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THE DESIGN OF CENTRAL HEATING SYSTEMS

PART I.

STATIONS TO SERVE BUSINESS AND RESIDENTIAL SECTIONS HAVE MANY ADVANTAGES. ECONOMICAL AND AESTHETICAL FEATURES OF CENTRAL STEAM OR HOT WATER PLANTS.

By A. G. CHRISTIE, M.E.,

Assistant Professor of Steam Engineering, University of Wisconsin.

A LEADING consideration in discussing heating problems is the duration of the season in which heat is required and the degree of cold experienced during such periods. Experience with several heating systems in the State of Wisconsin has shown that the average season during which heat must be maintained on the distribution service extends from October 1 to June 1, a period of eight months.

Table I. shows the normal and mean monthly temperatures for Madison, Wis., over a period of years.

Table I.—Normal and Mean Monthly Temperatures at Madison, Wis.

Month	Normal Temp.	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12
October	48.8	50	47	51	47	54	48
November	34.2	36	36	38	43	30	29
December	22.7	25	27	23	15	21	29
January	16.5	17	22	20	17	19	1
February	19.6	21	21	24	16	26	14.6
March	30.1	38	35	30	45	36	23
April	44.5	38	46	40	49	44	47
May	58.	49	57	55	53	63	58
Average	34.3	34.2	36.4	35	35.6	36.6	31.2

It can be seen that the year 1906-07 might be taken as approximately a normal season as far as heating demands are concerned.

Residence and Other Isolated Heating Systems.—In order to maintain comfortable living conditions in residences, offices, factories, stores, etc., during these cold months, it is obviously necessary to provide some means of artificially heating such rooms or shops. Usually this has been done in the past by providing individual heating apparatus for each building, which generally consisted of either a hot air furnace, a hot water heater, or a steam boiler, each with its accompanying heat distributing apparatus. Anthracite coal has been principally used, until recently, as fuel for burning in the furnaces of such heaters, largely on account of its cleanliness, its small ash content and its freedom from smoke. But the price of anthracite coal suitable for domestic purposes has now reached $9.50 per ton at Madison, Wis., and similarly high prices prevail in other cities and towns throughout the state. On account of this high price many householders and others are commencing to burn bituminous coal in their furnaces. Such coal can be successfully burned without smoke on only a few specially designed grates. It is therefore to be expected that as the price of anthracite is increased, the smoke nuisance in cities and towns will be aggravated by this increasing use of bituminous coal in domestic heating furnaces.

In a report on the work of the Smoke Investigation Committee at Pittsburg, Pa., it was pointed out that smoke not only results in losses to the coal consumer from the escape of unburned volatile matter, but also to the community as a whole through increased house cleaning bills, increased laundry bills, and damage to stocks of goods in stores and warehouses. Smoke limits plant growth, augments the persistency of fogs, decreases daylight and increases the prevalence of lung, throat and nose diseases among citizens of smoke-producing districts. In small cities these evils, though present, are not apparent to so marked a degree as in the large cities. Nevertheless, there are substantial reasons, as indicated above, for an active campaign for smoke abatement in any community, and such movements are now in vogue in all parts of the country.

In many cities steps have already been taken to minimize the smoke nuisance. Ordinances prohibiting chimneys from smoking more than a given number of minutes per hour have been passed, and smoke inspectors have been appointed to enforce these ordinances. Their attention has been principally directed towards the chimneys of large users of coal and to the locomotives on the railroads. Up to the present time little or no attention has been given to the chimneys of private residences. A short time ago the writer spent an early morning on a mountain top overlooking a large American residential city. The atmosphere was particularly clear that morning at daybreak and the homes of the city could be distinguished without difficulty by the naked eye. Just about sunrise coal fires were started in the furnaces of these houses and in an hour the whole city was obscured by a dense smoke cloud. The citizens of this city point with pride to their fine streets, beautiful homes and clean atmosphere, and are justified in doing so, while at the same time a long distance view of their locality showed that they made much smoke that they were not aware of.

Such conditions would be impossible with central station heating if the furnace designs at the station had been carefully made and the plant was operated intelligently.

Domestic heating apparatus needs attention in maintaining the fires, clearing out ashes, and cleaning and repairing the equipment before putting it into use each fall. These services are often not paid for in cash but are performed by the owner or one of his household. Yet there is a demand on such a person's time for this work. Then, again, there are also the many petty annoyances and irritations connected with the maintenance of the heating system which for comfort it is desirable to minimize or do away with entirely. Among such might be mentioned the fact that fires frequently go out when needed most, furnaces must be cleaned and fixed at the beginning of the season, coal gas escapes and is objectionable in the home or office and dust comes into the house from unloading coal and removing ashes and makes extra cleaning necessary. In apartment houses, the usually unsatisfactory janitor is practically eliminated when central heating service is supplied.

There is a tendency in such cases where individual furnaces are used to fire hard during the daylight and evening hours, and to bank the fires and allow the temperature of the building to drop during the night. This tends toward economy in fuel costs, although there is frequently a certain amount of physical comfort sacrificed for the sake of economy.

When hard coal is used, strict economy is practised. Storm windows and doors are put up after the first fall frost and from then on ventilation is sacrificed, while no space is heated that is not absolutely needed. This statement can be corroborated by any who have lived in rooming houses.

Many people follow the custom of purchasing the whole season's fuel supply during the summer months when coal is cheap. This often involves a certain degree of hardship as a comparatively heavy expenditure must be made at one time instead of having it spread out over a period of several months.

The Advantage of the Central Heating Plant.—Instead of providing individual heating furnaces in each building, a single building may be provided in a central location to accommodate the complete heat generating units for a given district, and heat can be transmitted to the different buildings by a system of underground pipes carrying hot water or steam. It is the purpose of this series of articles to discuss a number of phases of these central station heating systems in the light of personal experience and of the latest information available, especially with relation to conditions existing in Wisconsin.

