means, or the presence of which could not be known, shat-

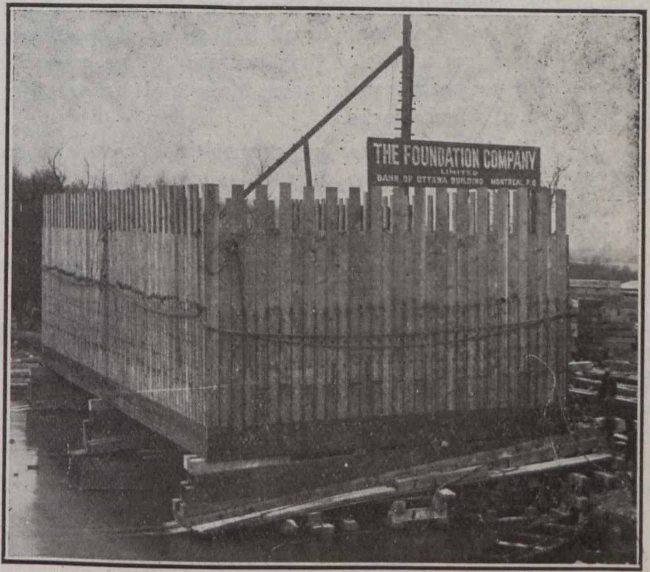


Fig. 4.—C.P.R. Pitt River Bridge Caisson No. 2, Ready for Launching.

tered some of the sheeting, which had to be pulled and replaced, while the layers of vegetation in this soil permitted the water, when under only a moderate pressure, to penetrate into the excavation rather freely, but all these difficulties either have been or are being successfully overcome.

The caissons which are to be dredged to proper depth are, roughly, 35 feet wide by 75 feet long, containing two dredging wells about 17 x 20 feet and, when complete, will be over 100 feet high. One of these has already been launched and is ready to be put in position, while the second one is on the launchways and almost ready to be put into the water. These caissons were built to a height of about 12 feet, caulked and otherwise made water-tight, and weighed, when launched, approximately 250 tons, with a draft of 8 feet. Owing to the scour which developed in the river bottom when the old piers were being constructed it was decided that it would be unsafe to place these large piers in position, namely, midway between the old piers, until after traffic was diverted to the pile trestle, so that this part of the work has been confined entirely to the construction of the caissons.

The work is handled by the Vancouver office of The Foundation Company, Limited, under the direction of Mr. J. G. Sullivan, chief engineer, C.P.R.; Mr. H. Rindal, division engineer, and Mr. J. R. Middleton, resident engineer. It is expected that the work will be nearing completion by the end of the year.

GOOD ROADS PROBLEM IN SOUTH VANCOUVER.

With the advent of the automobile two problems were created on the trunk roads in all countries which the various road authorities have since been endeavoring to solve as efficiently and as economically as possible, the abatement of the dust nuisance and the preservation of the surface of the roadway.

The South Vancouver counncil has recently decided upon two steps which, though at first glance do not seem to have any connection with each other, are yet very closely allied. The council has decided to engage the services of a consulting engineer to advise as to the practicability of establishing a municipally-owned gas-making plant on the North Arm of the Fraser River, and they have given a contract to the M. P. Cotton Company to oil five miles of roadways in the municipality at a cost of $175 per mile. The council has also decided to permanently pave Main and Fraser Streets with creosoted wood blocks.

The oiling and the paving propositions have two main objects, the abating of the dust nuisance and the preservation of a good road surface; and, though these two objects would at first appear to have no connection with the proposal to establish a municipally-owned gas-making plant, there is as a matter of fact a very close connection.

Probably in no country in the world are there better trunk roads than those running throughout the length and breadth of the British Isles; and in recent years nearly all of those roads have been treated either with raw coal tar or with some proprietary preparation of coal tar, which, as everyone knows, is a product derived from coal during the process of manufacturing gas.

The method of treatment varies, but whether raw tar is used or the more expensive proprietary preparations, the result of treating a road surface with coal tar is practically the same, a good, solid surface, over which an auto glides with a smooth, even motion, practically dustless, yet impervious to water during wet weather. The only difference is the cost.

Engineers differ in their opinions as to the best method of treating a road surface with coal tar or a preparation of tar. Some assert that the crude or raw tar needs to be refined before using it on the roadways; others declare that the raw tar is by far the best for painting the surface of a roadway, and they are of opinion that better results are obtained from the use of raw tar than from the use of any of the many preparations of tar.

While the road construction engineers are settling the question to their own satisfaction it may be interesting to record the result of an experiment carried out by the municipal engineer to one of the urban authorities on the North Wales coast over a period of five or six years.

The highway between Holyhead and Chester runs through his district, and in addition he has many miles of roadways under his control. The municipal council owns the gas works, and for the past five or six years the engineer has been experimenting with various preparations of tar and with the raw tar as it comes direct from the gas works, for the purpose of treating the roadways under his control; and, as the result of his experiments he has come to the conclusion that the tar direct from the gas works gives better results than any preparation on the market.

The method which the engineer in question has found to give the best results is a very simple and inexpensive one, working out in his case at less than a cent per square yard for the actual spraying and cost of tar after the roadway had been prepared for the treatment.

The first essential for the success of tar spraying is a good, even-surfaced macadamized roadway with a fairly level top; that is to say, with less fall to the sides than would be necessary if the surface was not to be sprayed. After the roadway had been thoroughly rolled the engineer mentioned had the road brushed, thus removing all dust and loose stones and soil. An old water-cart or sprinkler was then taken to the gas works and filled with warm raw tar, and on arrival at the piece of roadway to be treated the tar was sprinkled over the surface in exactly the same way as would be done in sprinkling water to lay the dust, the only difference being that two men followed the sprinkler armed with wide rubber squegees with which they distributed the tar evenly over the surface of the roadway, one-half of which only was treated at once, leaving the other half open to traffic and paths across the tarred half for foot passengers.

Dry weather is the second essential for success in tar-spraying, because two days are necessary to allow the tar to percolate into the roadway. Given those three essentials, a good macadamized surface, dry weather during operations and evenly distributed sprinkling of tar, a road surface is produced which is impervious to water and is practically dustless.

A second sprinkling given a few months later will still further improve the roadway, and with a third sprinkling a surface is produced equal to the most expensive asphalted pavement to be found anywhere.

RAILWAY IMPROVEMENTS IN ROUMANIA.

A bill has been introduced in the Roumanian parliament to authorize the expenditure within the next five years of $80,000,000, for the completion of railway lines now under construction, the improvement of existing lines by double tracking, building of new stations, etc., and the construction of new lines of about 1,000 miles in length, and of a bridge over the Danube.

It is stated that motor cycles are coming into extensive use in the cities and suburban roads of Egypt, the topography of the country being generally favorbale for sport and practical cycle riding. The machines used are almost all of French, Swiss and English make.

METHODS OF DESIGNING THE FLAT SLAB SYSTEM.

By W. G. Ure, B.A.Sc.

In taking up the question of design of flat slab floors it has been found impossible to give any definite and generally accepted solution, for the simple reason that, of all the methods of treating the subject outlined in the following pages, no one can be singled out as an established standard. Different lines of investigation pursued by different men have given different results, and these results lead to widely varying designs when applied to the solution of a definite problem. It is not possible in an article of this length to go fully into these methods of design, and this chapter will therefore be devoted to an attempt to place before the reader the fundamental principles upon which some of the commoner of these methods are based, and to a comparison of the results attained thereby. It must be left largely to the individual reader to use his own judgment and experience in deciding which solution he would prefer to adopt.

In the flat slab system of floor construction we have the three fundamental stresses to provide for, viz., tension, compression, and shear. The tension and compression are due to moment action and it is with regard to their computation that most of the uncertainty exists. The determination of the shearing stresses is comparatively simple and will be considered first.

The shear is of two classes as before noted—punching shear and shear tending to produce diagonal tension. The safe stress for concrete to be used in computing the resistance to punching shear has been placed by the Joint Committee at 120 lbs. per sq. in. The safe stress to which concrete may be submitted in diagonal tension is the same as that which is safe for straight tension or from 40 to 50 lbs. per sq. in. The usual practice in the design of reinforced concrete is not to compute the diagonal tension at all, finding the punching shear only and using such a low permissible stress that the other will be automatically provided for. Let us then assume the safe shearing stress for concrete as 40 lbs. per sq. in. There is a well-known principle that at any point in a beam, the vertical shear, the horizontal shear, the diagonal tension, and the diagonal compression are all equal. Hence by limiting the allowable stress in vertical or punching shear to 40 lbs. per sq. in., we are also at the same time limiting the stress in diagonal tension to the same amount, and we may then not consider the latter in the rest of the design.

In any flat slab design there is a large amount of steel centering at the column and this, of course, may be utilized in the resistance of shear. This steel reinforcement may be stressed in shear up to 10,000 lbs. per sq. in. Then the total resistance to shear is the strength of the concrete at 40 lbs. per sq. in. plus the strength of the steel at 10,000 lbs. per sq. in. It has been shown by experience that practically the same result is obtained if the steel be neglected and the concrete figured at a stress of 80 lbs. per sq. in.

In actual practice it is probably just as easy to compare the shear from first principles. However, a formula may be derived as follows:—

Consider a section around the edge of the column cap, which in general would be the critical section.

Let A be the area of floor in sq. ft. sending load to the column.

a, the area of the column cap in sq. ft.

p, the perimeter of the column cap in inches.

jd, the distance in inches from the centre of compression to the centre of steel.

w, the combined dead and live load per sq. ft. of floor.

v, the intensity of shearing stress per sq. in.

Then the load tending to shear the floor at the edge of the capital is $w\ (A - a)$ lbs.

The area provided to resist the shear is $(p\ .\ jd)$ sq. ins.

$$\text{Then } v \text{ equals } \frac{w\ (A - a)}{p\ .\ jd} \text{ lbs. per sq. in.}$$

The required depth of slab should be computed at the edge of the column cap, at the edge of the column shaft proper, and preferably at one or two points in between. Then, by plotting these depths the size and shape of the flare required at the top of the column is obtained. From the equation it will be seen that v may be decreased by an increase of either p or jd.

It frequently happens that the depth of slab is fixed from other considerations, hence in considering the section at the edge of the column cap jd is fixed, and v must be controlled by varying p. The tendency from æsthetic considerations is to fix the width of the cap by the size of the column beneath, and it may happen in an upper story where the columns are small that the width of cap be reduced too much. From a structural point of view the width of the column cap does not depend at all on the size of the column beneath, but only on the load to be carried on the floor above, and this load may be just as great on the top story as on the lower ones. The depth of the column cap will depend on both the size of the column and the floor load.

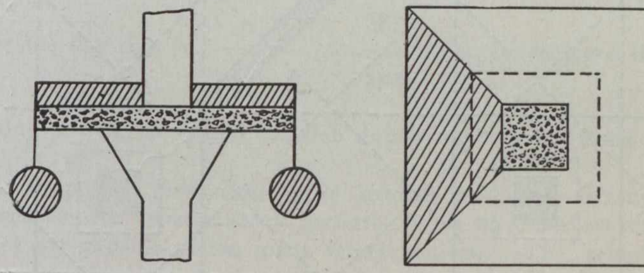


Fig. 1.

In all some eight methods of figuring the moments in the flat slab will be given brief consideration. The first two methods, viz., the "Cantilever Method" and "Turneaure and Maurer's Method," may be grouped together as being based on the principle that the portion of the slab over the column head out to the point of inflection acts as a cantilever, and the rest of the slab acts as a suspended span hanging from the edge of the cantilever.

The Cantilever Method is a simple application of the principles of statics, based on certain preliminary assumptions. The point of inflection is assumed at a distance out from the centre of the column equal to one-fifth of the span. The cantilever portion is then assumed to be a square whose side equals two-fifths of the span. Fig. 1 shows this part of the slab with a uniform load over its surface and a concentrated load equal to the weight of the suspended span hanging from its extremity. It is then a simple matter to compute the moment at any section. Moments should be found about the edge of the column shaft, the edge of the column cap, and preferably at one or two points between. The depths required can be then obtained, and the size of flare found in this way compared with that found by considering the shear.

The suspended span is analyzed by dividing it into strips, as in Fig. 2. Consider two such strips, one A—B running diagonally across the panel, and the other C—D

along the side of the panel. Fig. 3 shows the bands of steel and the location of these strips. The figures on the shaded portions indicate the number of bands of steel crossing at that point. Assume that where one band only is present it takes all the load, where two are present each will take half the load, and so on, each band taking its proportionate share of the load. Fig. 3 also shows the way in which these strips will then be loaded, and the bending moment in each can be readily calculated. Having obtained the moments, the depth of slab and amount of reinforcing required is found in the usual manner.

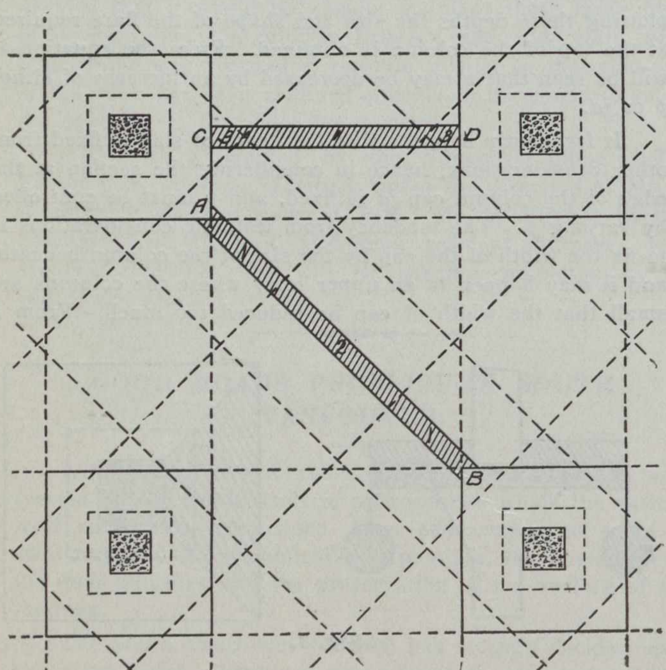


Fig. 2.

There are at least two serious objections to this method. In the first place it depends on the position and form of the line of inflection which is indefinite, and in the second place it takes no account of slab or arch action in the slab itself.

Turneaure and Maurer's Method is a modification of the above. It consists in considering the slab over the column head out to the point of inflection as a flat, circular plate uniformly loaded and supporting the rest of the slab as a concentrated load around its circumference. The radius of the circular plate is taken as the mean of the distances out to the point of inflection in a diagonal direction and in a direction along the side of the panel, the points of inflection being assumed at the fifth points. The determination of the moments is somewhat difficult mathematically, but they may be easily obtained by means of tables or graphs provided. The suspended portion of the slab is solved in a manner exactly similar to that used in the cantilever method. Graphs and tables for the solution of the flat slab by this method are given by Sanford E. Thompson in his paper entitled "The Practical Design of Reinforced Concrete Flat Slabs," published in *The Canadian Engineer* for March 28th and April 4th, 1912.

This method is open to the same objections as the previous one. It gives a thickness of slab approximately 50% in excess of that given by any other method, and this excess thickness, we can safely say, is unnecessary from our knowledge of the behavior of slabs under test loads.

Another Method of analysis is to divide the slab into a number of beam strips, as proposed by Mr. W. H. Ham in the proceedings of the National Association of Cement Users, 1911, page 195. The assumptions which he makes can be readily understood from Fig. 4. The load on the diagonally hatched portion is assumed to be carried by the diagonal beams, one-half being taken by each, and that on the vertically hatched portion by the cross-beams. The loading on diagonal and cross-beams would then be as indicated in the figure. The section required can then be obtained by the usual methods for solving reinforced concrete slabs, using the moment formula for beams fully restrained, partially restrained, or freely supported, as the case may be. The remaining portion of the slab over the column head is solved as a cantilever. The bars in the cross-beams are brought to the top of the slab over the columns. The bars in the diagonal bands run straight through on the bottom, and additional bars are provided at the top of the slab to take up the cantilever moment in the diagonal direction.

While this is, undoubtedly, a safe method of procedure it neglects the effect of arching action in the slab, and thus the result would tend to be unnecessarily heavy. On the other hand, it is simple to apply, uses only established engineering formulae, and the necessary allowance for end and corner panels is readily made.

Another Method is proposed by Louis F. Brayton in the proceedings of the National Association of Cement Users, 1910, page 269. He considers the structure as a slab reinforced in two directions and takes the moment at the centre as $\frac{Wl}{12}$. Considering the load to be carried one-half each way we get a maximum moment at the centre of $\frac{Wl}{24}$ and double this over the columns. Brayton claims that where the length of the panel is more than one and one-half times the breadth it is conceivable that the slab might not become a warped surface under certain conditions of loading, but that the maximum deflection might be along a line perpendicular to the middle point of the long axis. In such a case the whole load should be assumed going in the direction of the long span. In order to make use of the assumption of two-

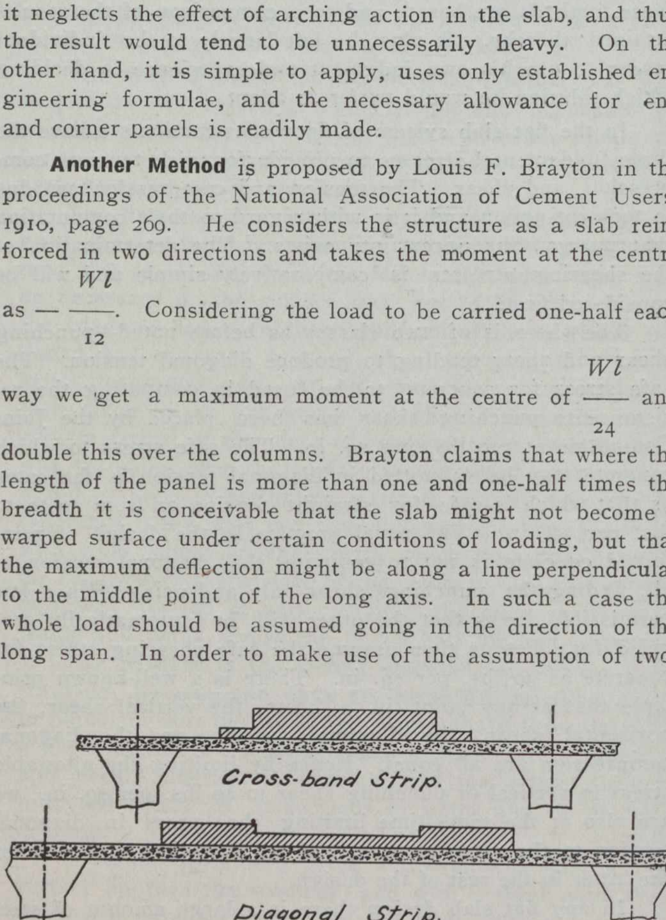


Fig. 3.

way reinforcement, Mr. Brayton assumes the strength of the diagonal bars replaced by its resolved parts parallel to the length and breadth of the panel. The use of such a low moment factor gives a heavy design, but his treatment of the long, narrow slab would seem reasonable.

In his book, C. A. P. Turner refers to Grashof's analysis and a treatise by Dr. Eddy entitled "Theory of the Flexure of a Thin Flat Plate or Ring Loaded Symmetrically About its Centre." However, his method of design appears to be purely empirical. From a series of experiments, such as were described in the writer's article in June 6th issue of this journal, he obtained the formula $\frac{Wl}{50}$ for bending moment. It would appear that his tests were made on isolated panels only, and if this be true he has built up his formula on insufficient data. His designs are extremely light and seem somewhat daring when compared with designs made by other engineers. In some cases floors built by Mr. Turner have not stood up well under service.

Grashof's Analysis of the "Stresses in an Infinite Flat Plate supported on a Series of Points Dividing it into Rectangular Panels" may be used for the design of flat slabs. The proof is rather intricate but the results are comparatively simple and are given by Mr. Mensch as follows:

Bending moment at centre $\frac{Wl}{52.8}$

Maximum bending moment $\frac{Wl}{26.4}$

Maximum deflection $.0284 \frac{Wl^4}{Et^3}$ in which the value of

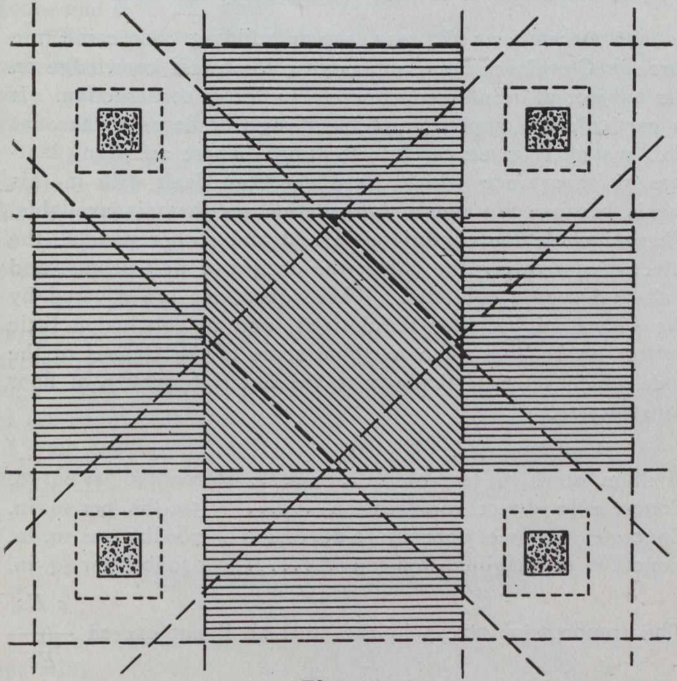


Fig. 4.

Poisson's ratio is taken as one-third. The objection to this method is that Grashof's Analysis is based on the assumption that he is dealing with a square plate of homogeneous material and uniform thickness, in fact the proof is indeterminate for other than a square plate. Actual flat slab floors are seldom exactly square, are not homogeneous throughout, and the flare of the columns, coupled with the fact that more layers of steel are present at some places than at others (changing the position of the centre of tension and thus the effective depth) make the assumption of uniform thickness unfair. Further, the slab can hardly be said to be supported at four points, as it is actually fixed over a considerable area at the corners. In spite of these discrepancies, however, the moment formulae given probably express pretty well the conditions actually existing.

L. J. Mensch describes a method based on the above. He claims that the formula $\frac{Wl}{48}$ for maximum bending moment at the centre of the span may be deduced from Grashof's writings. He then reasons that the same ratio of bending moment between the ideal condition of a continuous beam uniformly loaded, and such beams as designed and loaded in an every-day building, shall also hold good for the girderless floor. This ratio is $\frac{Wl}{24} \div \frac{Wl}{10}$ or 1 : 2.4. Then, reducing $\frac{Wl}{48}$ in the same ratio he obtains $\frac{Wl}{20}$ as his working moment formula, and this, he claims, gives a factor ot safety of four.

McMillan also obtains his formula from Grashof, but by a different line of reasoning. He quotes two of Grashof's formulae for maximum fibre stress in square plates uniformly loaded as follows:

Supported on two edges $f = \frac{3}{4} \cdot \frac{W L^2}{T^2}$, and fired on four points, $f = \frac{W L^2}{4.27 T^2}$. These values are in the ratio of 3.2 : 1. He then assumes that the ratio of the bending moment in a beam or slab simply supported and uniformly loaded and that in a flat slab will be the same. The formula for the former is $\frac{Wl}{8}$; therefore the corresponding formula for the flat slab is $\frac{1}{3.2} . \frac{Wl}{8}$ or $\frac{Wl}{25.6}$. For convenience the value $\frac{Wl}{25}$ is taken and the slab figured out on this basis.

From this discussion it is evident that the Grashof formulae are unsatisfactory because, if for no other reason, they are capable of too many interpretations. The revised Cleveland building code gives the formula $\frac{Wl}{27}$, and the writer is inclined to believe that the correct value of the moment coefficient lies around 25 or 27. For purposes of comparison it will be interesting to tabulate some of the coefficients in use. Very few municipal building codes adequately cover this type of construction, and some of these work on the cantilever principle, notably Portland, Oregon, so that it is not possible to make an extensive table.

Authority.	Moment coefficient.	Authority.	Moment coefficient.
Grashof	26.5	Turner	50
Mensch	20	Brayton	12
McMillan	25	Cleveland building code	27

The following table is given by G. C. Stone and will serve as a comparison of the results to be obtained by these methods. The original table was the work of A. B. McMillan and covers six methods, to these Brayton added the result as it would be according to his method, for the sake of comparison Stone added the figures for a slab, beam, and girder design, and the figures for Ham's method were added by the author. The comparison is defective because the same stresses are not used throughout. The steel stress in Turner's method is 13,000 lbs. per sq. in., in all others it is 16,000 lbs. per sq. in. This is probably justifiable because the low stress used by Turner may be said to be an integral portion of his system of figuring. In the figures according to the Cantilever and Turneaure and Maurer's methods the concrete stress is 750 lbs., and so far as the author has been able to determine 650 lbs per sq. in. is used in all the other designs. The only apparent reason for using the high stress is that by so doing the slab thickness is kept down to a value which compares with that obtained by the other methods. Unless the cantilever principle of analysis has some feature that would justify the use of a higher stress than otherwise, we cannot consider the comparison absolutely fair for all concerned. It is, however, the best obtainable.

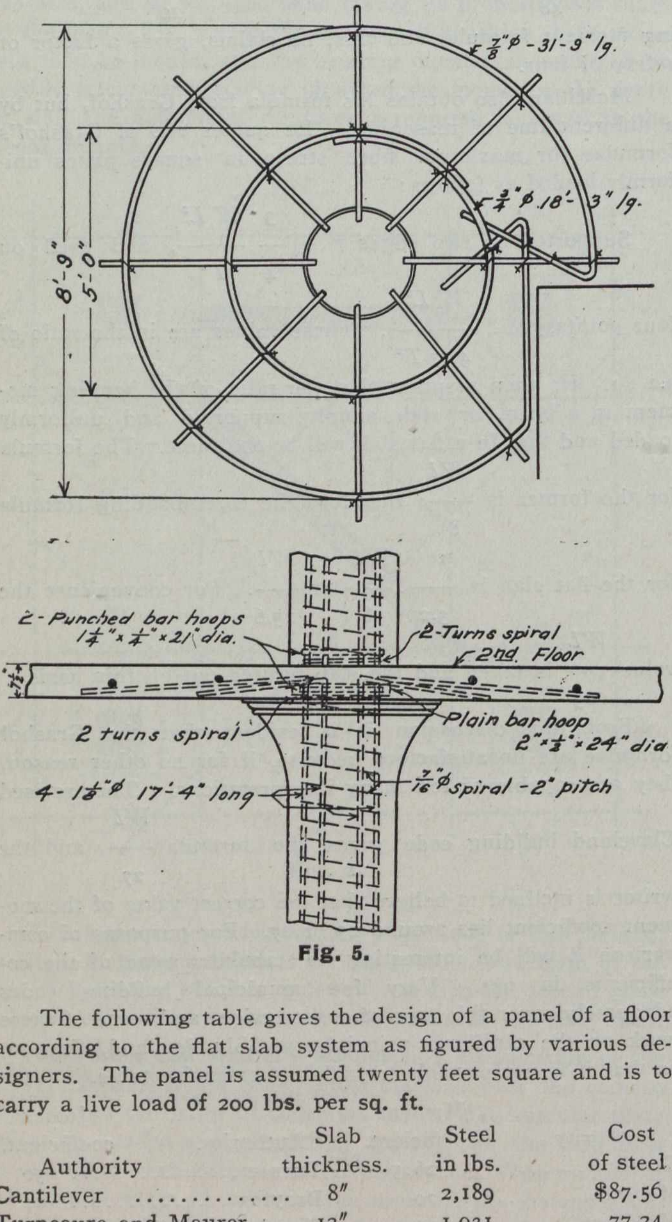


Fig. 5.

The following table gives the design of a panel of a floor according to the flat slab system as figured by various designers. The panel is assumed twenty feet square and is to carry a live load of 200 lbs. per sq. ft.

Authority	Slab thickness.	Steel in lbs.	Cost of steel
Cantilever	8"	2,189	$87.56
Turneaure and Maurer	12"	1,931	77.24
Ham	8"	2,378	95.12
Brayton	8½"	1,900	76.00
Turner	8"	718	28.72
Grashof	8"	784	31.36
Mensch	8"	2,120	84.80
McMillan	8"	1,084	43.36
Average	8.6"	1,638	$65.52
Slab, beam and girder	12"	2,300	92.00

The design of the radial steel cap on the column head which supports the bands of reinforcing is mostly a matter of economy and ease of erection. There are several patents on these caps, and one must either pay a royalty to the inventor or use a design materially different and probably inferior. In some of the designs it is certainly permissible to figure on their carrying a certain amount of stress; in others the practice would be indefensible. In general, it may be said that their function is primarily to hold the reinforcement in position, and any stress which they may carry is a secondary consideration only. Fig. 5 shows the details of a typical cap of this kind, it being Turner's design. It would appear to be very efficient although the wisdom of utilizing the main column reinforcement in this way might be questioned.

The reinforcing steel in usually plain medium steel bars of ½ in. or ⅝ in. diameter, used as they come from the mill and cut to length. They are commonly allowed to sag into position by their own weight, but it is much better if they are bent to the proper shape. This may be economically done by means of a right and left double-bar bender, which bends the bar to the exact shape at a very low cost.

The concrete is usually a 1:2:4 mix for broken stone or an equivalent one for gravel, no stone larger than ¾ in. being used. It should be mixed wet enough to flow readily around the reinforcement, it being generally recommended that it be of about the consistency of brick mortar. Where joints or bulkheads are necessary they should be made in a vertical plane and at or near the centre of the slab.

On December 13th, 1911, a new building code came into force in Cleveland, Ohio, embodying the latest knowledge on the subject of reinforced concrete building construction. It is particularly complete, and the design of floors by the flat slab system is given careful attention. There are many matters of importance which have not been dealt with in this thesis because not much information on them is available. These include the conditions in end and corner panels, the effect of narrowing the panel, the design of wall beams, and wall and corner columns. These questions are covered by the Cleveland building regulations, and in conclusion little better can be done than to quote some of the clauses of the code which refer particularly to the flat slab system of floor construction.

"Unit Stresses.

Medium steel in tension	16,000 lbs. per sq. in.
Concrete in direct compression	500 lbs. per sq. in.
Concrete, extreme fibre in compression	700 lbs. per sq. in.
Concrete in diagonal tension	40 lbs. per sq. in.

The compressive stress in the steel shall not exceed $\frac{c\ Es}{Ec}$ where c is the compressive stress in the concrete.

"Flat slab construction shall be figured with a bending moment in any quadrant over the column head of not less than $\frac{Wl^2}{27}$ in foot lbs, in which w is the total load per sq. ft., dead and live load; and l is the length in feet of the side of an equivalent square in rectangular panels, and the side of the square in square panels. This length shall be taken centre to centre of columns. The bands of reinforcing shall be made approximately $\frac{7}{16}l$ in width. In solving for the required area of steel over the column head, the distance from the compressive face to the plane of steel assumed shall be from the centre of gravity of all the steel to the under side of the slab. Any additional steel required over the column head shall extend beyond the centre of the column a distance not less than 0.3 l in all directions.

"The radial bars may be assumed as resisting tension, provided they are carried a distance horizontally not less than 0.1 l before bending downward; and further, that the allowed area of each radial bar figured to resist tension shall constitute not over one-half of the area of any single band of continuous reinforcement. The diameter of interior spirally reinforced columns shall never be less than $\frac{l}{13}$ for floors nor $\frac{l}{14}$ for roofs, and the diameter of column head shall never be less than $\frac{l}{5}$; and this head, if constructed of concrete, shall be dropped below the under edge of the slab at least three inches at the outer edge.

"Rectangular panels shall never be less in thickness than $\frac{l}{45}$ the diagonal distance from centre to centre of columns for floors, and not less than $\frac{l}{50}$ for roofs.

"The minimum thickness of slabs shall be 6½ in. for floors and 6 in. for roofs.

"The required percentage of steel in a single layer of bars shall not exceed 0.44% for medium steel or 0.36% for high carbon steel. In any flat slab type of construction provision shall be made to take care of circumferential stresses.

"In end or wall panels in which columns of reinforced concrete with heads are omitted, allowance shall be made for the increased moments. These moments shall be assumed to be 10% greater than the moments in the interior panels.

"If wall columns are used they shall be calculated to carry one-half the panel load plus any other loads, and if necessary the columns shall be designed for eccentric loadings. The wall beams shall be designed to carry one-third of the panel load plus any other loads. The minimum width of wall beams of reinforced concrete shall be 12 in., and never less than one-half the depth of the beam."

ELECTRIC STEERING-GEAR.

In a new method of controlling electric motors used for operating ordnance, steering-gear, swing bridges, etc., a rotatable resistance box is geared to the driven apparatus, so that when the contact arm is moved, and the apparatus is set in motion, the box follows the arm until the latter stands at the "off" position, when the motor comes to rest. The rheostat is arranged to act on the fields of both the dynamo and the motor, so as to reverse the direction of the latter without affecting the direction of the former.

The Robb Engineering Company has been completely reorganized with increased capital under the name International Engineering Works, Limited. The engine and boiler plants at Amherst, N.S., will continue to build the full line of horizontal and vertical Corliss engines, single-valve, high-speed, and English type of vertical compound engines, etc., so well known throughout Canada.

Tar as a covering for iron work must be used with great care, inasmuch as the crude material contains sulphuric acid and ammonia. This may cause serious pitting and rusting. Furthermore, it does not adhere well to bare metal and should never be applied except as a covering for other pigments The refined product offers the advantage of great resistance to foul atmospheres and corrosive gases. On account of its dark color the presence of rust cannot be easily detected.

FLOORS AND FLOOR SURFACE FOR FACTORIES.