When compared with individual heating plants, the central station systems have many points of superiority. Steam can be produced more economically in the large boilers in central plants than in small individual boilers. House heating boilers of 25 h.p. have shown efficiencies ranging from 40 to 50% under test conditions. Under average operating conditions such results would not be obtained continuously, and it is probable that the average operating efficiency is not far from 35%. Large sized boilers tested under actual daily operating conditions show efficiencies ranging from 60 to 80%, with an average of possibly 65%.

To illustrate some results that are actually obtained in a central heating plant of the best design, the boiler efficiencies obtained from three different tests of the boilers of the Capitol Heating Station at Madison, Wis., are as follows: The first two tests were made on single 400 h.p. Stirling boilers fitted with Murphy stokers. Boiler efficiencies of 80.9 and 82.9% respectively at nearly full load rating were obtained from these tests. A year after the first tests, a trial was made on two boilers together, with less than half load on each, with a resulting boiler efficiency of 66.2%.

Other results of considerable interest are from tests made in 1911 by Messrs. Pugh and Watson, seniors in the College of Engineering, forming a portion of their work for the degree of Bachelor of Science in Mechanical Engineering. The tests were made on several of the 350 horse-power B. & W. boilers at the University heating station at Madison, Wis. Their object was to determine the efficiency of operation and the rate of evaporation of the various boilers under actual operating conditions. The boilers under test were fired by the regular crew in the same way as all the other boilers in the plant, so that the results represent average conditions of operation. These trials showed boiler efficiencies ranging from 64.6 to 77.3%, depending on the amount of scale on the heating surfaces and the particular type of furnace construction installed under the tested boiler.

It can thus be seen that there is a difference in efficiency under average operating conditions in favor of the central station of from 75 to 100%.

A table in Bulletin No. 40 of the Bureau of Mines gives the details of operation of fifty-seven central heating plants. In commenting on the costs of service, the authors state as follows: "A comparison of the prices charged by central stations as given in this table with the cost of fuel only for an ordinary house heating boiler shows that in many cases the cost of producing heat on the premises equals the price charged by the central stations. When heat is purchased the customer avoids the annoyance of having to supervise the operation of the heating plant as well as of the dust resulting from the delivery of fuel and the removal of ashes."

In the central station smoke can be almost entirely eliminated by the frequent firing of small quantities of coal on properly designed grates. Slack and other cheap grades of bituminous coal can be used instead of the more expensive grades supplied for household furnaces. It is also possible to install such sized boilers at the central station that those in service may operate at maximum economy at all times. It is therefore apparent that the central station can effect considerable savings over individual plants so far as boiler operation and coal are concerned.

The savings already mentioned are offset to some extent by the fact that the central heating system is expensive to install and thus a heavy overhead charge must be made on the service rendered to meet interest, maintenance and depreciation charges on such distribution apparatus. At the same time, an operating force must be employed at the central station.

When a prospective customer undertakes to compare central station charges for heating with the cost of his individual service he usually considers only his coal costs and neglects to allow for the interest, maintenance and depreciation charges on his own furnace equipment, which would be rarely less than about $15, even in the smallest houses.

When central station heat is used, the fire risk on property is diminished and hence insurance rates are lowered. The property becomes more desirable on account of his heating service and, therefore, can command a higher price if one wishes to sell. It has also been found that in residences with such connection it is easier to secure and keep servants. These considerations are of considerable economic importance to every property owner and householder in a city where district heating is proposed and should therefore receive the careful consideration of the prospective customer.

That the central heating station is receiving considerable attention of late is evident from the following quotation from Bulletin No. 40 of the Bureau of Mines, which states: "The central heating plant is not a new thing; in fact, some of the plants have been in operation for twenty to twenty-five years. Development in this direction has been very slow, however, until within the last five or six years, when the idea has received renewed attention." A table in the same bulletin gives data on 57 plants throughout the United States in 1907, and from this table it is evident that the plants are most numerous in the States where coal is relatively cheap. It will be shown in a later part of this article that a very considerable portion of the cost of central station service is the overhead charges on the distribution system, and this proportion increases as the price of coal decreases. It is therefore apparent that in these cities where coal is cheap the citizens prefer central station service for other reasons than economy in fuel cost. If, under such conditions, this service has certain acknowledged merits to commend its use, it seems hard to understand why it has not been more widely adopted in localities where coal is expensive and where the distribution costs would form in consequence a smaller proportion of the charges for central station service. It seems evident that the value of this service will be recognized in the near future and that in consequence the number of central heating plants will increase quite rapidly.

Isolated plants in large office buildings, stores, hotels, factories, etc., are able to furnish the necessary heating, together with the power and light required, at a low combined cost. If a central heating company wishes to secure such business, it must be prepared not only to supply heat but also electricity under more favorable conditions than would the isolated plant. This may not necessarily mean at a lower cost, for many executives are willing to pay for the relief from the care and anxiety incident to the installation and maintenance of a steam-electric power plant.

The Central Heating System as a Public Utility.—A central heating system must be considered as a public utility, and it therefore comes under the control of the "Public Utility Commissions" in such states as these exist. In Wisconsin public utilities are controlled by the Railroad Commission.

The methods employed by the commission in making its valuations are of very great interest and deserve the careful study of all engineers engaged in public utility work. There have been no rulings up to the present time on any case involving district heating, so that there has been no fixed rate of return recognized. In the case of utilities supplying electricity, 8% profit on the entire valuation has been taken as a basis for ratio-making. The books of all public utilities must be kept according to methods and forms prescribed by the commission.

Public utility corporations in the State of Wisconsin are so regulated by the commission representing the state that they are true servants of the public. At the same time the guarantee of a fair return on capital honestly invested has so enhanced the value of the stocks and bonds of these corporations that they are now considered "gilt-edge" on the stock markets.

These laws have been extracted at some length to make perfectly clear the conditions that would be imposed on a corporation that proposes to organize and do a central station heating business in the State of Wisconsin.

The property of a public utility corporation can be assessed at an appraised value by the commission and taxed for municipal and state purposes in the same manner as other real property.

The corporation is required to report at regular intervals to the commission on forms provided for such purposes. These reports cover service records and financial statements.

There are greater natural limitations to the extent of the service of a heating station than in the case of an electric plant. The distance over which heat can be transmitted cannot compare with the transmission of electricity owing to the higher first cost of the underground distribution system and the greater power lost in forcing the heating medium—either steam or hot water—to the outlying portions of a long system. There will be a certain radius around the central station over which heat can be supplied to customers at a reasonable cost after allowing a fair return on the investment.

The greatest distance over which heat can be transmitter from a central station is determined by the allowable friction losses in the mains and the amount of service at the end of the line. Mr. Chas. R. Bishop, in a paper before the New England Section of the National Electric Light Association, stated that in general this radius of distribution should be from one to one and three-quarter miles from the central plant. From data pertaining to the heating stations in the United States, it would appear that a reasonable radius of distribution is from 4,000 to 5,000 feet.

Plant Location and Design.—In considering plant location and design, it is of first importance to determine the probable extent of the heating service, for on this depends the entire design of plant equipment and underground pipe lines. The central business portions of cities and the more thickly populated well-to-do residential sections will provide the greatest heating loads for the least capital expenditure.

When a central heating plant is under consideration, a careful examination should be made of all territory, both business and residential, that it is proposed to serve, and a scaled map of this section should be prepared. The distance to the extreme portions should not exceed about two miles from the station. The type of each building (whether wood, brick, concrete, etc.) should be noted on this map, together with the classification of the use to which the building is put, as, for instance, stores, residences, theatres, hotels, etc. The next step is to secure weather records of the city or of a neighboring city. Then the maximum and minimum temperatures throughout the heating season should be plotted. From these curves it is possible to select other cities where similar conditions prevail, and data should be secured from those cities as to the maximum and average heat demands for each type of structure in such a town. This information should be applied to each block or section of the town in question and the results will form a fair estimate of the probable requirements that must be met by the proposed heating system. The design of mains from the station may now be commenced and the proportions of these should be such as to meet modern engineering requirements for such service. The complete system for which the plans were made need not be installed during the first season. The plans, however, should always be made for the ultimate installation capacity. Otherwise, the system would become inefficient as the load increases.

Theoretically, the central heating plant should be located at or close to the centre of the area over which heat is to be distributed. But this location is often out of question in an actual case owing to high costs of real estate, poor facilities for handling coal and ashes, lack of suitable water supply, and the location elsewhere of existing plants whose facilities will be utilized. A high first cost of real estate for the plant places an initial heavy overhead charge on the service, though this may sometimes be offset by other economies to be gained by a central location. Neighboring property owners frequently object to the location of such a station adjacent to their buildings on the plea that the attendant noise, dirt and smoke will tend to lessen the value of their holdings. The New York Edison Company has had to defend several suits for damages due to alleged injury to surrounding property from soot and cinders which were discharged by the smokestacks during periods of heavy loads. The Murphy Heating Company, of Detroit, on the other hand, have located their central station near the heart of the business district instead of on the river front. In general, however, it is not advisable to buy an expensive site even in a centralized location unless there are special considerations that make such a site more desirable than any other one available.

The cost of handling coal and ashes at the central station must be a minimum if low operating costs are to be obtained. This is more nearly possible when the plant is located beside a railroad or a dock so that coal cars may be switched to or unloaded into the station itself. When coal has to be trucked a considerable item is necessarily added to the costs of operation, and thus to the heat sold to customers. The saving of such charges will very frequently greatly offset the extra losses in pipe lines reaching to the distributing centre from a less central location.

A central heating plant, especially one using a low-pressure steam distribution system where the condensed steam is wasted to the sewers, uses a large quantity of water daily. It is desirable that such a plant should have access to a water supply independent of the city mains, either by means of a small pumping plant on a nearby lake or stream or by artesian wells. When the plant contains electric generating equipment which is run condensing during the summer season, large amounts of water must be at hand for cooling purposes. Such possible water demands should receive careful consideration in connection with the location of the plant.

In a later part of this series, it will be shown that the losses in distribution systems vary with the length and size of the pipe lines. Hence a central location is the most desirable from a distributing standpoint, for then the heating load can be secured by comparatively short pipe lines throughout the district it is proposed to serve and these lines can radiate in all directions from the plant. This would result in minimum heat losses and would also provide a more uniform pressure over the whole system provided the pipe lines were properly designed.

Systems for Distributing Heat.—Heat may be distributed from a central station either by means of hot water or by low pressure steam. At the present time there is a considerable difference of opinion regarding the relative advantages of these two systems. It is not intended in this thesis to advocate either system but rather to discuss the application of both in central heating practice.

Flow and return pipes must be provided in the hot water system. The return water enters the plant at a lowered temperature, passes through some type of re-heater and is then forced out through the system again by pumps. Several types of re-heaters utilizing the exhaust steam from engines are in use. Hot water systems are spoken of as "closed" or "open." On the former system closed heaters are used and the pump forces the return water through the heater and out into the flow pipe. By attaching a condenser with an air pump in series with these heaters, it is possible to carry any degree of vacuum desired. Live steam heaters in series with the exhaust heaters are also in common use for meeting peak loads. Sometimes it is desirable to place these above the level of the boilers so that the condensed steam flows back by gravity. The amount of heating to be supplied by this heater is adjusted by throttling the steam supply. Frequently a number of the boilers in the plant are so piped up that they can serve as water heaters.

The "open" system of hot water heating operates with open heaters or with a type of barometric condenser called "co-minglers." In the latter the exhaust steam and return water mix together and are drawn off by the circulating pump connected to the tail pipe which discharges the mixture into the heating system. The condensed steam goes to make up the losses in the system from leakage, while the excess is used as boiler feed. With the closed system the condensed steam from the re-heaters is pumped back into the boilers. The open system requires more power to circulate the water than the closed system as the return static pressure is necessarily lost in the vacuum of the co-mingler or in the open heater. The selection of the open or closed system depends largely on local conditions. When engines are used, and it is desired to carry a vacuum, the co-mingler would be the logical choice though other systems are also used for the same purpose.

Vacuum and pressure systems are both in use foı distributing steam heat. In the vacuum system two pipe lines are installed—a large pipe to carry the low pressure steam to customers' installations, while a smaller one under vacuum acts as a return for the condensed steam to the plant. It is possible at times to operate this system with a partial vacuum at the engine exhaust, thus increasing the power and economy of the engine. The condensed steam is all returned to the plant and can be used again for boiler feed water. In some localities this item is of considerable importance.