H. N. Allott, C.E., in the course of an address to the Manchester Society of Engineers, says that for shop floors laid on concrete, where the work is of a heavy description, the best floor surface is one of wood blocks, 4 inches deep, which may be formed by sawing off 3-inch deals to lengths.

To prevent damp from rising through the concrete, the upper surface of the foundation should receive a coat of coal-tar pitch about ¼-inch thick, applied hot, and the blocks should be dipped in the hot coal-tar and bedded while the pitch is hot, any open joints being afterwards run in with pitch.

Where the work is of a lighter character, the most astisfactory wearing surface is grooved and tongued maple planking, nailed either to 4 by 3-inch battens laid in the concrete, or to planks laid transversely.

The battens should be creosoted, or dipped in "jodelite" or "sideroleum," or some similar wood preservative, and the planking laid in hot tar. It is very important that the whole surface of the floor should be thoroughly tarred before the wood blocks or planking is laid, and that any wood blocks or pegs used for levelling purposes should be removed.

Where the loads are very light and the foundation good, tar concrete may be substituted for the cement concrete, the upper surface being tarred as before.

The supported floors of a multi-story building, or of galleries, are usually constructed of concrete where a fire-resisting floor is required, or of timber in other cases. Where a concrete floor is used it may be constructed of reniforced concrete, or preferably of rolled-steel joists and concrete, as the more or less concentrated loads from machines and materials coming on the floor can be more easily arranged for.

In this case the floor can be constructed of small steel joists from 4 to 7 inches deep, according to the span and load, spaced about 2 feet apart, and finished with a flat ceiling. If the concrete is arched or recessed between the joists, hangers can be easily attached by hook bolts to carry countershafting. Another method, where the loads are considerable, is to use joists of heavier section, and to form an arched floor of concrete between these.

The upper surface of the floor can be finished with wood planking as previously described. If the floor is constructed of timber, wood joists bedded on the steel main girders can be used, with wood planking laid on top.

AUSTRALIAN RAILWAY GAUGE.

A conference of the chief engineers of the Commonwealth and state railway departments in Melbourne has urged the immediate adoption of a uniform 4 ft. 8½ in. gauge throughout Australia. The estimated cost of carrying this into effect is $185,000,000.

According to Prof. J. Goodman, in his paper read before the Institute of Civil Engineers, the safe load for a roller bearing, when the speed is not abnormal, may be calculated by the formula $P = Klnd^2/(ND + 2{,}000d)$, in which P is the safe load in lb.; l and d the length and diameter of rollers, in in.; n the number of rollers in the cage; N the r.p.m. of shaft; D the diameter of shaft or sleeve upon which the rollers run; and K a constant which has a value of from 1,200,000 to 2,000,000 when steel rollers are used, the workmanship is of the highest class, and when all surfaces are hardened and ground. For bearings with cost-iron casings and soft steel rollers and shafts, where the workmanship is of an ordinary grade, K may be taken at about 400,000.

CANADA'S ESTIMATED EXPENDITURE, 1913-14.

The following carefully compiled table will be of interest to readers of the *Canadian Engineer*. It shows the estimated expenditure of the Dominion for the fiscal year to end March 31st, 1914, together with the grants which were made for the year ending March 31st last. The table also includes a statement showing the increase or decrease for each service when the two fiscal years are compared.

Service	1912–13	To be Voted, 1913–14	Authorized by Statute	Total	Compared with Estimates 1912–13	
					Increase	Decrease
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Public Debt, including Sinking Funds	13,380,614 31	...	13,144,913 01	13,144,913 01	...	235,701 30
Charges of Management	451,800 00	509,800 00	...	509,800 00	58,000 00	...
Civil Government	5,535,765 84	5,637,745 52	267,066 66	5,904,812 18	369,046 34	...
Administration of Justice	1,360,383 34	86,183 34	1,285,300 00	1,371,483 34	11,100 00	...
Dominion Police	97,000 00	104,000 00	...	104,000 00	7,000 00	...
Penitentiaries	645,700 00	650,500 00	...	650,500 00	4,800 00	...
Legislation	1,686,032 83	861,614 00	801,500 00	1,663,114 00	...	22,918 83
Arts, Agriculture and Statistics	2,610,500 00	2,508,500 00	...	2,508,500 00	...	102,000 00
Quarantine	199,000 00	273,000 00	...	273,000 00	74,000 00	...
Immigration	1,431,250 00	1,520,250 00	...	1,520,250 00	89,000 00	...
Pensions	250,992 27	22,868 75	286,506 25	309,375 00	58,382 73	...
Superannuation	400,000 00	400,000 00	...	400,000 00	...	...
Militia and Defence	8,896,397 00	10,479,065 00	21,600 00	10,500,665 00	1,604,268 00	...
Railways and Canals—Income	1,034,716 13	985,397 33	55,000 00	1,040,397 33	5,681 20	...
Public Works—Income	22,290,251 40	22,927,635 00	15,000 00	22,942,635 00	652,383 60	...
Mail Subsidies and Steamship Subventions	2,232,600 66	1,916,934 00	321,666 66	2,238,600 66	6,000 00	...
Naval Service	3,140,500 00	2,570,000 00	...	2,570,000 00	...	570,500 00
Ocean and River Service	1,265,400 00	1,240,400 00	...	1,240,400 00	...	25,000 00
Lighthouse and Coast Service	2,742,300 00	2,569,300 00	...	2,569,300 00	...	173,000 00
Scientific Institutions	417,500 00	471,400 00	...	471,400 00	53,900 00	...
Marine Hospitals and Sick and Distressed Seamen	73,000 00	68,000 00	...	68,000 00	...	5,000 00
Steamboat Inspection	57,000 00	60,000 00	...	60,000 00	3,000 00	...
Fisheries	1,076,200 00	1,163,900 00	160,000 00	1,323,900 00	247,700 00	...
Subsidies to Provinces	10,281,042 56	...	11,008,402 26	11,008,402 26	727,359 70	...
Mines and Geological Survey	444,900 00	496,400 00	...	496,400 00	51,500 00	...
Labour	85,300 00	90,300 00	...	90,300 00	5,000 00	...
Indians	1,929,825 00	1,647,662 00	204,560 00	1,852,222 00	...	77,603 00
Royal Northwest Mounted Police	785,100 00	838,000 00	...	838,000 00	52,900 00	...
Government of the Northwest Territories	8,800 00	8,000 00	...	8,000 00	...	800 00
Government of the Yukon Territory	303,000 00	303,000 00	...	303,000 00	...	...
Dominion Lands and Parks	2,464,109 50	3,084,909 50	...	3,084,909 50	620,800 00	...
Miscellaneous	1,046,170 00	728,885 00	196,500 00	925,385 00	...	120,785 00
Customs	3,070,000 00	3,830,000 00	...	3,830,000 00	760,000 00	...
Excise	825,800 00	911,607 00	...	911,607 00	85,807 00	...
Weights and Measures, Gas and E. Light Inspection	234,166 00	258,600 00	...	258,600 00	24,434 00	...
Adulteration of Food, &c	32,000 00	32,000 00	...	32,000 00	...	...
Railways and Canals—Collection of Revenue	11,859,015 00	14,904,830 00	...	14,904,830 00	3,045,815 00	...
Public Works—Collection of Revenue	646,600 00	684,400 00	...	684,400 00	37,800 00	...
Post Office	10,596,287 91	11,942,975 00	...	11,942,975 00	1,346,687 09	...
Trade and Commerce	1,931,462 00	1,294,262 00	...	1,294,262 00	...	637,200 00
Total Consolidated Fund	117,818,481 75	98,082,323 44	27,768,014 84	125,850,338 28	8,031,856 53	...
Railways and Canals—Capital	41,197,372 82	38,638,845 00	...	38,638,845 00	...	2,558,527 82
Public Works—Capital	8,332,512 91	12,202,000 00	...	12,202,000 00	3,869,487 09	...
Public Works—Capital—Marine Department	1,878,000 00	2,461,000 00	...	2,461,000 00	583,000 00	...
Total Capital	51,407,885 73	53,301,845 00	...	53,301,845 00	1,893,959 27	...
Grand Total	169,226,367 48	151,384,168 44	27,768,014 84	179,152,183 28	9,925,815 80	...
Redemption of Debt	...	...	9,720,043 34	9,720,043 34	...	...

A new pulp mill is being constructed for the Abitibi Pulp and Paper Company in the vicinity of Lake Abitibi.

It is stated that the management of the Intercolonial Railway is to pass from that of a board of managers into the hands of a single commissioner, who is Mr. F. P. Gutelius, who was formerly superintendent of the Canadian Pacific Railway, and for the past year has been engaged in an investigation of the construction of the Transcontinental Railway.

In 1907 Canada imported 533 traction engines, valued at $588,234; in 1908, 698, valued at $6,043,723.

Manganese steel dredge buckets are to be used to overcome the difficulties experienced in excavating the Pacific entrance channel to the Panama Canal. The experiment is being tried, as the carbon steel buckets which are now in use are not sufficiently strong to endure the hard digging. The new buckets have a capacity of 35 cubic feet each and weigh 5,400 pounds.

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

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

Vol. 24. TORONTO, CANADA, JUNE 19, 1913. No. 25

CONTENTS OF THIS ISSUE.

MONTREAL FILTRATION PLANT.

In Montreal some conflicting opinions among engineers are forming the basis of much controversy concerning the $5,000,000 filtration works under construction at Verdun, to supplant the city's present water supply system.

It will be remembered that, in 1910, Montreal called in the services of Messrs. Hering & Fuller, consulting engineers, of New York, to report on the prospect of a safer and better supply of water for the city. In July of that year the engineers submitted their report, recommending the use of St. Lawrence River water, subjected to double filtration. The recommendation was adopted, and they were retained to co-operate with Mr. Janin, chief engineer, and Mr. Lesage, engineering superintendent of waterworks, in the preparation of plans and specifications and in the supervision of building operations.

Of the four contracts into which the work of construction was divided, those covering the building of the prefilters, filtered water reservoir and final filters, were awarded to Mr. F. H. McGuigan, contractor, of Toronto. Details regarding the general type of construction were published in the January 18th, 1912, issue of *The Canadian Engineer*.

Owing to ill-health Mr. McGuigan found it necessary to discontinue operations last fall, and the work, which had progressed favorably through several months, was taken over by Mr. Norman M. McLeod, contractor, of Montreal.

Recently Mr. McLeod served the city council of Montreal with a protest, alleging that the site chosen by Messrs. Hering and Fuller, in conjunction with Mr. Janin and Mr. Lesage, was most unsuitable for such a structure, the soil being insufficiently firm, owing to the presence of quicksand. He also claimed that there were serious defects in the design of the filters, and that severe cracking and similar symptoms of failure and collapse were in evidence. He predicted that the structure would be of little usefulness when completed. Opinions of prominent engineers, familiar with the conditions, corroborated, in whole or part, Mr. McLeod's statements.

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CANADA'S ESTIMATED EXPENDITURE, 1913-14.

The following carefully compiled table will be of interest to readers of the *Canadian Engineer*. It shows the estimated expenditure of the Dominion for the fiscal year to end March 31st, 1914, together with the grants which were made for the year ending March 31st last. The table also includes a statement showing the increase or decrease for each service when the two fiscal years are compared.

Service	1912–13	To be Voted, 1913–14	Authorized by Statute	Total	Compared with Estimates 1912–13	
					Increase	Decrease
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.
Public Debt, including Sinking Funds	13,380,614 31	...	13,144,913 01	13,144,913 01	...	235,701 30
Charges of Management	451,800 00	509,800 00	...	509,800 00	58,000 00	...
Civil Government	5,535,765 84	5,637,745 52	267,066 66	5,904,812 18	369,046 34	...
Administration of Justice	1,360,383 34	86,183 34	1,285,300 00	1,371,483 34	11,100 00	...
Dominion Police	97,000 00	104,000 00	...	104,000 00	7,000 00	...
Penitentiaries	645,700 00	650,500 00	...	650,500 00	4,800 00	...
Legislation	1,686,032 83	861,614 00	801,500 00	1,663,114 00	...	22,918 83
Arts, Agriculture and Statistics	2,610,500 00	2,508,500 00	...	2,508,500 00	...	102,000 00
Quarantine	199,000 00	273,000 00	...	273,000 00	74,000 00	...
Immigration	1,431,250 00	1,520,250 00	...	1,520,250 00	89,000 00	...
Pensions	250,992 27	22,868 75	286,506 25	309,375 00	58,382 73	...
Superannuation	400,000 00	400,000 00	...	400,000 00	...	...
Militia and Defence	8,896,397 00	10,479,065 00	21,600 00	10,500,665 00	1,604,268 00	...
Railways and Canals—Income	1,034,716 13	985,397 33	55,000 00	1,040,397 33	5,681 20	...
Public Works—Income	22,290,251 40	22,927,635 00	15,000 00	22,942,635 00	652,383 60	...
Mail Subsidies and Steamship Subventions	2,232,600 66	1,916,934 00	321,666 66	2,238,600 66	6,000 00	...
Naval Service	3,140,500 00	2,570,000 00	...	2,570,000 00	...	570,500 00
Ocean and River Service	1,265,400 00	1,240,400 00	...	1,240,400 00	...	25,000 00
Lighthouse and Coast Service	2,742,300 00	2,569,300 00	...	2,569,300 00	...	173,000 00
Scientific Institutions	417,500 00	471,400 00	...	471,400 00	53,900 00	...
Marine Hospitals and Sick and Distressed Seamen	73,000 00	68,000 00	...	68,000 00	...	5,000 00
Steamboat Inspection	57,000 00	60,000 00	...	60,000 00	3,000 00	...
Fisheries	1,076,200 00	1,163,900 00	160,000 00	1,323,900 00	247,700 00	...
Subsidies to Provinces	10,281,042 56	...	11,008,402 26	11,008,402 26	727,359 70	...
Mines and Geological Survey	444,900 00	496,400 00	...	496,400 00	51,500 00	...
Labour	85,300 00	90,300 00	...	90,300 00	5,000 00	...
Indians	1,929,825 00	1,647,662 00	204,560 00	1,852,222 00	...	77,603 00
Royal Northwest Mounted Police	785,100 00	838,000 00	...	838,000 00	52,900 00	...
Government of the Northwest Territories	8,800 00	8,000 00	...	8,000 00	...	800 00
Government of the Yukon Territory	303,000 00	303,000 00	...	303,000 00	...	...
Dominion Lands and Parks	2,464,109 50	3,084,909 50	...	3,084,909 50	620,800 00	...
Miscellaneous	1,046,170 00	728,885 00	196,500 00	925,385 00	...	120,785 00
Customs	3,070,000 00	3,830,000 00	...	3,830,000 00	760,000 00	...
Excise	825,800 00	911,607 00	...	911,607 00	85,807 00	...
Weights and Measures, Gas and E. Light Inspection	234,166 00	258,600 00	...	258,600 00	24,434 00	...
Adulteration of Food, &c	32,000 00	32,000 00	...	32,000 00	...	...
Railways and Canals—Collection of Revenue	11,859,015 00	14,904,830 00	...	14,904,830 00	3,045,815 00	...
Public Works—Collection of Revenue	646,600 00	684,400 00	...	684,400 00	37,800 00	...
Post Office	10,596,287 91	11,942,975 00	...	11,942,975 00	1,346,687 09	...
Trade and Commerce	1,931,462 00	1,294,262 00	...	1,294,262 00	...	637,200 00
Total Consolidated Fund	117,818,481 75	98,082,323 44	27,768,014 84	125,850,338 28	8,031,856 53	...
Railways and Canals—Capital	41,197,372 82	38,638,845 00	...	38,638,845 00	...	2,558,527 82
Public Works—Capital	8,332,512 91	12,202,000 00	...	12,202,000 00	3,869,487 09	...
Public Works—Capital—Marine Department	1,878,000 00	2,461,000 00	...	2,461,000 00	583,000 00	...
Total Capital	51,407,885 73	53,301,845 00	...	53,301,845 00	1,893,959 27	...
Grand Total	169,226,367 48	151,384,168 44	27,768,014 84	179,152,183 28	9,925,815 80	...
Redemption of Debt	...	...	9,720,043 34	9,720,043 34	...	...

A new pulp mill is being constructed for the Abitibi Pulp and Paper Company in the vicinity of Lake Abitibi.

It is stated that the management of the Intercolonial Railway is to pass from that of a board of managers into the hands of a single commissioner, who is Mr. F. P. Gutelius, who was formerly superintendent of the Canadian Pacific Railway, and for the past year has been engaged in an investigation of the construction of the Transcontinental Railway.

In 1907 Canada imported 533 traction engines, valued at $588,234; in 1908, 698, valued at $6,043,723.

Manganese steel dredge buckets are to be used to overcome the difficulties experienced in excavating the Pacific entrance channel to the Panama Canal. The experiment is being tried, as the carbon steel buckets which are now in use are not sufficiently strong to endure the hard digging. The new buckets have a capacity of 35 cubic feet each and weigh 5,400 pounds.

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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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, Western Manager.

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

Address all communications to the Company and not to individuals.

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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. 24. TORONTO, CANADA, JUNE 19, 1913. No. 25

CONTENTS OF THIS ISSUE.

MONTREAL FILTRATION PLANT.

In Montreal some conflicting opinions among engineers are forming the basis of much controversy concerning the $5,000,000 filtration works under construction at Verdun, to supplant the city's present water supply system.

It will be remembered that, in 1910, Montreal called in the services of Messrs. Hering & Fuller, consulting engineers, of New York, to report on the prospect of a safer and better supply of water for the city. In July of that year the engineers submitted their report, recommending the use of St. Lawrence River water, subjected to double filtration. The recommendation was adopted, and they were retained to co-operate with Mr. Janin, chief engineer, and Mr. Lesage, engineering superintendent of waterworks, in the preparation of plans and specifications and in the supervision of building operations.

Of the four contracts into which the work of construction was divided, those covering the building of the prefilters, filtered water reservoir and final filters, were awarded to Mr. F. H. McGuigan, contractor, of Toronto. Details regarding the general type of construction were published in the January 18th, 1912, issue of *The Canadian Engineer*.

Owing to ill-health Mr. McGuigan found it necessary to discontinue operations last fall, and the work, which had progressed favorably through several months, was taken over by Mr. Norman M. McLeod, contractor, of Montreal.

Recently Mr. McLeod served the city council of Montreal with a protest, alleging that the site chosen by Messrs. Hering and Fuller, in conjunction with Mr. Janin and Mr. Lesage, was most unsuitable for such a structure, the soil being insufficiently firm, owing to the presence of quicksand. He also claimed that there were serious defects in the design of the filters, and that severe cracking and similar symptoms of failure and collapse were in evidence. He predicted that the structure would be of little usefulness when completed. Opinions of prominent engineers, familiar with the conditions, corroborated, in whole or part, Mr. McLeod's statements.

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It is understood that the board of examining engineers has made a thorough study of the ground upon which the structure is being built, and that the earth has been found by them to be quite suitable for the purpose.

The probable result of the report is predicted to be that the contractor will be required to complete the filtration plant according to specifications, and that the responsibility of damage by frost may not be charged to other than himself.

Because filtration plant installation is, as yet, in a more or less experimental stage in America, from the difference of opinion among Montreal engineers concerning suitability of site, it is to be expected that information of value to other cities and towns with similar problems ahead of them, will be derived.

OCEAN FREIGHTS.

The question of advances in ocean freight rates, both import and export, is of considerable importance to engineering and contracting supply houses, and many will be interested to know that it has again been discussed by the Montreal board of trade. It was decided to call the attention of the government to the matter, with a view of learning whether Great Britain and the other maritime nations could be induced to take joint action for the control of rates. As a preliminary step the transportation bureau committee of the board recommended that the Dominion government should be asked to appoint a commission of inquiry with a view to arriving at all the facts in connection with the advances in rates that have taken place within the last few years.

The question of ocean rates arises periodically. It is alleged, and generally believed, that they are regulated by combination. The question was investigated to some extent by Mr. Richard Grigg, chief Canadian Trade Commissioner, when he held the position of British Trade Commissioner in Canada. In a report to the Imperial Government in 1907 he said: "It must be a matter of opinion as to whether rates of carriage are higher than the service warrants, and if they are, it is perhaps easier to state the fact than to formulate a remedy. Assuming them to be so, it would appear that part of the preference designed to encourage the import of British manufacture goes into the pockets of steamship owners, and thereby to some extent defeats the intention of the preference by checking the import of British goods. Of course, no such conditions operates in regard to American goods, which are not subject to ocean carriage.

"It seems only reasonable to suppose that the officers of a company or conference whose employment and advancement must be justified by results, will strive to use every means placed at their disposal for the advancement and profit of the service to which they are attached unless restrained by policy imposed upon them by higher authority, and if this be so, the question is considerably narrowed. The condition with regard to the deferred rebate by means of primage (which is incapable of concealment) appears to establish the desire of the conference to discourage competition, and so to maintain rates; and the remaining problem is the extent to which the line of policy indicated is pursued. The answer is important to British trade, and it appears desirable that it should be sought and the whole facts made known upon competent authority."

That was apparently an appeal to the Imperial Government to investigate the matter. The subject of the control of ocean freight rates has frequently been brought to their attention, but little progress has been made with a view to an unbiased investigation. Meantime shippers pass sheafs of resolutions and the shipping companies are looking after their own interests.

EDITORIAL COMMENT.

The Canadian Electrical Association meets in Toronto June 25th, 26th and 27th. An excellent programme has been prepared and special rates are at the disposal of those desiring to attend.

* * * *

In his report for the year 1913, just issued, the Commissioner of Works for the city of Toronto recommends the construction of 20,400 feet of cement concrete sidewalks, 2,050 feet of asphalt pavements, 400 feet of brick pavements, and 10,000 feet of concrete pavements. His recommendation also includes 4,000 feet of curbing.

* * * *

An interesting feature of Col. Ruttan's report to the Winnipeg City Council, concerning the city's water supply project, is his proposal to bring the supply into the city through a tunnel to be driven through the rock below the bed of the Red River, the tunnel to be of sufficient size to carry three or four forty-eight-inch pipes, with provision for future extensions.

* * * *

A Convention of the American Waterworks Association will be held in Minneapolis during the week of June 23rd, and a very complete programme has come to hand concerning the papers to be read, the reports to be presented and provision for entertainment. It is not unlikely that Canadian cities will be well represented. At any rate the nature of the proceedings will be of great value to Canadian waterworks engineers. The Society for the Promotion of Engineering Education hold their convention in Minneapolis at the same time, and at one session the two organizations will hold a joint meeting.

* * * *

The Government has awarded the contract for the construction of lock-gates on sections three and four of the Trent Valley Canal. The southern portion of the canal is thus nearing completion. It is also reported at Ottawa that tenders will shortly be called for the beginning of work on the northern section, from Lake Simcoe to Georgian Bay via the Severn River. This will complete the waterway from Georgian Bay to Lake Ontario. To date, the canal has cost in the neighborhood of $11,000,000, and will require approximately $5,000,000 before it is finished.

LETTERS TO THE EDITOR.

Sir,—Referring to the article under the heading "Disadvantages of Chemically Pure Water as a Beverage" in your issue of May 15, the writer came across an instance of its truth a few years ago in Gibraltar, where the naval authorities, for a while, supplied all the dockyard staff in government quarters with distilled water which had not been aërated.

The use of this water brought on constipation, and for a time caused a good deal of unnecessary discomfort to the unfortunates to whom it was supplied.

Distilled water was largely sold to the citizens by the sanitary commissioners during the dry summer months, but this was properly aërated and no trouble ever seemed to result from drinking it.

Yours faithfully,

ALFRED S. L. BARNES.

Toronto, May 22, 1913.

THE PLOTTING OF RAILWAY CURVES

A METHOD OF PLOTTING TO A DISTORTED SCALE—SUITABLE FOR RELINING EXISTING CURVES—DOUBLE TRACK WORK—STATION LOCATION ON CURVE, ETC.

By J. L. BUSFIELD, B.Sc., A.C.G.I.

In a paper read before the British Institute of Civil Engineers in 1909 by Mr. W. H. Shortt, A.M.I.C.E., on "Railway Transition Curves," a method of plotting railway curves was described, together with the mathematical proofs of the accuracy of this method, and also details of some of the uses of this method in practical railway work were given.

Mr. Shortt, in his paper described the interdependence of scales in distorted diagrams in the following way: "If a given circular arc be plotted with the radius struck to a scale of $a \times b$ feet per inch, and the length of the arc marked

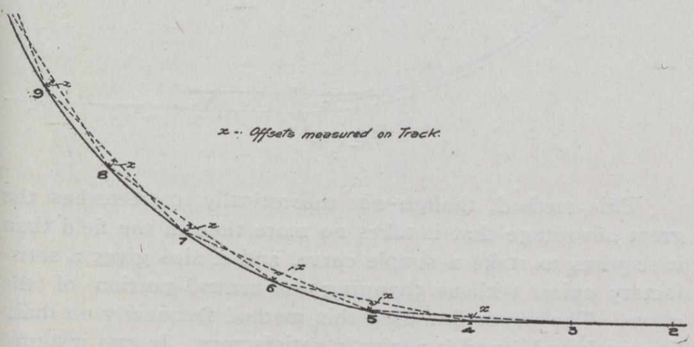


Fig. 1.

off to a scale of a ft. per in., then a scale of a/b ft. per in. must be used to scale off the true distance of any given point from the arc, **provided such distance is small compared with the radius of the arc.**"

Now, for general use scales in the proportions of 100 to 10 to 1 should be used for the radius, arcs and offsets respectively, i.e., if the radius of the arc is made 400 ft. per in., and a distance measured along the arc to a scale of 40 ft. per in., then the small measurements at right angles to the arc can be made to a scale of 4 ft. per in.

This method of plotting has been used with success in Great Britain, and the writer has used it for different purposes and found it satisfactory for practical use.

The use to which it was originally put in Great Britain was for the re-alignment of existing railway curves, with the insertion of transition curves where they did not formerly exist. A preliminary survey was first made of the curve to be remodelled, by marking off on one predetermined rail, consecutive stations, one chain length apart, commencing at a point on the tangent at least 2 or 3 chains before the commencement of the curve. After this was done the curvature was obtained by means of taking offsets from chords 2 chains long. This was very rapidly and easily performed by stretching a cord between alternative stations and taking the offset at the intervening station. In addition to this all controlling features, such as the edges of the fills, or cuts, bridges, tracks, platforms, etc., were located by means of offsets from the rail used as a base line.

The survey thus obtained of the track and adjacent structure was then plotted to a distorted scale, preferably using either the 100-ft., 10-ft. and 1-ft. per in., or the 200-ft, 20-ft. and 2-ft. per in. scales. This was done by laying off the tangent and then plotting the chords by the offsets obtained in the field, and then joining up the ends of the chords with a continuous curve, as shown in Fig. 1. The full line representing the alignment of the rail used as a base line, and the dotted lines showing the chords and offsets x by means of which the curve was located and plotted.

In Fig. 2 the same curve is shown by the dotted line, the construction lines being erased, and the controlling structures have been plotted, also to the distorted scale, and from these the maximum shift permissible on either side is obtained. In the figure the arrow heads represent the limits between which the rail may be moved. The next thing to be done is to fit on an improved alignment. This is shown as finally completed by the full line.

The best position for this improved alignment is obtained by trial. A curve is drawn to the same distorted scale of about the same radius, and a transition curve is inserted between the points marked A and B in Fig. 3. The curve DBC is drawn with a radius approximately that of the curve on the ground with the beginning of curve at point D. The correct distances DF and FA for the transition curve can be computed from various formulae, then B the end of the tran

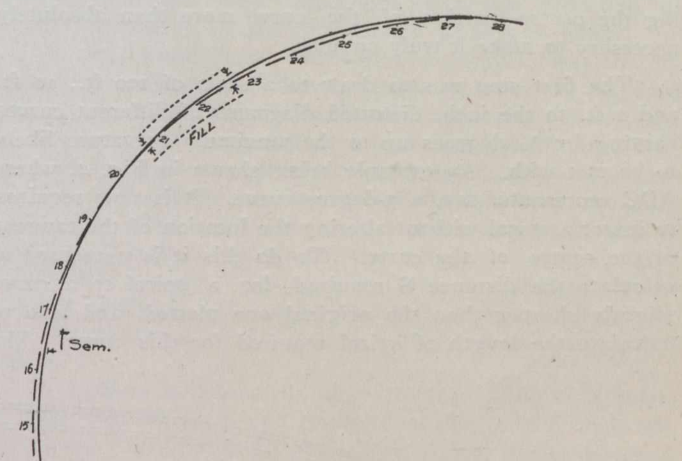


Fig. 2.

sition curve is located by making DB = FA, and also G, bisects DF, so three points on the transition curve are obtained. The intermediate curve can then be readily plotted as a cubic parabola, by dividing AF and DB into an equal number of parts, and taking cubic proportions of the distance GF. If this curve is plotted on tracing paper, it can then be superimposed upon the original alignment curve and by trying different curves a suitable one can be obtained to give the best alignment with the minimum shift of track and keeping within the defined limits, as shown in Fig. 2. The distance the track has to be moved at each station can now be measured off on the diagram to the correct scale, and if these measurements are then staked out in the field and the track lined over a good alignment will be obtained. This is only one of the simpler cases in which this method of

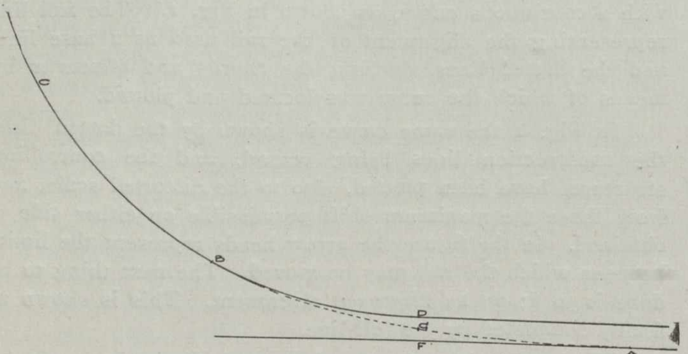


Fig. 3.

plotting was used, and other more complicated ones are described by Mr. Shortt in his paper.

The writer has used this method of plotting curves for two different purposes and found it very satisfactory in both cases. The first case was for relining existing railway curves, with the insertion of a spiral curve without disturbing the centre portion of the curve more than absolutely necessary to make it truly circular.

The first step was to draw to a scale of 100 ft., 10 ft. and 1 ft. to the inch, distorted diagrams of different curves varying by ½ degrees up to the maximum curvature likely to be met with. An example being shown in Fig. 4, where ADC represents, say, a 3-degree curve. It is now required to insert a spiral without altering the location of the tangent of the centre of the curve. To do this it is necessary to calculate the distance S required for a spiral to a curve slightly sharper than the original one plotted, and also to calculate the length of spiral required for this curve. The line EG should then be drawn parallel to the tangent AD, and a curve EFC drawn tangent to EG at E, and tangent to curve ADC at C, care being taken that EC is longer than half the length of spiral, and then a cubic parabola can be drawn in, as shown by the dotted line ABF.

Starting from the BC of the original curve 25 ft. or 50 ft. distant are marked off to the 10-ft. scale, along the arc DC and also along the tangent DA, and at each of these points the offsets x are measured between the circular curve and the spiral curve ABFC. As the scale for these offsets is 1 ft. to the inch they can be measured within a ¼ of an inch, which is just close enough for track work. The offsets can then be tabulated for the different degrees of curvature, ready for use in the field.

In staking out a curve with the new alignment, the BC is located in the usual way and the transit is sighted along the tangent and stakes put in every 25 or 50 ft. (according to choice) from the BC, each being offset a certain amount according to the tables, until the point of spiral is reached where the stake is set on the centre line. The transit is then reversed and angles deflected in the regular way round the curve, the stakes again being offset the correct amount until the end of the spiral is reached. In this way the curve ABFC is staked out on the ground.

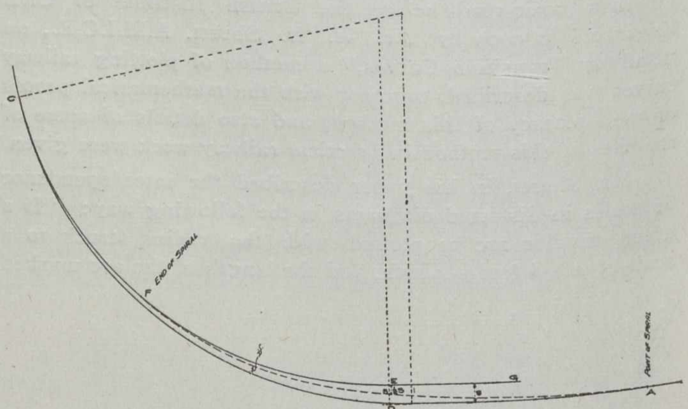


Fig. 4.

This method, though not theoretically correct, has the great advantage that it takes no more time in the field than it requires to stake a simple curve, and it also gives a satisfactory spiral without changing the central portion of the curve. The writer has used this method frequently on main line work and found it perfectly satisfactory. In one instance a 5½° curve at the foot of a 1% grade was spiralled in this manner, and the trains passing onto this curve did so in a smooth and easy manner. The portion of the curve CF that is sharpened above the main curve can be made so short and of such a small amount sharper that it is practically negligable.

It frequently happens in railway double track work that it is required to take advantage of a curve in the tracks to increase the distance between the centres of the tracks; for example, if a bridge is required at the centre of a long curve it might be desirable to use a girder between the two tracks which would have to be separated to perhaps 15 ft. centres instead of 13 ft. Another instance where this occurs is at stations located on a curve, it may be desirable to put a platform or standpipes between the two tracks requiring 18 ft. to 20 ft. centres at the centre and only the standard 13 ft. centres at the ends of the curve. The distorted curve diagram can readily and easily be used to assist in the laying out of work of this nature.