The pressure system consists of a single pipe line with a steam pressure between 3 and 10 pounds about atmosphere. The condensed steam is usually metered at the customer's premises and wasted to the sewer. Exhaust steam from engines is generally used on this system, augmented when necessary by live steam passed through reducing valves. This is the simplest system of all.

It seems generally agreed with regard to the first cost of plants that both the station and distribution equipment of the steam pressure system can be installed for less money than the vacuum or either hot water system. On the other hand, the piping must be better insulated to prevent excessive line losses as the steam temperature is higher than if hot water or vacuum systems were used.

Steam is capable of furnishing such general service as cooking, laundry work, etc., which water will not do. Steam can be adapted to customer's hot water installations already in place, either directly or through reheaters, and can be applied to hot air systems by means of indirect radiators. Hot water, on the other hand, cannot be successfully applied without alteration to steam systems which are already installed.

When the cost of operation is considered, hot water systems have the advantage that partial vacuums can be carried on the engine exhaust. However, as the load factors are usually low in electric stations, it is advisable in all cases—as will be pointed out later—to figure the plant for the production of heat alone, in which case this apparent advantage largely disappears. Higher circulating pressures must be maintained on hot water systems than with steam. Hence heavier and more expensive pipe lines and fittings must be installed.

The elevation of the area to be served in relation to the plant location, and also the height of the highest building to which heat is furnished, will determine the pressure to be maintained on a hot water system. This is usually about 15 pounds above the static pressure at the plant. If a city is hilly, then the hot water system cannot compare favorably with steam on account of excessive pressure in the pipes, the power required for pumping and the friction losses in the system.

Some device must be employed on hot water systems to regulate the amount of water flowing through the customer's radiators. Valves with adjustable openings controlled by a special key are sometimes installed. On other systems choking discs or nipples are inserted in the return pipes and also at each of the radiators. The holes in these are so proportioned that only the proper amount of water will be forced through the radiators by the prevailing pressure.

Hot water lends itself more readily to temperature regulation than steam. With the latter some form of thermostatic control must be employed, while with hot water a schedule of flow temperature to be maintained at the central station can be prepared for varying outside temperatures and wind velocities. In this way the customer receives heat in just the right amount to avoid overheating his rooms in any kind of weather.

The amount of steam used by various customers can be determined by metering the condensed steam and charges for service may be based on this amount. The customer then pays for the heat used and may be as economical or wasteful as he desires. In such systems cooling or economizing coils with 15 to 20% of the total radiation capacity should be installed by each customer to recover the heat in the condensed steam before discharging it through the trap and meter to the sewer. This is an absolute necessity in some cities where citizens are prohibited by ordinance from discharging water into the sewers above 125° F. or so.

Hot water service, on the other hand, cannot be metered, and charges for the same must be made on the basis of square feet of radiating surface or on some other flat rate basis. In actual service it has been noted that where there is no financial incentive to economy 25 to 50% more heat will be used than is actually required. As a result of this, all flat rates must be higher proportionally than metered service, and so the economical customer helps to pay for the carelessness and extravagance of others.

As a rule, steam service is more popular in business sections, while in residence districts hot water seems to be more generally sought.

When a customer has his residence or building piped up for hot water and the district heating system supplies steam, all that is necessary to secure central station service is to install some form of heat transformer or interchanger, of which there are many on the market. These devices consist, as a rule, of double tube manifolds with the steam supply connected to the inner tube while the hot water circulates between the tubes. The steam in condensing gives up its heat to the water which rises and establishes a circulation in the same manner as when a coal-fired heater is used. The condensed steam can be metered and charged for in the usual way. Kitchen and bath heaters can also be piped up to one of these heat interchangers, or a coil of pipe carrying steam can be placed in the water reservoir itself.

Some schedule of service for varying outside temperatures should be prepared for the guidance of the central station operators with either hot water or steam systems. For the former, tables of flow temperatures to be maintained at the central station should be prepared, with corrections to be applied for various velocities and directions of wind. Such a schedule of temperatures is shown in Table II., and applies to a central hot water heating station in Columbus, Ohio.

Table II.—Relation Between Outside Temperature and Hot Water Flow Temperature.

Temperature. Weather.	Flow.	Temperature. Weather.	Flow.	Temperature. Weather.	Flow.
70 above	stopped	36 above	157	Zero	210
68 "	106	34 "	159	2 below	212
66 "	112	32 "	162	4 "	215
64 "	117	30 "	165	6 "	218
62 "	121	28 "	170	8 "	221
60 "	125	26 "	175	10 "	224
58 "	128	24 "	178	12 "	226
56 "	131	22 "	180	14 "	229
54 "	133	20 "	184	16 "	232
52 "	135	18 "	187	18 "	235
50 "	137	16 "	189	20 "	237
48 "	139	14 "	191	22 "	240
46 "	141	12 "	194	24 "	243
44 "	144	10 "	196	26 "	246
42 "	147	8 "	198	28 "	249
40 "	150	6 "	201	30 "	252
38 "	154	4 "	204		
		2 "	207		

The above schedule is to be applied in still weather only. With falling outside temperature and a wind of 12 miles per hour add 5 degrees; with falling outside temperature and a wind of 18 miles per hour, add 10 degrees.

[A second part of this article, dealing with the design of heating stations, pipe lines and conduits, will appear in the next issue of *The Canadian Engineer*.—Ed.]

Drills of hard electric steel have recently been adopted in connection with the boring machines employed by the State mining authorities in the Goslar district of Germany. The result is stated to be not only an increased output, but a marked reduction in the number of replacements necessary, and also in the number of drills that require sharpening.

THE FIRE HAZARD IN TURBO-GENERATORS.

By G. S. Lawler,
Elec. Engr., Inspection Dept., Assoc. Mut. Fire Ins. Cos., Boston, Mass.

THAT there is a great chance of serious damage by fire, following arcing in turbo-generators, and suggestions for minimizing this hazard form the subject of a paper by Mr. Lawler appearing in the July number of the Journal of the American Society of Mechanical Engineers.