Taking the case where a 13-ft. platform is necessary between the two main lines, as shown in Fig. 5, at the ends of the curve on the tangents the tracks are 13 ft. centres and opposite the platform the tracks are 18 ft. centres and parallel, so that between the ends of the platforms and the tangents the two tracks have to converge 5 feet.

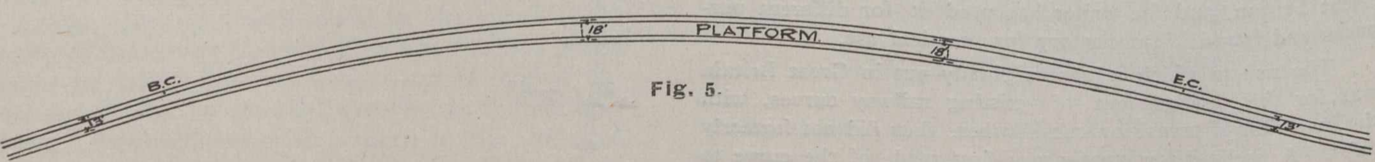


Fig. 5.

In laying out this work one track would be staked out as a uniform curve in the usual way, and one method of locating the second track would be to run intersections at either end of the curve and then stake these out independently of the first curve. This method takes considerable time and requires several men to do it. The other method is to plot a 3-scale curve which will facilitate the work, requiring the time of one man for about half an hour to do the necessary plotting.

The method of procedure is to draw the tangent and regular curve as staked out on the ground, and shown in Fig. 6 by xyz. If a 100-ft. scale is used for the radius, the distance from the BC to the beginning of the platform GF is scaled off 10 ft. to the inch. Now we have the condition that the two curves must be parallel at the platform and 18 ft apart, and also parallel at the tangents 13 ft. apart, or the same result is obtained by assuming 2 curves to run from the one

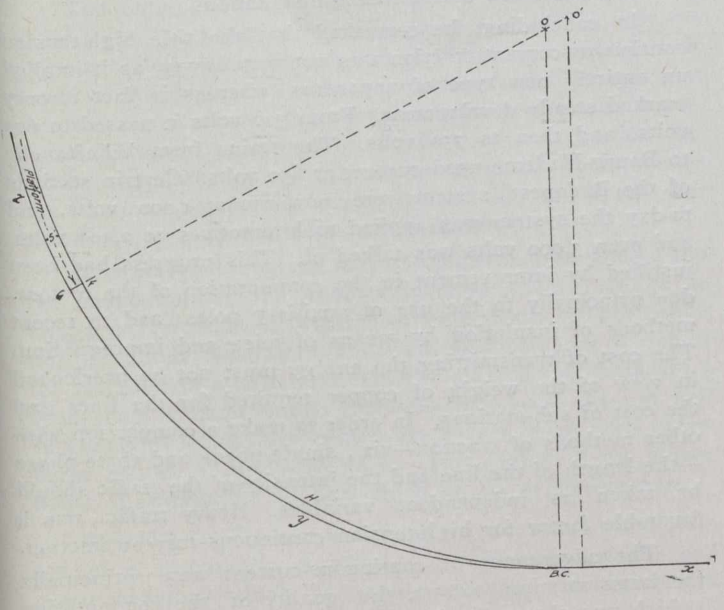


Fig. 6.

tangent and spread out 5 ft. apart at the platform, or at the point G in Fig. 6. Now, making FG = 5 ft. at 1 ft. = 1 in., it is now necessary to draw in a curve with its centre on the line GO, or GO produced which will also be tangential to the tangent X. This curve is shown FHX.

Equal distances can now be marked off along the tangent and curve XYZ, corresponding to the positions of the stakes on the ground. The offsets between these points and the new curve GHX can now be scaled off and made us into tabular form. If necessary, the process should be repeated for the other end of the curve and the tables giving the station of the stakes (or numbers for identification) and the corresponding track centres opposite each stake should be given to the track foreman who will then be able to give the second track its correct alignment.

This method has been used by the writer with success, and it has proved to save time in the field and work more satisfactorily than staking out individual curves.

The International Geological Congress will be tendered a reception by the civic authorities on Monday, August 12th. Delegates will be received in the council chamber, city hall, by His Worship the Mayor. It is understood that the Federal and Provincial Governments are providing for similar receptions to the delegates on their extended trip across Canada. It is expected that the convention will be attended by over eight hundred members.

LAYOUT, DESIGN, AND EQUIPMENT OF INDUSTRIAL PLANTS.

By A. Home-Morton.

The importance of an adequate amount of time being spent upon the design proper in the creation of industrial works and establishment of industries is receiving increasing attention as a special branch of Applied Engineering involving the consideration of every problem which might arise from the conception to the realization of the enterprise. In recent issues of *The Canadian Engineer* the design of a structural steel plant was carefully dealt with, every phase bearing upon construction and subsequent operation receiving its due amount of attention. In a paper read recently before the Liverpool Engineering Society Mr. A. Home-Morton dealt with the design of industrial works in general, dividing his subject into six sections, viz.: General and financial considerations; labor and labor conditions; general arrangements; generation and transmission of energy; design and consideration of the works structure; and reconstruction.

Efficiency and Economy.—The stress of competition in modern industry demanded efficiency with economy in every department. Industrial engineers were in consequence frequently called upon to supplement estimates of the capital cost of a projected undertaking with estimates of the working costs, maintenance, and even of profits. These demands in proprietors' interests were, under certain conditions, legitimate and desirable, and the engineer-designer must be able to satisfy the proprietor with such estimates, accurate to within a moderate percentage. Careless estimating ought to be inconsistent with professional honor.

Due consideration of and for the worker was now being accepted as a sound business policy. There was a tendency toward improved labor conditions and the reduction of physical drudgery by the introduction of aids to labor.

A certain school of economics contended that the increase of mechanical appliances tended to lower the standard of excellence and skill in handicraft, and, consequently, the intelligence of the craftsman, but it was equally true that the greater perfection of the results, increased rate of production, and usually greater reward obtained with mechanically aided labor tended to improve labor conditions, and to uplift, rather than to degrade, the worker.

It must be clear that in order to secure not only quantity but quality of output, the interest and skill of the worker and the perfection of equipment must be maintained unimpaired.

A general arrangement must be considered with reference to the character and quantity of the output, and the limitations and disabilities of the site. Actual plants designed to produce the same commodity on sites of varying form were found on examination to have similar essential areas, even although they might differ somewhat in arrangement. This suggested a relationship between floor area and output, which, theoretically, ought to hold, and on investigation would be found to apply even in plants which had grown from humble beginnings. Such a ratio of floor area to output would vary with the magnitude of the output, although it would probably hold for average conditions over a considerable range in magnitude.

Processes and Routing of Work.—The first essential to a general arrangement design was the "process diagram," and the second the "routine diagram." The process diagram was simply the enumeration in tabular form, or the graphical presentment, of the several shop processes. When to a graphical diagram of a process of manufacture was added a complete schedule of the areas required to house the machines necessary to produce a given output, then a complete "process diagram" was the result.

From the process diagram and the basis areas already mentioned, the engineer-designer with an intimate knowledge of the whole process of manufacture, and of the machines necessary to accomplish the process in each particular section, might proceed to prepare the routine diagram, which represented graphically the flow of work in process. In preparing this, the plant should be so arranged that the material dealt with and manufactured should flow through them in an orderly manner, in one direction, so far as might be, and without waste of time, energy, or material.

The routine diagram was probably the most difficult part of works design. It involved the sequential arrangement of the machines within each department, and thereafter the laying out of the departments relative to each other. To carry this out successfully required great skill and care, and probably much tactful discussion with the proprietors, managers, and foremen of the proposed works.

From the data available, however, suitable approximate linear dimensions and heights for buildings might be fixed, and thereafter the manipulation of these blocks might proceed until the most satisfactory relative positions of departments were secured. The routine diagram was complete when the several departments were arranged on paper, and the flow of work in progress through the departments was as perfect as possible. The first design was rarely final, for the final plan was usually a combination of the leading features of several draft plans.

It could not be too well remembered that the buildings should accommodate the plant, that the process of manufacture should not require to accommodate itself to the buildings, and that the transmission of power was an integral part of the scheme, and must be considered from that standpoint.

The subject of power generation and transmission in industrial works had been frequently and exhaustively treated in recent years. The mass of information was, however, so technical, so varying, and so conflicting in its conclusions as to be, in a great measure, beyond the grasp of most power users. The first conclusion, and that to which it was difficult to reconcile the partisan mind, was that each system of power generation and transmission had its particular advantages and superior economy, and that maximum economy in works driving in a particular case might be obtained by a combination of two or more systems.

Transmission of Power.—The difficulty was usually not so much the selection of the system as the determination of the extent to which it should be utilized. Where the plant was compact and conveniently arranged within a radius of, say, 100 or 150 feet, from the central power plant, mechanical transmission was economical, while with an increased radius, gas or electrical transmission had advantages. In small works and factories the most careful thought ought to be given to the works design in order to ensure a compact arrangement and efficient mechanical transmission. The chief advantages of the electrical transmission system were its adaptability and the ease with which it could be extended.

Under the industrial conditions which held to-day and were becoming increasingly stringent, no manufacturer who was building or reconstructing works or mills could afford to neglect the technical skill which was at his disposal quite irrespective of cost. It might be argued that a works manager or proprietor knew most about his business and its needs.

But it could be urged quite legitimately that the proprietor's business might be the mining of coal, or the manufacture of iron or steel, ships, chemicals, or textiles. In that sphere he was at his best, but in the design of buildings, the selection of power plant, or even the economical arrangement and correlation of them he was at a disadvantage. Whether this disadvantage was serious or might only involve a permanent tax upon his business, when accepted, must be left to his own judgment.

Those industries which held a world-wide reputation in America, in Germany, and in England had in every instance been either originally designed or reconstructed by experts.

HIGH-TENSION CONTINUOUS-CURRENT TRACTION.

In a paper in which he considered the high-tension continuous-current system of traction M. L. Gratzmuller discussed the generation of such current, the overhead conductor, the motors and their accessory apparatus, the control, and the safety of the system and the protection of the staff. He also described a few recent installations.

In concluding, he remarked that the title high-tension continuous-current traction was not very happy, as it implied an entirely new type of apparatus, whereas in fact it only marked steady development. From 500 volts it passed to 600 volts, and then to 750 volts. The trains from Villefranche to Bourg-Madame used current at 850 volts. Certain sections of the Budapest system were now run at 1,000 volts, and to-day the system was applied to locomotives at 2,400 volts, and even 3,000 volts was talked of. This progress had been justified by improvement in the commutation of the motors, due principally to the use of auxiliary poles and to recent methods of insulation by means of mica and impregnation. The cost of transmitting the energy must not be overlooked in view of the weight of copper required for the lines and the cost of sub-stations. In order to make a comparison with other methods of traction—viz., single-phase and three-phase—the length of the line and the intensity of the traffic should be taken as independent variables. Heavy traffic was a favorable factor for high-tension continuous-current traction.

The advantages of continuous-current were principally the large starting torque, the quality of the commutation (which was shown by the small wear of the commutator and the brushes), and the light coaches. On the other hand, there were the drawbacks of the use of an exposed high-tension rotating part—particularly dangerous in damp localities—the use of a commutator, and the control of the large currents necessary when a large amount of power was required.

CANADA'S SHARE OF IMMIGRATION.

A total of 52,580 British emigrants, left the United Kingdom for countries outside of Europe during April, 1913. As many as 37,948 proceeded to other parts of the Empire, 29,984 going to Canada and 5,533 to Australia. Of the remaining 14,632, all but 603 went to the United States.

In the first four months of the year 133,350 natives of the British Isles emigrated, over three-fourths of whom have been retained within the Empire. They were distributed as follows:—

Canada	66,911
Australia	23,432
New Zealand	4,881
British South Africa	3,366
Other colonies and possessions	3,418
Total British Empire	102,008
United States	25,522
Other foreign countries	2,820
Grand total	133,350

PERMISSIBLE DILUTION OF SEWAGE.

By George W. Fuller, M. Am. Soc. C.E.

At a meeting of the hydraulic, sanitary and municipal sections of the Western Society of Engineers the more salient features of the sewage dilution problem formed the subject of a most instructive paper. Reference is made at the outset to the extensive literature concerning the Chicago drainage canal, the various streams of Massachusetts which the State Board of Health has subjected to report, and the general scheme of sewage disposal for the metropolitan district tributary to the New York harbor, as well as to the more recent investigations carried on by numerous large cities throughout America. The subject matter of the address directly pertaining to the permissible limits of sewage dilution is contained in the following:—

The liquid portion of all sewage or water-carried waste must go to the water courses sooner or later. The only exception occurs where the sewage is evaporated. Mention is made of this feature in order to accentuate the thought that the water courses of this country must receive the water-borne wastes in some form or another. The question becomes, therefore, one of the degree to which liquid wastes are improved as to their quality before they are finally disposed of by dilution in some water course.

It is perfectly obvious that as civilization advances, and the population of the country increases, there can be no longer any streams of original pristine purity. That condition absolutely disappears, and such disappearance is one of the penalties of civilization. On the other hand, there are a great many streams in this country—some large ones, as well as numerous small ones—which are over-polluted with water-borne wastes. This is due to an overstepping of the proper limits of permissible dilution which we are to discuss here.

Definitions.—Sewage is defined as the spent water supply of a community together with those trade wastes and street washings which in some instances are removed in underground channels called sewers.

Sewage Disposal.—The art of sewage disposal means the economical elimination or prevention of nuisances with respect to these water-borne wastes.

Types of Nuisances.—Nuisances due to sewage naturally are grouped into two classes: One refers to conditions that are offensive to the senses of sight and smell. The other refers to the hygienic aspect of the matter and to the transmission of disease germs contained in the sewage to neighboring communities through the water of the stream into which the sewage is discharged. These disease germs refer, of course, to those of the water-borne group, such as typhoid fever, Asiatic cholera, and others of intestinal origin.

The hygienic aspect of sewage disposal is naturally related in many instances to questions of water supply. It is also intimately associated with shellfish problems along the seaboard. Public health officials also have to deal with this aspect of the question with respect to public bath houses and possibilities of transmission of certain diseases by flies from deposits along the shore of some highly polluted water courses.

Hygienic Aspects of Sewage Disposal.—The sterilization of sewage discharged into tidal waters in the general vicinity of shellfish layings has within the last few years proved an economical and, in the hands of careful operators, an efficient means of dealing with one of the important phases of the hygienic side of this question. While there are only a few sewage sterilization plants now in operation, there have been a dozen or more recommended for adoption and it seems unnecessary here to state more on this question in view of the thorough discussion which it has received from Professor Phelps in Water Supply and Irrigation Paper No. 229 of the U.S. Geological Survey. Hypochlorite of lime, or some similar sterilizing agent, has a great future before it in the treatment of sewage at places where shellfish are found within certain distances.

Sewage disposal in its relation to public water supplies is, of course, the most important hygienic feature, and it is a question upon which viewpoints vary widely. Some believe that all sewage should be purified so thoroughly that it will practically resemble spring water and so that there will be no need of water purification.

In the opinion of the writer all questions of water supply and sewage disposal should be viewed in the light of all local conditions, having in view that the treatment adopted should give the best returns for the money spent when due regard is given to the benefit derived in the interests of the public health.

The Royal Commission on Sewage Disposal of Great Britain has considered this question at length and its conclusion was as follows:

"We are satisfied that rivers generally, those traversing agricultural as well as those draining manufacturing or urban areas, are necessarily exposed to other pollutions besides sewage, and it appears to us, therefore, that any authority taking water from such rivers for the purpose of water supply must be held to be aware of the risks to which the water is exposed, and that it should be regarded as part of the duty of that authority, systematically and thoroughly, to purify the water before distributing it to their customers."

"Apart from the question of drinking waters, we find no evidence to show that the mere presence of organisms of a noxious character in a river constitutes a danger to public health or destroys the amenities of the river. Generally speaking, therefore, we do not consider that in the present state of knowledge, we should be justified in recommending that it should be the duty of a local authority to treat its sewage so that it should be bacteriologically pure."

The conclusion of the commission is a sound one and as a general proposition water purification rather than sewage purification affords a better safeguard of the public health in the present state of the art. It is also to be noted that water purification is not only more reliable, but it is also cheaper under most conditions.

In this connection it is to be borne in mind that untreated surface water supplies as a rule do not afford a thoroughly safe drinking water. The reason of this is that there are too many opportunities for pollution from the soil wash and indirect sewerage of small villages and hamlets, and the infection of the water from the casual huntsman, fisherman, or those who for pleasure or business traverse the watershed. There are, of course, exceptions to this rule, but they are growing fewer and fewer. This is well shown in Europe where, since the great cholera epidemic of Hamburg some years ago, it is an unwritten but practically effective law that all surface water supplies shall be filtered.

Many large cities in this country are provided with combined sewers, the entire flow of which at times of storms can scarcely be purified completely. It is true that hypochlorite of lime has proved to be of much help in securing an improved quality of drinking water at many places, but the fact remains that as a general proposition the surface water supplies in this country should be filtered in order to make them thoroughly first-class in point of hygienic character.