The chances of electric generators of the older types being seriously injured by fire in the event of some part of the insulation failing is slight. Occasionally arcing will ignite the insulation at some point, but it is seldom that the fire will spread much before it is extinguished. This freedom from fire damage is due principally to the comparatively low speeds, the accessibility of the combustible insulation, and the fact that the machines, being of large mass per unit capacity, the insulation is considerably distributed.

This condition of practical freedom from fire is reversed in the case of generators of the turbo type, for when a short circuit occurs in one of them there is a great chance that the insulation will be ignited and the machine be badly damaged; in fact such damage has occurred in a number of instances.

The chief causes of the increased hazard in the more modern type generators are as follows:—

1. The volume occupied by this type of machine is very much less for the same capacity than that of the older types of generators, so that the combustible insulation is more concentrated and, therefore, much of it is exposed, even to a slight arc or fire. The covering on the conductors depends greatly for its insulating qualities on the presence of oils or gums of a highly combustible nature. The amount of this combustible insulation on the higher voltage generators is naturally greater than in the low voltage machines.

Owing to turbo-generators having only a few poles the end connections between slots form a large proportion of the total length of conductors, in fact in some designs approximately one-half of the coils are outside of the slots. These end connections, one-half being on one side of the machine and one-half on the other, are exposed to fire, and as with a pile of loosely laid sticks, fire will rapidly extend from the insulation on one coil to that on the others.

2. Owing to these generators being of exceedingly large capacity in many instances, (one of 30,000 kva. capacity now being constructed) an enormous amount of energy is involved in a short circuit, especially at the instant the short occurs and as the arc is confined in the limited space with the combustible insulation, it would seem impossible for the insulation to escape being set on fire at many points simultaneously.

3. The machines are cooled by forcing large quantities of air through the spaces between the conductors. The large and constantly renewed supply of oxygen will hasten combustion when it is once started.

The air is given somewhat of a rotary motion by the rapidly revolving rotor which has the ventilating vanes on it and consequently fire when started will be quickly swept around the exposed insulation.

4. The generators are totally encased with the exception of the air inlets and outlets and even these in some designs are under the machines. This construction prevents access to a fire and much valuable time will necessarily be consumed before extinguishing agents can be used effectively. When the field current is cut off, as is necessary in case of short circuit, the only means of bringing the rotor quickly to rest is lost and it will continue to run for a long time after the steam has been shut off. Some machines will run for over an hour. This continued rotation is not conducive to the quick extinguishing of fire, especially when the ventilating vanes are mounted on the rotor.

In addition to the possible causes of arcing existing in the case of the older types of generators, the turbo-generator is subject to momentary large current rush at instant of short circuit, even if the short is external to the machine itself, unless means are taken to keep the current within safe limits. The heavy rush of current causes mechanical stresses in the conductors, which in some cases are severe enough to distort the conductors, especially where outside the slots, and to injure the insulating covering, resulting in a short circuit within the generator itself. In some designs the internal reactance of the machines will permit of the momentary current rush amounting to 40, or possibly more, times the normal full-load current of the machines.

The possibility of the conductors being distorted has been reduced in some cases by designing generators with sufficient internal reactance, or by providing external reactance such that the current at the moment of short circuit will not be great enough to damage the generators. Attention has also been given to supporting the stator end connections to prevent their distortion. These means have undoubtedly greatly increased the safety of the turbo-type of generator from possibilities of internal short circuit, but in no way tend to prevent a fire resulting should an arc occur.

A short circuit in the rotor will probably not result in a severe fire unless under exceptional conditions. This is also true if the short circuit occurs inside of a stator slot. A short circuit involving a stator coil, however, is more apt to occur at the end of the slot where the conductors are exposed.

As asbestos is now used largely for insulating the rotor windings and as these windings are well protected, it is probable that only in cases of severe fire in a machine will the rotor windings be damaged to any extent.

While the generators may be free from fires during the earlier portions of their life owing to the proper use of reactances which prevent external troubles seriously affecting the machines, as they get older the ordinary causes of breakdown of insulation are liable to occur and fires result. Probably in most cases generators will not be discarded until some trouble, usually in the nature of a short circuit, has occurred at least once in each, so that it is reasonable to expect that unless further preventive means are taken, turbo-generators stand a good chance of serious damage by fire at some time during their life. Although many fires have occurred, probably most of them have happened during the generator development stage. Generators of the turbo type are of such recent production that none of them has yet reached a life which could be considered old and, therefore, the troubles which can be expected near the end of their life by fire have still to come.

Undoubtedly the manufacturing companies have given serious thought to the matter of the reduction of the fire hazard in turbo-generators and have employed all means practical at the present time to this end, but there is still very much to be desired. The following several means if taken together would seem to minimize the chances of a serious fire:

1. If a suitable material could be found a non-combustible outer covering could be placed over the insulation on the stator end connections. This would greatly delay the spread of fire and even if no other protective means were taken, would undoubtedly prevent much serious damage. Where fire extinguishers were used the covering would at least hold back the fire until they could be brought into play. At present no material suitable for such a covering appears to be available.

2. If a non-combustible outer covering should be put on, its advantages would be partially lost in time unless the cooling air were freed of the dirt and oily vapor liable to be in it. This could be done by filtering, as has already been advocated several times.

3. Means could be provided for cutting off the air supply in case of fire in generators by placing dampers in the inlet ducts designed so as to be normally held open by fusible links. The links could be placed so that they would be quickly fused by the heat and allow the dampers to close automatically. By reducing the oxygen supply to that entering by leakage the action of the fire would be slow.

4. Arrangements could be provided for the quick introduction of carbon dioxide gas into the machines. The carbon dioxide could be kept in liquid form and piped through valves, expansion tanks, etc., to the generators. The valves could be arranged to be opened by the closing of the air inlet dampers so that the gas would be automatically introduced into the generators. This gas would be very effective in extinguishing fires inside the machines after the air supply had been cut off.

The employment of some efficient method of reducing the fire hazard in generators of the turbo type either along the lines mentioned or in some other way is important. The value of these generators is great and the damage by fire may amount to a considerable proportion of the first cost. It is probable that the damage is more liable to occur towards the end of the life of the generators, but even then the loss may be large, both directly and indirectly. The large central stations have reserve units so that the increased damage due to fire in one of their generators would probably not affect the continuity of service, but the increased time necessary for repairs may be long and during this time the reserve capacity will be weakened. In the case of industrial plants the longer time needed for repairs might be serious. Many manufacturing concerns who generate their own current depend on only one unit and, therefore, their whole production, or a large part of it, would be affected.

UTILITY AND ATTRACTIVENESS IN ECONOMIC RESERVOIR DESIGN*

DESCRIPTION AND DESIGN OF A CIRCULAR REINFORCED CONCRETE RESERVOIR, 200 FEET IN DIAMETER, 26 FEET DEEP, WITH SIDE WALL WHOLLY ABOVE GROUND.

By ALEXANDER POTTER,
Consulting Engineer, New York City

MUSKOGEE, Oklahoma, takes its water supply from the Grand River. The present intake is located in the channel of the river, about 1,800 feet above its confluence with the Arkansas River. Two 16-inch cast iron pipes, each 2,600 feet long, laid in the bed of the Grand and across the Arkansas, convey the water to the pumping station. Low-lift pumps raise the water to a three-million-gallon settling basin. The water is then pumped through a 24-inch main, 20,800 feet long, to the city. A standpipe located in the northern part of the city, equalizes the pressure in the town.

The improvements to the water system are the result of recommendations made by the writer, who, in the fall of 1910, was retained by the city to investigate the existing water and sewerage systems, and to devise methods and means to adapt the existing systems, then overtaxed, to the present and probable future needs of the city. The improvements consist of the replacing of the two 16-inch suction lines by a 4-ft. 6-in. intake constructed in rock tunnel, with an intake tower at the upper end; the installation of additional high and low-lift pumping units; the construction of a water purification plant, including a six-million-gallon settling basin; the construction of the six-million-gallon reservoir with which this article deals; together with the construction of a 24-inch supply main, 12,600 feet long, connecting the reservoir located on the other side of the city from the pumping station with the existing distribution system.

The Need of a Large Storage Reservoir.—The object in constructing the reservoir was twofold; namely, to increase the pressure throughout the town, and to have at all times a large quantity of water available at a sufficently high elevation to maintain the pressure in the town at times of heavy draft or in case of a serious breakdown of the pumping station or force line.

The pressure in the central portion of the city ranges from sixty to seventy pounds. At times of heavy draft, these pressures cannot be maintained. A stand-pipe, 25 feet in diameter and 120 feet high, was erected in 1903 to help maintain the pressure in the city. The effect of the stand-pipe in this direction, however, is very slight, because of the small quantity of water in the pipe at the height at which it is required.

Conditions Which Influenced Design of Reservoir.—A storage and distribution reservoir, to be effective, should always be located as close to the city as possible; otherwise, too great a fluctuation in pressure will exist in

* Before the Convention of the American Waterworks Association, Minneapolis, June 25, 1913.

the distribution system. A site suitable for a reservoir exists within the city limits. In the northern part of the city, there is a knoll which reaches an elevation of 653 feet above mean sea level. The stand-pipe was erected on this knoll when the plant was built. In the extreme western end of the city is another knoll, known as Agency Hill, which reaches an elevation of 760 feet, thirteen feet lower than the highest water level in the standpipe. The top of this knoll has a hog-back shape, and averages about 200 feet in width. This is the only hill available for the construction of a distribution reservoir of the size required.

Good waterworks practice would require a city of the size of Muskogee to maintain a fire pressure of at least seventy-five pounds. A reservoir with its average water level at the elevation of the surface of the ground on the hill, viz., 760 feet, would give a static pressure of only

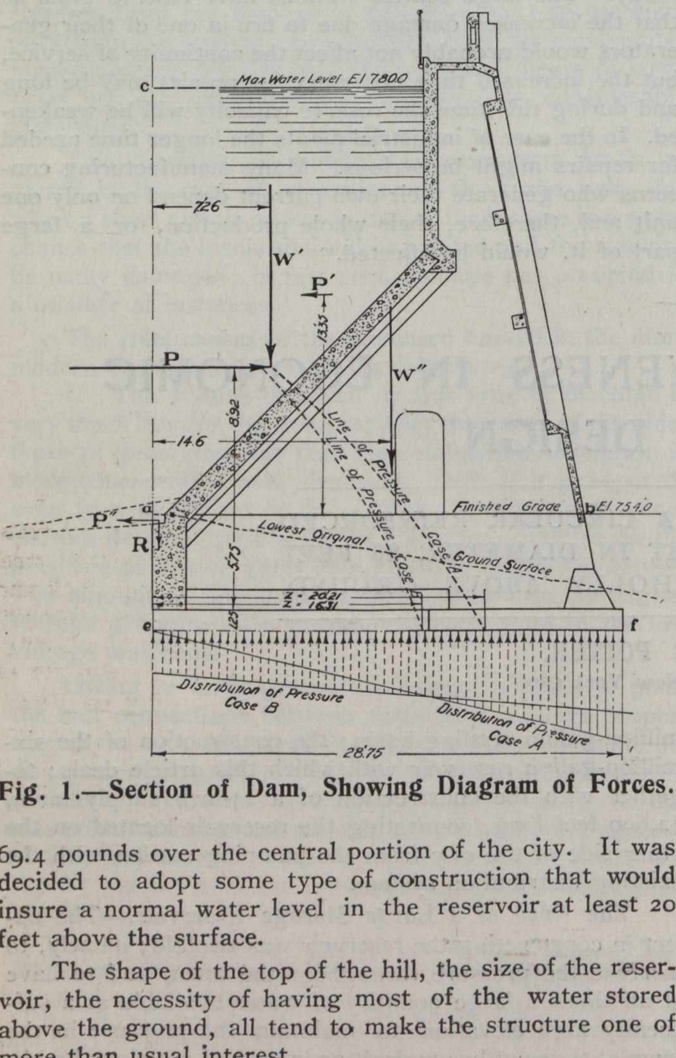

Fig. 1.—Section of Dam, Showing Diagram of Forces.