While it is believed that the purification of public water supplies in this country is a subject that must stand on its own feet first and foremost, it is undoubtedly true that there are some exceptions to this rule and that sewage purification sometimes should be provided to aid the neighboring water supply. The medical man feels that everything that can be done to destroy disease germs should be done, and is inclined to say purify all sewage and also purify all water. This brings up the question of much practical significance of how a certain expenditure of money can be best applied in the interests of the public health.

The water purification should come first so far as the hygienic side of the matter is concerned, and sewage purification or perhaps sewage treatment by sterilization should come into play in order to make sure that water filters are not overloaded if there is likelihood of inferior quality of filtered water being furnished the consumers.

Double filtration of water supplies and the judicious use of sterilizing arrangements and the advantageous employment of coagulating processes can all be brought to the aid of the water purification plant. Even with all of these precautions as to the water supply, there are times when purification of the sewage of a neighboring community or of the community whose water supply is under consideration, should be carefully provided for. We shall say no more on this question of the hygienic aspects of sewage disposal, as it is hoped that the viewpoint has been made plain that the dilution method of sewage disposal is not barred from this line under ordinary circumstances. The limitations in the dilution method are really to be found in relation to the nuisance question as noted by sense and smell, and this is the question that we shall now proceed to discuss at length.

Nuisances as Related to Sewage Dilution.—Sewage dilution is an important, rational, and proper method of disposal of sewage if it is properly applied and is not abused. Disregarding the question of disease germs which we have already considered, the dilution method of disposal is a proper one when by dispersion in water the impurities of the sewage are consumed by bacteria and larger forms of plant and animal life, or otherwise disposed of so that no nuisance results.

The dilution method is by far the most prevalent one now in use in this country. As our knowledge becomes more precise as to its advantages and disadvantages, the conclusion becomes more clear that the method has not been applied in a satisfactory way in a large number of instances. On the other hand, there seems to be no good reason why advantage should not be taken of this method within reasonable limits. Between the so-called complete purification of the sewage and the dilution method there are intermediate procedures which allow advantage in point of economy to be taken of the dilution methods, and at the same time the nuisances to sight and smell, which have been so common at various places, may be effectively prevented.

Nuisances attending the sewage dilution method may be due to, (1) floating solids; (2) settling solids; (3) non-settling putrescible organic matters.

These three constituents, or groups of constituents, in sewage explain most of the difficulties that are encountered to-day with the sewage dilution method. We can all recall instances where orange peel and other household wastes float in bodies of water around sewer outlets. We are also accustomed to deposits of "sewage mud" or sludge near the outlets, and the likelihood of their decomposing and producing foul odors particularly at times of low stream flow. There is also the condition where there is inadequate dilution of the sewage as it enters the stream, and where the entire body of water turns black owing to anaerobic decomposition or so-called septic action.

Clean Rivers.—There is undoubtedly a well-defined movement on foot to free American rivers of small and moderate size of solid organic matter and filth coming from the flow of sewers. This movement, in my opinion, is a proper one and, when combined with adequate purification of water drawn from rivers receiving such sewage, the whole question of sewage disposal by dilution assumes a more reasonable and favorable aspect than hitherto. Furthermore, it does not involve communities in the expense called for by sewage filtration. It modifies, however, the limits that are permissible as to sewage dilution and calls for a recasting of the engineer's views and calculations upon the question. We shall outline briefly some of the features involved in the permissible limits of sewage dilution in connection with "clean rivers."

Screens.—In America there has not been as much progress as in Europe in the use of screens or other arrangements by which floating matters objectionable to the sight are removed from sewage as it enters the stream. In Germany so-called fine screens with an opening of 0.4 in. or less have had many warm advocates. The fine screens have not the standing to-day that they had a few years ago, in the opinion of many engineers, owing to the success attending the sedimentation devices as a cheaper and simpler means of keeping back floating matters and at the same time of removing the coarse heavy solids that subside. In America fine screens have been regarded with questionable favor, owing to the cost of their maintenance. We shall not discuss the relative merits of different devices, but will confine ourselves to the statement that without question floating matters should be removed from sewage before the latter is disposed of by dilution in an adequate body of water.

Sedimentation Tanks.—An examination of the Massachusetts State Board of Health reports, and other American data on pollution of streams, quickly shows that the stranding of solids in the vicinity of sewer outlets has in the past proved one of the drawbacks to the satisfactory use of the dilution method. This is particularly true at times of low river stages when banks of "sewage mud" or sewage sludge are exposed to "putrefaction" with attendant bad odors. Some 60% of the total suspended solids in the ordinary sewage are responsive to subsidence, and unless the sewage is discharged into a river with uniformly high velocities, these solids are bound to strand or settle. The removal of these "settling solids" is an important feature in the establishment of "clean rivers" in this country and, if we eliminate a few of the larger streams, it is my opinion that sedimentation of sewage is going to come into general use as a preliminary step in the modern arrangements for sewage dilution.

In earlier days difficulties in disposing of the sewage sludge or solid matters deposited in tanks were the cause of the slow adoption of this important improvement. It is true that chemical precipitation and sludge presses provided a solution of the problem, but at an expense that proved discouraging to many communities, and such that in Europe the cities near the seacoast were led to "barging" the sludge to sea. It is believed that septicization, particularly as embodied in tanks of the two-story type, will allow this matter in the future to be handled far more satisfactorily than in the past.

Unimportance of Organic Matter in Settled Sewage.—If a sewage has been clarified to such an extent that there will be no deposits in the stream bed at or near the sewer outlet, and if the disease germs are killed, there then remains to be considered the sanitary significance of organic matter coming from the settled sewage, and diluted with large volumes of river water. In most cases where the sewage is diluted so that there is formed no offensive odors due to decomposition, and where the sewage has undergone sterilization, it does not seem likely to us that it is necessary in the interests of the public health to go to the expense in most cases of removing the dead organic matter of the settled sewage.

It is intimated by some that the germ theory of disease and the specific infection of water through disease germs does not necessarily tell the whole story as to the hygienic disadvantages of sewage-polluted waterways. On the other hand, the extensive investigations of the United States National Board of Health, as stated in their report for 1882, page 201, indicate that with sewage-polluted waters, it would be necessary to drink half a gallon at once of the waters under test in order to get as much nitrogen and carbon as is contained in a single medicinal dose of strychnine, which is stated to be one of the most energetic of recognized poisons.

A similar view as to the harmlessness of organic matter *per se* was stated by the late Dr. T. M. Drown in the Special Report of the Massachusetts State Board of Health, 1890, Part I., page 537.

A similar view has also been given by Dr. A. C. Houston, now chief water examiner of the Metropolitan Water Board of London, in the Second Report of the Royal Commission on Sewage Disposal, page 27.

"Organic matter *per se* in water is seemingly harmless; it is the bacteria likely to be associated with the organic matter that constitute the element of danger. Only bacterioscopic analysis can hope to reveal the kinds of bacteria in an effluent which are of a sort liable to be related to disease. Chemistry is quite powerless in this respect, and, indeed, all chemical standards of potability are apparently based on an assumed relationship, which may or may not exist, between the amount of organic matter and the number and kinds of the associated bacteria. Typhoid fever stools, whether sterilized and innocuous, or unsterilized and highly dangerous, would yield to chemical testing practically the same results as regards the nature and amount of organic matter present."

Furthermore, where there is adequate dilution of settled and sterilized sewage in a river used for a water supply, it is not difficult, as already stated, to effect a substantial removal of organic matters in works well adapted for water purification and involving coagulation, aeration, and sterilization by powerful oxidizing agents.

Degree of Dilution.—On the assumption that floating and settling solid matters are removed from the sewage and that disease germs are killed, where necessary, by sterilizing chemicals, we can now come to the discussion of what the permissible limits are for the dilution of sewage. We can answer it by saying first that the limits should be such that there should be present at all times and in all places sufficient dissolved oxygen to prevent anaerobic or so-called putrefactive decomposition becoming established, and furthermore that there should be a reasonable margin of dissolved oxygen to take care of fish life unless it should prove in some instances that the question of fish life is not of sufficient significance to justify consideration.

On the degree of dilution the first scientific data in this country were obtained in the early days of the consideration of the Chicago drainage canal, and it is from the technical staff of the Chicago Sanitary District that engineers have received their latest information bearing upon this important subject. A few years ago, and in fact until quite recently, all data as to the degree of dilution of sewage referred to crude sewage with its floating and settling solids. The Chicago drainage canal was established on the legal limit of 3⅓ cu. ft. of water per second to dilute the sewage of each 1,000 persons connected with the sewers. That limit was probably too low for the crude sewage of a city which has such a large proportion of manufacturing wastes in its sewage flow as is the case in Chicago. For a city without manufacturing wastes it is probably a fair limit, although some data obtained from Massachusetts suggest that it might be wiser to provide a somewhat more liberal volume of water for dilution.

Generally speaking, a dilution of 4 cu. ft. per second per 1,000 population is as close a general figure for crude sewage as can now be obtained, although undoubtedly there are various local factors which influence the dilution and may establish a range as wide as from 3 to 7 cu. ft.

As to the degree of dilution necessary for settled sewage, present evidence indicates that at least 2.5 cu. ft. per second per 1,000 population should be provided for residential communities and where the diluting water is well supplied with atmospheric oxygen. For manufacturing cities, where the diluting water is moderately depleted in oxygen during the summer months, this dilution may perhaps have to be doubled, that is, increased to 5 cu. ft. per second per 1,000 population.

There is no precise rule now available, and the above ranges establish as closely as can now be done the permissible limits in the dilution which properly should be applied to settled sewage in preference to raw sewage with floating and settling solids in it.

Dispersion,—Mixing.—One of the great drawbacks to the dilution method of sewage disposal as applied in earlier years was then the tendency to conduct the sewage only to the margin of the stream and perhaps only to the high-water shore line. This explains the nuisances that prevail in many American cities where the stream flow throughout the entire cross-section of the river is sufficient to provide reasonable results by the dilution method. Enough has been said to indicate that if dilution is to be advantageously used, it should be done under conditions where the sewage is so mixed with the stream flow that the degree of dilution above mentioned will be secured at all points. Naturally, streams with comparatively high velocities allow better results to be obtained than those in which the velocity is reduced or checked entirely at times by mill ponds or other obstructions.

Residual Oxygen.—This is a question upon which there are many divergent views. Until it is put on a more satisfactory basis than at present, it is hardly feasible to state the degree of permissible dilution more closely than given above. Colonel Black and Professor Phelps have advocated that a residual margin of 70% of dissolved oxygen should be provided for the waters of New York Bay. A more common opinion places this margin at 50%. Messrs. Wisner and Pearse (of the Sanitary District of Chicago) have put this margin at 2.5 c.c. of dissolved axygen per litre, which is equal to about 20% of saturation of oxygen during winter months, and 30% for the summer temperatures. These gentlemen, however, have reference to fish life. My own experience is that if stranded solids have been kept out of the stream there will be no occasion for difficulty as to anaerobic or putrefactive decomposition, provided there is some dissolved oxygen present in the stream at all times and at all places. One of the earliest and most important points established at the Lawrence Experiment Station was that a little oxygen, say, 1% to 3% of that necessary for saturation, would allow oxidation and nitrification to take place as satisfactorily or nearly so, as if the water were saturated with oxygen. I know of no reason for departing from the teachings of those early experiments at Lawrence, and I believe that estimates of 50 or 70% for the required residual of dissolved oxygen can be explained only by extraordinary allowances made for the consumption of oxygen by existing sewage sludge, or by more than liberal allowances of oxygen for major fish life. In fact, whatever margin is needed above a slight positive quantity at all times and places in the stream is, in my opinon, solely accountable for by the oxygen necessary for fish.

Fish Requirements.—Data are somewhat meagre as to the amount of dissolved atmospheric oxygen which is required in the streams to protect major fish life. The quantity no doubt varies with different species of fish and perhaps other local conditions. In the Lower Elbe near Hamburg it is stated that the margin of dissolved oxygen during the ordinary summer periods falls as low as 20%, and the figure in the Lower Thames is understood to be about 30%. At Hamburg there has been no serious complication as to fish life other than during the summer of 1911, when it is understood that for three or four weeks fish actually migrated from the vicinity of the city. This does not mean that there was any nuisance as to putrefactive odors. In fact, it is stated that none existed. It shows also another point and that is that since the fish returned after a period of three or four weeks, it will be quite debatable whether once or twice in a generation it is necessary to prevent the migration of fish, if by such prevention there will be involved expenditures of vast sums of money for the more complete purification of the sewage.

I was told in Berlin a year ago that an amount of residual dissolved oxygen equal to 1 c.c. per litre was considered sufficient under ordinary circumstances in the immediate vicinity of a sewer outlet, although 1.5 c.c. were preferable.

Fungus Growth.—Professor Thumm, of Berlin, has stated to me that in waters containing a great abundance of oxygen it is possible that offensive odors might result through the growth of certain fungi, namely, Leptomitus, Sphaerotilus and Cladothrix. The staff of the Royal Prussian Testing Station have observed that these growths are said to be characteristic of streams receiving a lot of industrial wastes, such as come from wood pulp mills. The growths seem to be favored by the presence of much putrescible organic matter, ample dissolved oxygen, and a high velocity of stream flow. These comments are not in harmony with my recollections of the life history of these organisms, unless it be that their growth is fostered in certain deposits which are dislodged under certain conditions. The question is an interesting one, and it is the only suggestion that I have heard of which limits the permissible dilution of sewage in other than by the dissolved oxygen, in cases where disease germs are destroyed or may be properly ignored. This is a question which needs further study, and it may be entitled to more consideration than we now realize in America.

Comprehensive Designs.—While a firm believer in the dilution method of sewage disposal within permissible limits, as roughly outlined above, I am aware that many American towns and cities are likely to grow to proportions where the dilution method will require more and more complete treatment of the sewage in order to be satisfactory. It is the part of wisdom to prepare designs for sewage disposal works so that if filtration is not needed at the outset it can be adopted as conveniently as practicable in later years and without embodying too great a sacrifice in works now undertaken. This means, among other things, that intercepting sewers, sites for screening plants, and sedimentation tanks could well be arranged with the idea that some day filtration also must be provided. If this were done it would probably save considerable money that otherwise might be lost.

Relaxations.—In England the principal topic of conversation among engineers was found to be the forthcoming report of the Royal Commission on Sewage Disposal and the disposition in that report to provide for "relaxations." By this is meant that there would be installed, piecemeal, works which would provide ultimately for purification to the degree set out by standards recommended by the commission a few years ago. It is proposed now to take full reasonable advantage of dilution, but to arrange the works so that further and more complete treatment may be secured when and as required in the future.

Separate Sewers.—So far as household wastes are concerned, in all new systems and in many cases of extensions to existing sewer systems, it will be helpful to adopt the "separate system" to a greater extent than has been the vogue hitherto. The prevention of a mixture of the sanitary wastes of the household with the storm water from the streets will aid materially in minimizing the expense and in increasing the success attending sewage purification, sewage treatment, and the utilization of the dilution method within safe practicable lines.

Finally, then, it is permissible to dispose of sewage by dilution provided that complications can be prevented so far as disease germs are concerned, and this should be best done in connection with water filtration, and further provided that offensive conditions to sight and smell do not result.

In some large streams, as in the lower Mississippi near New Orleans, sewage which is passed through coarse screens may with care be disposed of in a satisfactory way. In large lakes, tidal estuaries, moderate and small streams, it is important, if not necessary, for the success of maintaining "clean rivers" or "clean bodies of water" to free the sewage from floating and settling solids.

Permissible dilution of sewage without treatment in water courses with fairly high velocities ranges apparently from about 3.5 to 7 cu. ft. per second per 1,000 population, depending upon the manufacturing wastes in the sewage and the dissolved oxygen content of the diluting water. For well settled sewage, these limits become about 2.5 to 5 cu. ft. per second per 1,000 population according to present information.

INTERNATIONAL ENGINEERING CONGRESS, 1915.

In connection with the Panama-Pacific International Exposition, which will be held in San Francisco in 1915, there will be an International Engineering Congress in which engineers throughout the world will be invited to participate. This congress will be conducted under the auspices of the following engineering societies: American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers.

A scale-testing car is being built by the United States Bureau of Standards for testing scales in yards, grain elevators, and other places where interstate traffic is handled. It will not itself be used as a load, but will carry movable weights, which will be used for testing. It is proposed to have the car carry a number of standard weights of 10,000 pounds each, and a large number of 50-pound weights. A truck, capable of carrying 50 tons, will be carried on the car to be used for moving the standard weights, in testing scales. The car will be equipped with a crane for lifting the truck and the heavy weights.

CALGARY'S PUBLIC UTILITIES.

Preparatory to striking the rate, based on the estimated expenditure for 1913, Calgary's city commissioners prepared a report on all the public utilities under their control. It showed:—

"During 1912 there were 47 miles of water mains laid, 324 hydrants set, and 3,116 new connections made to the mains. The expenditure on the aforesaid works charged to capital account was the sum of $558,846.52. The estimated revenue was $258,550.10, and the actual income amounted to $244,423.37.