69.4 pounds over the central portion of the city. It was decided to adopt some type of construction that would insure a normal water level in the reservoir at least 20 feet above the surface.

The shape of the top of the hill, the size of the reservoir, the necessity of having most of the water stored above the ground, all tend to make the structure one of more than usual interest.

The top of the hill consists of three or four feet of clay and scattered boulder, underlaid with layers of clay and shale.

Reinforced concrete is practically the only material that could be used to construct a reservoir of the proportion and shape required by the conditions assumed above.

Possible Types of Construction.—A circular shape was decided upon. This shape is usually the most economical, but under the existing conditions, unquestionably so.

To obtain the required capacity of 6,000,000 gallons, a circular tank with its diameter limited to 200 feet requires a depth of 26 feet. To construct a circular tank of these dimensions in which the internal pressure is resisted by the tension in the shell, was considered inadvisable; first, because of the high cost of construction, and second, because of the probability of structural defects developing at the junction of the shell and the bottom. Such defects might permanently impair the value of such a structure as a reservoir.

A circular reservoir 200 feet in diameter will, when filled with water, expand 0.96 inches, on the assumption that the steel in the shell is stressed to 12,000 pounds per square inch. This enlarging of the cylindrical shell, as it affects its connection to the bottom of the tank, can be taken care of in one of several ways, all of which are more or less unsatisfactory:

First. By rigidly connecting the bottom to the side and making the bottom a thin section not more than 6 inches thick and sufficiently reinforced with steel so that it can stretch this amount without producing cracks large enough to allow the water to escape.

Second. By the use of a water-tight expansion joint at the point where the bottom joins the shell.

Third. By preventing the expansion at the bottom of the shell.

The third method calls for heavy, massive construction, is correspondingly costly, and is not successful unless the lower portion of the tank is designed with the greatest of care. When this is done, the economy of this type of construction no longer obtains, as the stress in the circular reinforcement depends on the expansion of the shell, which, if prevented by a rigid connection at the bottom, will reduce the working tension in the circumferential bars directly proportional to the amount by which the expansion of the shell is prevented.

As all of the methods mentioned for overcoming the weakness at the connection of the bottom to the cylindrical shell, are more or less experimental in a large reservoir, the writer was opposed to this type of construction. The amount of circumferential steel reinforcement required in the circular type, also increases with the square of the diameter. Therefore, the economy in the cost of construction found in the smaller tanks, no longer obtains in the larger sizes.

Another type of construction for the side walls of large reinforced concrete tanks is the cantilever section. This type of construction is not, it is believed, adapted to tanks deeper than 15 feet. In a tank of this type there is always the possibility of hydrostatic pressure developing under the broad base, thereby endangering the stability of the structure.

A third method, and one which has been in general use, is that in which the side walls are supported by buttresses or counterforts. This method of supporting the wall sections is a very economic one for tanks of considerable size in which the depth exceeds 8 to 10 feet. A modified type of this construction, in which the deck is inclined and supported by buttresses, is a very economic one for tanks of greater depth and is the one adopted for the Agency Hill reservoir described in this paper. The latter type of construction is not adapted to rectangular tanks of considerable depths. In rectangular construction, the corners are very apt to give trouble. Here, the pressures are at right angles to each other, and with the resultant deflections which are appreciable at the top of the tank, also as right angles, it is almost impossible to prevent large cracks from forming at the corners. These cracks are apt to be of such magnitude as to render the structure of little value as a reservoir. This criticism does not hold good when circular or elliptical construction is resorted to.

Description.—The reservoir as built is circular in form, 200 feet in diameter on the inside, and 31 feet deep in the centre. The walls of the tank are supported by fifty buttresses, radially spaced. The deck is carried straight between the buttresses, thus the reservoir is not truly circular but a fifty-sided polygon. For a distance of 10 feet below the water level, the sides are carried down straight; below this point, the sides are inclined at an angle of 45°. The bottom of the reservoir is a segment of a sphere, with a maximum ordinate of 5 feet at the centre.

The shape adopted is one in which practically all of the available water is stored above the surface of the ground. Of the total storage, amounting to 6,000,000 gallons, only 580,000 gallons, or 9.7 per cent. of the total storage, is below the finished grade, and approximately 40 per cent. is stored in the upper 10 feet, thus making it a very effective pressure-equalizing reservoir.

Fig. 1 shows the stresses acting on a portion of the dam subtending an angle of 7° 12′ at the centre, all of which is supported by one buttress. In this figure are shown all of the forces acting on the section.

The horizontal component "P" of the water pressure acts radially outward and amounts to 244,880 lbs. Its line of action is 8.92 feet above the line a-b (Fig. 1). The total weight of the water—W′—resting on the inclined deck is 218,560 lbs. with its line of action 7.26 feet to the right of the line a-c. The prismoidal form of the body of water resting on the inclined deck makes the computations, both for the amount of these pressures and their locations, somewhat involved, and for this reason they are not reproduced in this paper.

The weight of the concrete section—W″—based on 145 lbs. per cubic foot of concrete, amounts to 191,000 lbs. Its centre of gravity is 14.6 feet from the line a-c.

As several intermediate factors enter into the computations necessary to determine the line of pressure in the buttress and the distribution of the foundation pressure over the footing course of each buttress, it was deemed best to compute the limiting values of these pressures under the following assumptions:

Case A.—Based on the assumption that each section must stand independent of its neighbor.

Case B.—Based on the assumption that the various sections are united into a monolithic structure and that all the forces resulting therefrom are taken into account to the full extent that they may be counted upon to develop in the structure.

Case A.—The point where the resultant pierces the base, e-f, under this assumption can be obtained by taking moments about the point "e," as follows:

$$P\ (= 244{,}880) \times (8.92 + 5.75 + 1.25) = 3{,}898{,}490$$
$$W'\ (= 218{,}560) \times 7.26 = 1{,}586{,}700$$
$$W''\ (= 191{,}000) \times 14.60 = 2{,}788{,}600$$
$$\Sigma M = 8{,}273{,}790$$

$$z = \frac{\Sigma M}{W' + W''} = \frac{8{,}273{,}790}{409{,}560} = 20.21$$

"z" is the distance from the line e-a to the point where the resultant pressure on the foundation pierces the base.