"All bills chargeable to the waterworks system, up to December 31st, 1912, have been settled.

"The asphalt paving plant has been operated by the city since the month of July, 1912. Paving was constructed at an average cost of $2.10 per square yard; price quoted includes an allowance for debenture interests, sinking fund and plant depreciation.

"The capacity of this plant in 1912 was, approximately, 1,000 square yards per day, and the new unit now nearing completion will much more than double the capacity of the plant.

"The revenue derived from this utility was $87,558.02; the expenditure $103,247.38, $24,954.71 of the latter amount representing stock on hand, leaving a surplus of $9,265.53.

"The street railway has expanded beyond expectations. Starting operations in 1909 with two cars, half a mile of track and 16 employees, in December, 1912, the system had increased to 54 cars in operation, 60 miles of track, 246 regular men employed.

"During the past year it carried 14,627,370 passengers, earning a gross revenue of $603,975.38, with a total expenditure of $502,254.81.

"Its capitalization account stands at $1,615,000, of which has been expended $1,537,490, leaving a balance of $77,509.08 which is available for construction purposes.

"The electric light and power plant department, in the seventh year of municipal operation, continues to show gratifying financial results and satisfactory service.

"The normal peak load, namely, 7,000 horse-power, 5,000 horse-power of which is purchased from the Calgary Power Company, generating this energy by means of water-power obtained at Kananaskis Falls; the remaining 2,000 horse-power is produced by means of a battery of 16 boilers, six of which use as fuel, natural gas, and 10 coal, representing a total of 5,000 horse-power. There are 11 generators, whose prime movers consist of steam and electrical energy. The remainder of the city's power plant, representing 3,500 horse-power, is under stand-by to take over full capacity at short notice.

"The gross revenue received from the sale of electric light and power was $489,264.72, and the expenditure was $471,473.81, showing a net surplus of $17,790.91. The gross capital account amounts to $1,507,000, of which $1,454,017.40 has been expended, leaving a balance of $52,982.60. This makes a total gross plant account of $1,454,017.40."

The mill rate has not yet been officially announced, but it is expected that even though it has to provide for the unpaid bills of last year on sundry accounts, it will not exceed 16 mills.

Forest trees around the waterworks reservoir of Hornell, N.Y., will be planted by the Board of Public Works of that city in co-operation with the College of Forestry, of Syracuse University. It is stated that about 30,000 trees will be planted.

IRON AND STEEL PRODUCTION.

From the statistics which have just been published by the American Iron and Steel Institute relating to the production in the United States and in Canada of pig-iron and of iron and steel structural shapes, wire rods, and cut and wire nails, the increase in demand for these commodities in 1912, as compared with that of preceding years, can be fairly estimated. Taking the total of all grades of pig-iron, the increase of output by the United States between 1912 and 1911 was rather more than six million tons; and it is noteworthy that in making the 29,726,937 gross tons which constituted the output for 1912 the fuel consumed included 35,721,127 tons of coke, about 47,022 tons of bituminous coal, 73,794 tons of anthracite coal, and 35,436,017 bushels of charcoal, with over 15,000,000 tons of limestone and dolomite. In Canada there was also a substantial increase in output of pig-iron, thus maintaining the improvement which has been recorded year by year since 1903, with the single exception of 1908. The consumption of iron and steel structural shapes in the United States, which declined from the year 1909 to 1912, showed an increase in 1912. A feature of the figures representing output from the United States of these shapes, which include beams, tees, angles, and channels, and iron and steel for use in the manufacture of bedsteads, agricultural implements, fences, safes, plates, and girders, is that about 10 per cent. is exported, and that of these exports Canada in 1912 absorbed 169,952 tons, as compared with 103,054 tons in 1911. In 1912, the United States reached the maximum production of wire rods, and it is to be observed that in regard to the total 64,978 tons exported, Canada was again the best customer, taking 63,963 tons, as compared with 22,583 tons in the previous year.

REGINA IS WATCHING POWER EXPERIMENTS.

Regina's civic officials are desirous of solving the cheap power problem, and are following closely the experiments being made by Professor Darling for the provincial government. The board of trade recently had Professor Darling deliver an address when he very ably outlined his views. As the lignite coal fields from which it is proposed to develop power are about 150 miles from Regina, he proposes that the coal be carbonized, then shipped to Regina, and used as fuel for the generating of power. To generate the power at the mines and transmit it to the city would be an expensive proposition, he claims, unless numerous towns along the line, required power which is not the case at the present time. The cost of transmission such a distance would be very considerable. Mr. Darling has erected an experimental station at the coal fields, and the Regina board of trade intends to keep closely in touch with the results obtained, as the city is ever anxious to secure lower power rates for manufacturers, etc.

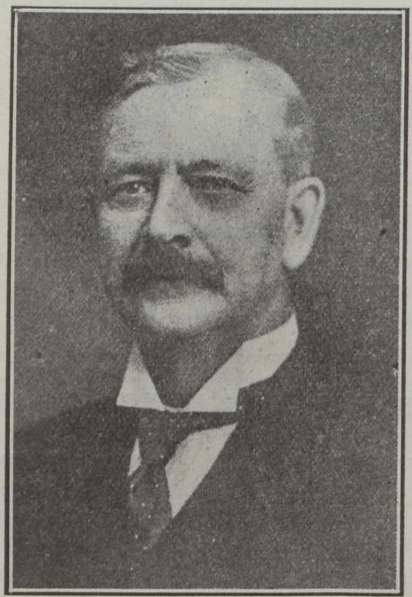
Mr. A. S. Porter, a well-known Regina citizen, who owns considerable coal lands, is organizing a $1,000,000 company for the purpose of developing power from the coal deposits on his land. He has set aside 15,500 acres of land to be mined for this purpose. A line of the Canadian Pacific Railway runs right through the property owned by Mr. Porter, and this he considers would make it an easy matter of getting the by-products such as briquettes, etc., to the cities and towns where they could be marketed.

Concrete work in the Panama Canal locks is nearly completed, the aggregate amount in place at the close of work on May 31, being 4,459,356 cubic yards.

ENGLISH INDUSTRIAL PLANT FOR MONTREAL.

The big industrial corporations of Great Britain and the United States are realizing the significance of the rapidly-growing markets of Canada. The United States Steel Corporation is establishing a large branch plant in Ontario and the Sir W. G. Armstrong Whitworth Co., Ltd., of England, will take a similar step, although their establishment will be in Quebec province. The company have acquired a site on the south shore of the St. Lawrence River, within Montreal harbor, and a plant will be erected there at an estimated cost of $1,000,000. This will be extended as often as needs justify. The Canadian branch of this famous company will be used solely for commercial or civil or mechanical engineering, and not for naval or military work. At no time will the company make guns, boats, or anything of that nature here. This is, at any rate, in keeping with the spirit of the celebration of one hundred years of peace in North America.

They will manufacture twist drills, punches, milling cutters, cranes, drop forgings, tool steel, etc.



M. J. BUTLER,
Largely through Mr. Butler's efforts and those of Sir Percy Girouard, the Armstrong Whitworth Company, of England, will establish a million dollar plant at Montreal.

The decision of this large English corporation to erect a branch plant in Canada is a great event in Canada's industrial history. It indicates the confidence of keen and observant business men and capitalists in Canada's future and that confidence is welcome and gratifying to Canadians.

British capital will finance the entire enterprise and no issue will be made in Canada. The share and debenture capital of the company is as follows:

	Authorized.	Issued.
Ordinary Shares of £1 each	£4,012,500	£4,012,500
Four per cent. cumulative preference shares of £5 each	1,000,000	1,000,000
Five per cent. non-cumulative second preference shares of £1 each	2,000,000	—
Four per cent. mortgage debenture stock	2,500,000	2,500,000

Largely through the efforts of Mr. M. J. Butler, of Montreal, was the company induced to locate a plant in the Dominion. He was successful in interesting their board of directors, however, only through the kindly co-operation of Sir Percy Girouard, a Canadian, and a director of the Sir W. G. Armstrong Whitworth and Company, Limited. To these two gentlemen, therefore, is chiefly due the establishment in Canada of such an important industry. Mr. Butler is well known as the former general manager of the Dominion Steel Corporation. Prior to that, he was chairman of the board of management of the Canadian Government railways, and previously deputy minister and chief engineer of the department of railways and canals. He is a member of several engineering societies, and has been engaged in some notable engineering projects in various parts of the Dominion. A contemporary recently described him as a man possessing "keen business instincts, systematic methods of work and all the firmness of the disciplinarian."

Sir Percy Girouard was born in Montreal and gained his railway experience while on the engineering staff of the Canadian Pacific Railway. He acted as director of the Soudan Railways from 1896 to 1898. He was also president of the Egyptian Railway Board and later director of the railways of South Africa. As a military man he has served with honor in many engagements. Lord Kitchener described him as an officer of brilliant ability, and Lord Desborough has stated that he is a great civil servant who has succeeded in every position he has undertaken.

Oiling grade crossings so as to prevent a dust nuisance is being regularly practiced on the Delaware, Lackawanna & Western R.R. Two equipments are in use in different parts of the line, each consisting of an oil car provided with compressed-air tanks and special nozzles for spraying the oil. These cars are drawn along the line, and the crossings are oiled in succession by a crew that goes with the car, so that each crossing is oiled about twice each year. It has been found that this procedure is successful in keeping down the dust to such an extent that there is no offense from that source to passengers, particularly to those on rear-end observation cars, where before the oiling the nuisance had been great.

Mr. Frank Shuman, a distinguished American engineer, has installed near Cairo, a hundred horse-power sun plant for irrigation, and he has left London for Egypt to complete the installation and to begin operations almost immediately.

Four times only in the history of the human race has the generation of power been the subject of invention. First came the windmill, then the water-wheel. The third departure, and the greatest so far, was the combustion of fuel. Now comes the use of the solar rays, which, if successful, will be the most complete revolution of all, solving at once for the tropics the problem of fuel, which in the past has been so great a handicap to remunerative labor, and which in the future, with the diminishing supplies of coal, must become a greater handicap still.

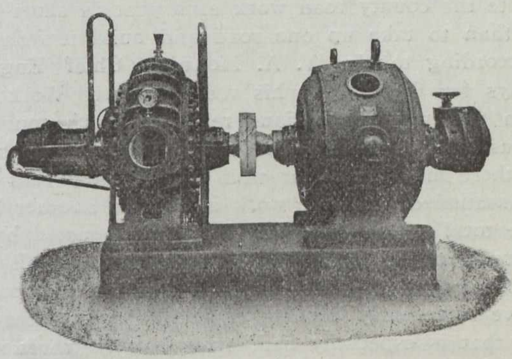
Explaining the character and purpose of his sun-power plant, Mr. Shuman said that "by means of parabolic mirrors the heat of the sun is concentrated to five times its natural intensity.

"This gives us a temperature of about 600 deg. Fahr., and by means of this heat concentrated on boilers the steam is generated, which is used for driving a low-pressure condensing engine. This engine in turn drives a large reciprocating pump capable of pumping 13,000 gallons a minute, and thus irrigating in this particular locality 1,000 acres of land.

AN EFFICIENT HYDRAULIC PUMP.

The accompanying photograph shows a view of the "Victoria" hydraulicking pump. It is one of these pumps which was supplied to the Nipissing Mining Company. The pump, as shown, delivers 4,000 gallons per minute against a head of 415 feet, and has a speed of 1,180 revolutions per minute.

Details of the test made of this pump under actual working conditions will be found on the table accompanying this article, from which it will be seen that the efficiency in normal working reached 84 per cent. Boving & Company, Limited, who are the designers and manufacturers of this pump, and who are represented in Canada by Canadian Boving Company, inform us that similar pumps of various sizes have been sent to different parts of the world. It is interesting to note that the "Victoria" pump has the impeller automatically balanced, which obviates the necessity of a high-pressure stuffing box. One of these pumps installed at the Goss Moor tin mines has effected a great saving over the pumping methods previously used. The results obtained at Goss Moor are shown herewith and speak for themselves. The Victoria pump has been designed especially to overcome the difficulties experienced where water containing a large amount of mud and grit would cause heavy wear and tear. That it has done this effectively may best be seen from the results obtained in actual practice.



Some test results as obtained in the Goss Moor pump after it had been running for some time are given herewith. The engine is of the compound type, 11 in. x 19 in. cylinder diameter, 2 ft. 6 in. stroke, built by Messrs. Marshall.

Official Test Figures of Victoria Pump Supplied to the Nipissing Company.

No. of test	Pressure of pump	Vacuum	Total head	Speed R.P.M.	Water rise	Time for rise	Imp. galls. per min.	U.S. galls. per min.	Pump H.P.	Volts	Amps.	Kilowatts	Elec. H.P.	Overall efficiency
1	174	12″	416.1	1,183	8.45′	126.5 sec.	3,850	4,620	485	2,155	149½	500	670	72.4
2	174	12″	416.1	1,183	8.45′	127.5 sec.	3,820	4,580	481	2,150	150	500	670	72.1
3	171	12″	408.44	1,179	8.40′	121.8 sec.	3,970	4,765	492	2,145	153	500	670	73.4
4	171	12″	408.44	1,175	8.25′	121.8 sec.	3,910	4,690	485	2,160	150	500	670	72.4
5	171	12″	408.44	1,175	9.1′	132.8 sec.	3,950	4,740	490	2,140	151	500	670	73.1
6	172	12″	410.75	1,184	9.0′	130.4 sec.	3,970	4,765	494	2,168	152.5	500	670	73.7
7	170	12″	406.6	1,181	7.6′	107 sec.	4,080	4,896	501	2,150	142	500	670	74.8
													Average:	73.1

Speed of pump	Pressure in lbs. per sq. in.	Vacuum at pump inlet	Vertical distance	Total head in feet	Quantity discharged, gal. per min.	Engine speed	Indicated H.P.; Pressure high	low	Water H.P. I.H.P.	Approximate efficiency of Victoria pump
628	47	3″	5′	116.4	3,460	116	111	52.5	74.5	85%
628	—	—	—	116.4	3,460	116	—	—	74.5	
628	—	—	—	116.4	3,460	115	—	—	74.5	
630	47.2	—	—	46.9	3,460	116	—	—	75	

The pressure readings were taken with test gauge on the top of the horizontal discharge of the pump. The pressure was very unsteady, the pointer vibrating about 5 lbs. The average is entered in the above table.

The vacuum readings were taken on the top of the horizontal suction pipe. The vacuum fluctuated about ½ inch to 1 inch during all tests.

The water was measured in a circular tank of 14 feet inside diameter, and the discharge from the end of the pipe was diverted into the tank by means of a "bucket" mounted on a truck. The truck was running on rails and the flow could thus be diverted very quickly. The results obtained on the amount of water discharged are very accurate, as there was no leakage or waste of water whatever. The time of diverting the water into the tank was measured by a stop watch.

The volt and ammeter readings were taken by the switchboard instruments, the kilowatt was taken by means of a standard instrument mounted on the switchboard. The total consumption during two hours continuous running was 1,000 kw. hours, corresponding to an average consumption of 500 kw.

At the National Physical Laboratory in England, there is a recently constructed road machine, which is the first of its kind in any country. It is a building containing a circular track on which experimental lengths of road can be readily laid down and tested to destruction by the passage over them of wheels driven by motors which are guided in the circular track by a revolving framework.

The machine is now at work. The track has been filled with four lengths of water-bound macadam made up in four different ways and the behavior of these lengths will be compared and each of them tested until it is broken up. The designers hope that by means of this machine they will be able to arrive rapidly at conclusions which otherwise would take years to reach on the actual roads themselves. The roadway is under cover and protected from weather influences, thus eliminating weather conditions entirely. It will be possible to introduce certain weather conditions one at a time and to study their individual effect.

For instance, the track can be heated by hot air blown upon it; rain can be imitated by spraying devices; it can be artificially cooled to the freezing point. The wheels used can be either standard wheels with plain steel tires carrying a fixed weight of one ton each; the diameter and widths of these wheels can be varied; solid rubber tires or pneumatic tires, plain corrugated or studded, can be substituted in turn and the effects of each on a road surface noted.

COAST TO COAST.

Toronto, Ont.—There is a tendency in some counties to distribute the county road work each year in short sections, rather than to take up one road and build it from end to end, according to Mr. W. A. McLean, Chief Engineer of Highways for Ontario, in his recent report. Work is scattered in this way for various reasons. Each councillor is ambitious to have some work done in the township he represents; there may be a fear that certain ratepayers will become dissatisfied if all the work is done in another locality; that the total expenditure may become exhausted before all roads are reached; there may be a desire to let all sections in the county see the class of work done on the roads, and to receive some early benefit; a wish to construct a section of road that is especially bad, or is largely travelled. The tendency is greatest in counties where there are numerous market centres or shipping points, and less in the counties with one well-defined centre, such as York with roads radiating from Toronto, Wentworth with Hamilton as a leading market, or Prince Edward with much traffic leading to Picton. To build roads in short sections in some cases may serve a useful purpose, but the practice is an expensive one and adds largely to the cost. Road-building is almost entirely a work of labor, and it is essential to economy that a well-arranged organization be created. It commonly takes a month to build a mile of road, and takes nearly that time to get the work going smoothly. To move the plant and equipment from place to place for every mile of road means that the work will be kept in constant disorganization, that laborers and teamsters who have become accustomed to the location will leave, and new men will take their place, that much time will be lost in moving the machinery from place to place while wages are still going on. Every move made means a loss of efficiency, loss of time, useless expenditure for wages, fewer miles built and a much increased cost. Short sections are justifiable and necessary in some cases, but to carry work on in that way as a fixed practice involves a useless increase of cost. The necessarily increased cost of "model roads" is not an expenditure which counties should assume.

Port Moody, B.C.—Preparations for the early construction of a sewer system will shortly be made. At a recent meeting of the city council the aldermen decided that a topographical survey of Port Moody would be advisable before undertaking the planning of a sewer system or its construction. This topographical survey will be made to ascertain the levels and the best location of main and lateral sewers, as well as outfalls and other details of their construction. From information gathered from this survey the council will be in a position to decide on the advisability of constructing a separate system of storm sewers or combining the two systems into one general scheme of drainage. Other statistics will be gathered by the engineers, who will do this work, and when the council is ready to lay out the system, the engineers will be prepared to give an accurate estimate of the cost of the entire system. The construction of a sewer system will, of course, follow the installation of the waterworks and the extension of this system.

Montreal, Que.—A model of the city filtration plant is under construction at Verdun on land of the same nature as that on which the ill-starred plant has its site. The model will be a replica of the plant in every important detail. Its pillars have been designed to carry a pressure of 2¾ tons a square foot—which is approximately the pressure exerted by the pillars of the plant. When the model is completed. the action of the soil will be carefully observed and minute tests taken of its power of resistance to pressure. The tests on the nature of the soil are the result of the protest which Norman McLeod, contractor for the construction work of the plant, recently filed with the city. Mr McLeod claimed the soil had an insufficient resisting power, causing the pillars to sink and a consequent upheaval of the concrete beds. The engineers for the city, on the other hand, contended the damage was due to the work not being properly protected from the effects of frost.

Victoria, B.C.—To construct the north-west sewer system of sufficient capacity to take care of a drainage area of 775 acres in Saanich, and approximately 1,000 acres in Esquimalt and make the proposed city system adequate for the future requirements, not only of that portion of the city alone, but also for the greater area covering the north-west section of the three municipalities, will cost in the neighborhood of $325,000, according to figures submitted by City Engineer Rust to the city council. The construction of the city system, including the main trunk outlet through Victoria West and on out to Macaulay Point will cost $240,000. To make this outlet sufficient for Saanich requirements in that section would mean an addition to the cost of $42,000, and to provide Esquimalt also with outlet facilities will mean a further expenditure of $43,000. The Saanich area addition would mean facilities for a population of about 11,000 and the Esquimalt addition for about 20,000. On the recommendation of the engineer, the two other municipalities will be approached with a view of coming to a mutually satisfactory agreement relative to the joint expenditure to provide larger accommodation, and also to an annual rental for use of the sewer. Esquimalt will be asked to grant permission to the city to drain ninety acres of surface water into the former municipality's surface drains which it proposes to construct. If this is done it will obviate the necessity of the city constructing a surface drain in the proposed sewer tunnel. City Engineer Rust stated that the engineers of Esquimalt and Saanich have practically agreed upon the plans of the proposed sewer system, but that the arrangements as to cost must be taken up by the respective municipal councils. Pending the submission of the scheme to the ratepayers of Esquimalt and Saanich, a tentative agreement could be arrived at. If the outside municipalities do not fall in with the proposed scheme, it would cost them in the neighborhood of $200,000 to provide an adequate sewer system for themselves.

Toronto, Ont.—Parks Commissioner Chambers hopes to make a start this summer on the construction of a complete system of boulevards, forty-two miles long, costing $7,000,000, and reaching around the city. The Parks and Exhibition Committee have appointed a sub-committee to make a trip over the proposed route, which is as follows: Lakefront, from Woodbine to the Humber, north up the Humber to Black Creek, east to Vaughan Road, north to York Mills, south through the Don Valley to the junction of the north and west branches of the Don River, east to Woodbine Avenue and south on Woodbine to the starting point at Woodbine Avenue and the lake front. The plan proposed would connect all the important parks in the city, in addition to many beauty spots in the county. The committee also decided to visit Hanlan's Point and look over the route of a 66-foot roadway it is proposed to construct along the west shore of Blockhouse Bay, from the Hanlan Memorial Park to a point near the Lakeside Home, a distance of 2,400 feet. The plan does not interfere with the waterfront development work contemplated by the Harbor Commission, and it is believed the road would relieve the congestion that always exists on the lake front on holidays and Saturdays. The cost of the work has not yet been estimated.

PERSONAL.

MR. F. S. B. HEWARD, Canadian manager for James Howden & Company, Limited, Glasgow, was in Toronto this week on a business trip.

M. W. SPARLING, B.A.Sc., has recently accepted a position at Campbellford, Ontario, as superintendent of the Seymour Power and Electric Company.

MR. ARTHUR C. HEAP, of the firm of Heap & Digby, inspecting and consulting engineers, of London, England, was a visitor to *The Canadian Engineer* offices this week.

Following the visit of Mr. G. B. Hunter to Canada, MR. WIGHAM RICHARDSON, of the celebrated Tyne shipbuilding firm, Swan, Hunter, Wigham Richardson, Limited, is now on a tour through the Dominion.

MR. WILLIAM STORRIE, acting waterworks engineer of Ottawa, has handed in his resignation, to take effect on July 1st, next. His two assistants, Messrs. H. M. Lee and T. C. Campbell have also resigned their positions.

R. G. SWAN, B.A.Sc., of Vancouver, B.C., has been appointed assistant chief engineer, Railway Belt Hydrographic Survey, of the Water Power Branch of the Department of the Interior, with headquarters at Kamloops, B.C.

W. A. McLEAN, provincial highway engineer for Ontario, and W. G. HENDERSON, president of the Manitoba Good Roads Association, were entertained at luncheon by the York Highway Board previous to their departure for Europe.

H. E. M. KENSIT, Mem. Inst. E.E., Mem. Am. Inst. E.E., electrical mechanical engineer of the Water Power Branch of the Department of the Interior, has accepted an appointment as Commissioner of the City of Prince Albert, Saskatchewan.

The appointment of J. T. JOHNSTON, B.A.Sc., as hydraulic engineer of the Water Power Branch of the Department of the Interior, with charge of water power surveys, investigations and inspection work in Manitoba, Saskatchewan and Alberta, has been gazetted.

MR. JAMES C. HARDING, consulting engineer, has opened an office at 170 Broadway, New York City. Mr. Harding has been engaged in the practice of hydraulic and sanitary engineering for the past 21 years, and has been a member of the firm of George W. Fuller for the last two years.

MR. JOHN S. MacLEAN has been appointed to take charge of the publicity and advertising work of the Canadian General Electric Company, Limited, and of the Canadian Allis-Chalmers, Limited, with headquarters in Toronto. The latter company, in addition to manufacturing an extensive line of machinery and appliances, will also act as sales agents for all the products of the Canada Foundry Company, Limited. Mr. MacLean held a similar position with Allis-Chalmers-Bullock, Limited, for a number of years.

MR. CHARLES B. BUERGER has joined the staff of Mr. George W. Fuller, 170 Broadway, New York City. Mr. Buerger entered the service of the Bureau of Filtration at Philadelphia in 1906 as a mechanical engineer, and was engaged upon the design, construction and testing of pumping stations and equipment. Later he was on the design of the preliminary filters at Torresdale and Belmont and had charge of the design of the Queen Lane filter plant. For the past two years he was senior assistant engineer in the Filtration Division of the Department of Water Supply in New York City on the design of Jerome Park filter plant.

ARTHUR H. BLANCHARD, M. Can. Soc. C.E., professor of Highway Engineering in Columbia University, sailed on June 12th to attend the Third International Road Congress, London. Professor Blanchard is a United States reporter on Question 3, "Construction of Macadamized Roads Bound With Tarry, Bituminous, or Asphaltic Materials," and Communication 10, "Terminology Adopted or to be Adopted in Each Country Relating to Road Construction and Maintenance." He has been appointed a delegate to the Congress by Columbia University, the American Society of Civil Engineers, the National Highways Association and the American Road Builders' Association.

MR. H. O. EDWARDS, who for the past twelve years has been advertising manager of the Canadian General Electric Company, Limited, and its subsidiary companies, has resigned. Mr. Edwards organized the advertising department of that company in 1903 and since that time has taken charge of all advertising, publishing of catalogues and technical bulletins as well as the purchasing of office supplies, stationery, etc. Mr. Edwards is to become sales manager of the Photo Engravers, Limited, 70 Bond Street, Toronto, where, no doubt, his long experience in the purchasing of engraving will serve him in good stead.

NOTICE OF EXHIBIT.

At the annual meeting of the Society for the Promotion of Engineering Education, which will be held in the Engineering Building of the University of Minnesota, Minneapolis, Minn., during the week beginning June 23rd. W. and L. E. Gurley, of Troy, N.Y., will have a representative exhibit of the instruments which they manufacture and which will include engineers' and surveyors' field instruments, water stage registers and current meters, physical and electrical laboratory apparatus, standard weights and measures, accurate mercurial thermometers.

Engineers and others interested will find that a visit to this exhibit will repay them, as an opportunity will be given to inspect the latest improvements in the instruments and to talk with the firm's representatives.

TENTH ANNUAL AMERICAN ROAD CONVENTION.

The American Road Builders' Association will hold its tenth annual Convention and fourth American Good Roads Congress in Philadelphia, December 9th to 12th, 1913.

The annual meeting of the Association is of great interest to those actively interested in road construction and maintenance. It always brings together the leading men identified with road building and street paving, for the purpose of discussing the problems in which they are vitally concerned. Plans are now being laid to make the Philadelphia meeting the largest and most important gathering of the kind ever held. As usual, there will be in connection with this meeting an exhibition, or rather exposition, of road and paving machinery, materials, etc.

The American Road Builders' Association was formed in 1902, and is the foremost organization of its kind in the world. Among its members are the leading road and paving experts, highway officials, engineers and contractors in America. The president of the association is Mr. Samuel Hill, of Seattle, Washington, who is also life president of the Washington State Good Roads Association, and is also identified with other good roads organizations. The other general officers of the association are as follows: First vice-president, Mr. Harold Parker, ex-chairman Massachusetts Highway Commission; second vice-persident, Mr. W. A. McLean, Provincial Engineer of Highways of Ontario, Canada; third vice-president, Mr. George W. Tillson, Consulting Engineer Borough of Brooklyn; secretary, Mr. E. L. Powers, editor "Good Roads;" treasurer, Mr. W. W. Crosby, Consulting Engineer.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The sixth annual meeting of the American Society for Testing Materials will be held at Atlantic City, N.J., June 24th to 28th. A provisional programme has been arranged, according to which the following subjects will be discussed: "Preservative Coatings," "Steel," "Wrought Iron," "Cement, Concrete and Waterproofing," "Ceramics and Road Materials," "Non-Ferrous Metals," "Testing Apparatus and Methods."

COMING MEETINGS.

CANADIAN ELECTRICAL ASSOCIATION.—Annual Convention will be held in Fort William, June 23, 24 and 25. Secretary, C. E. Bawden, Birkbeck Bld., Toronto.

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.

THE INTERNATIONAL GEOLOGICAL CONGRESS.—The Twelfth Annual Meeting to be held in Canada during July and August. Opening day of the Toronto Session, Thursday, August 7th. Secretary, W. S. Lecky, Victoria Memoriam Museum, Ottawa.

THE INTERNATIONAL ENGINEERING CONGRESS.—Convention will be held in San Francisco in connection with the International Exposition, 1915.

NATIONAL ASSOCIATION OF CEMENT USERS.—Tenth Annual Convention to be held at Chicago, Ill., Feb. 16-20, 1914. Secretary, E. E. Kraus, Harrison Bld., Philadelphia, Pa.

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—176 Mansfield Avenue, Montreal. President, Phelps Johnson; Secretary, Professor C. H. McLeod.

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

MANITOBA BRANCH.—Chairman, J. A. Hesketh; Secretary, E. E. Brydone-Jack, 83 Canada Life Building, Winnipeg. Regular meetings on first Thursday of every month from November to April.

OTTAWA BRANCH—177 Sparks St. Ottawa. Chairman, R. F. Uniacke, Ottawa; Secretary, A. B. Lambe, 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, A. R. Decary; Secretary, A. Amos; meetings held twice a month at room 40, City Hall.

TORONTO BRANCH—96 King Street West, Toronto. Chairman, E. A. James; Secretary-Treasurer, A. Garrow. Meets last Thursday of the month at Engineers' Club.

CALGARY BRANCH—Chairman, H. B. Mucklestone; Secretary-Treasurer, P. M. Sauder.

VANCOUVER BRANCH—Chairman, G. E. G. Conway; Secretary-Treasurer, F. Pardo Wilson, Address: 422 Pacific Building, Vancouver, B.C.

VICTORIA BRANCH—Chairman, F. C. Gamble; Secretary, R. W. MacIntyre; Address P.O. Box 1290. Meets 2nd Thursday in each month at Club Rooms, 534 Broughton Street.

MUNICIPAL ASSOCIATIONS

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

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

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

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

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

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

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

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

UNION OF ALBERTA MUNICIPALITIES.—President, F. P. Layton, Mayor of Camrose; Secretary-Treasurer, G. J. Kinnaird, Edmonton, Alta.

UNION OF MANITOBA MUNICIPALITIES.—President, Reeve Forke, Pipestone, Man.; Secy-Treasurer, Reeve Cardale, Oak River, Man.

CANADIAN TECHNICAL SOCIETIES

ALBERTA ASSOCIATION OF ARCHITECTS.—President, R. W. Lines, Edmonton; Hon. Secretary, W. D. Cromarty, Edmonton, Alta.

ALBERTA ASSOCIATION OF LAND SURVEYORS.—President, L. C. Charlesworth, Edmonton; Secretary and Registrar, R. W. Cautley, Edmonton.

ASSOCIATION OF SASKATCHEWAN LAND SURVEYORS.—President, A. C. Garner, Regina; Secretary-Treasurer, H. G. Phillips, Regina.

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

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

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

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

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

CANADIAN CEMENT AND CONCRETE ASSOCIATION.—President, Peter Gillespie, Toronto, Ont.; Secretary-Treasurer, Wm. Snaith, The Thor Iron Works, Toronto, Ont.

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

CANADIAN ELECTRICAL ASSOCIATION.—President, A. A. Dion, Ottawa; Secretary, C. E. Bawden, Birkbeck Bld., Toronto.

CANADIAN FORESTRY ASSOCIATION.—President, Hon. W. A. Charlton, M.P., Toronto; Secretary, James Lawler, Canadian Building, Ottawa.

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

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

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

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

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

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

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

CANADIAN STREET RAILWAY ASSOCIATION.—President, Patrick Dubee, Montreal; Secretary, Acton Burrows, 70 Bond Street, Toronto.

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

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

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

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

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, F. C. Mechin; Corresponding Secretary, A. W. Sime.

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

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

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

INSTITUTION OF MINING AND METALLURGY.—President, Bedford McNeill; Secretary, C. McDermid, London, England. Canadian members of Council:—Prof. J. B. Porter, H. E. T. Haultain and W. N. Miller and Messrs. H. W. Claudet, S. S. Fowler, R. W. Leonard and J. B. Tyrrell.

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

MANITOBA ASSOCIATION OF ARCHITECTS.—President, W. Fingland, Winnipeg; Secretary, R. G. Hanford.

MANITOBA LAND SURVEYORS.—President, J. L. Doupe; Secretary-Treasurer, W. B. Young, Winnipeg, Man.

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

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

ONTARIO ASSOCIATION OF ARCHITECTS.—President, C. P. Meredith, Ottawa; Secretary, H. E. Moore, 195 Bloor St. E., Toronto.

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, N. Vermilyea, Belleville; Hon. Secretary-Treasurer, J. E. Farewell, Whitby; Secretary-Treasurer, G. S. Henry, Oriole.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, J. S. Dobie, Thessalon; Secretary, L. V. Rorke, Toronto.

TECHNICAL SOCIETY OF PETERBORO.—Bank of Commerce Building, Peterboro. General Secretary, N. C. Mills, P.O. Box 995, Peterboro, Ont.

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

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

QUEEN'S UNIVERSITY ENGINEERING SOCIETY.—Kingston, Ont. President, W. Dalziel; Secretary, J. C. Cameron.

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

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—President, H. C. Russell, Winnipeg, Man.; Hon. Secretary, Alcide Chausse, No. 5. Beaver Hall Square, Montreal, Que.

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

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

TECHNOLOGY CLUB OF LOWER CANADA.—President, F. E. Came; Secretary-Treasurer, E. B. Evans. Meets twice yearly.

UNDERGRADUATE SOCIETY OF APPLIED SCIENCE, McGILL UNIVERSITY.—President, W. G. Mitchell; Secretary, H. F. Cole.

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

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