The total width of the base is 28.75 ft. Therefore, the line of pressure falls 1.13 ft. outside of the middle third, thus making it appear that there will be considerable uplift at the heel of the buttress. This, however, is not the case. The total supporting area amounts to 117.65 sq. ft. Under the assumptions of Case A, the maximum pressure at the toe would amount to 6,727 lbs. per square foot, and the minimum to 29 lbs. per square foot. There is no uplift whatever at the heel. If, instead of a spread footing, a rectangular-shaped footing of the same area were used, the maximum pressure in the footing would be 7,755 lbs. per square foot, and the minimum, a tension of 795 lbs. per square foot.

Case B.—The line of pressure determined under Case A will not be the true line of pressure in the complete structure. In the complete structure a number of forces are developed, all of which add to the stability. The effect of these on the stability of the structure will be taken up in detail.

Effect of Bottom Connection.—Prior to placing the concrete in the bottom of the reservoir, further study of the problem indicated a probable weakness in the design of allowing the 6-in. bottom slab to span the refilled excavation made necessary in building the cut-off wall between buttresses. The plans of the bottom, therefore, were revised as follows:

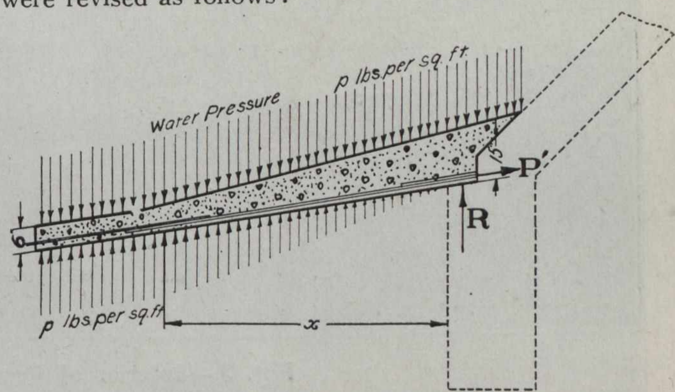

Fig. 2.—Connections at Base, Showing Acting Forces.

To strengthen the structure, the reinforced concrete bottom rests upon and is tied into the face slab by steel reinforcement. The concrete bottom is 6 inches thick and is reinforced wih ⅜-in. bars spaced 12-inch centres. Seven feet from the wall, the thickness of the concrete bottom was gradually increased from 6 ins. to a depth of 15 ins. directly over the supporting wall. The reinforcement in the bottom immediately adjacent to the wall consists of ⅜-in. square bars spaced 6 inches at the perimeter. The bottom is tied into the deck by half-inch bars, 5 feet long, spaced 12-inch centres.

Fig. 2 shows the connection of the bottom to the sides. In this figure are shown all of the forces that act on the section A, viz., the weight of the water resting on the bottom with an intensity of "p" pounds per square foot, the supporting pressure of the foundation increasing from zero at the support to a maximum of "p" pounds per square foot, "x" feet distant from the support; R, the reaction per lineal foot of the supporting wall, and P′, the pull per lineal foot exerted by the side walls. This construction would add appreciably to the stability of the buttresses in transferring the line of pressure nearer to the centre of the wall.

In Fig. 2 the distance "x" is limited by the strength of the bottom slab. Assuming a fibre stress of 20,000 pounds per square inch as the limiting stress that can be developed in the steel without permanently impairing the strength of the structure, we obtain a value of 6.28 ft. for x and a value of 3,400 pounds for R. The force T is developed in the ½-in. bars spaced 12-inch centres along the perimeter of the bottom and can reach 5,000 pounds per lineal foot without injury to the structure.

A new city engineer was appointed about this time, who was placed in actual charge of the construction. He was wholly out of sympathy with all the writer's plans.

The need of some additional reinforcement of the bottom at this weak point of connection was apparent when pointed out. As a substitute therefor, all the excavated material disturbed by the construction of the toe of the deck slab was removed and the space filled with plain concrete and the original thickness of the bottom maintained. This not only required more concrete, but it effectually destroyed the function of the drain laid at the foot of the wall to prevent hydrostatic pressure from developing under the structure. The opinion of the writer was not asked upon the wisdom of this change.

Effect of Continuity of Circumferential Reinforcement on the Stability of the Structure.—The circumferential reinforcement of the structure consists of sixty-five ¾-in. bars, eleven ½-in. bars, and six ⅜-in. bars, giving a total cross-section of 39.97 square inches. All of this reinforcement is lapped sufficiently at all connections so that the steel reinforcement of the shell can be considered to be practically continuous. As the shell expands under the internal pressure, this steel reinforcement is subjected to tension, thereby resisting directly a certain amount of internal pressure. The writer has every reason to believe that the diameter of the tank when filled with water will increase by ½ to 1 inch at the top. This expansion of the tank under pressure produces a stress of from 6,250 to 12,500 pounds per square inch in the circumferential steel reinforcement.

Assuming the average stress in the ring tension due to the circumferential reinforcement to be 6,000 pounds and to increase from 3,000 pounds at the bottom to 9,000 pounds at the top, the total outward pressure per lineal foot of tank thus resisted by the steel, amounts to 2,585 pounds. This is obtained from the formula,

$$T = pr$$

where T = ring tension = 6,000 × 39.97 = 239,820 lbs.
p = total hydrostatic pressure per lin. ft. of perimeter resisted by ring tension.
r = radius of tank, 92.75 ft. measured at the same height as the resultant line of action of the horizontal water pressure.

The height at which the force "p" acts can only be approximately determined. The centre of gravity of the steel reinforcement is 11.5 ft. above the line a-b and with the assumption as to the distribution of the pressure, the line of action of "p" is about 13.35 ft. above the line a-b.

In Fig. 1 are shown all of the forces acting on a portion of the dam, supported by one buttress, when this section is considered to form a part of the complete structure. The additional forces acting on the section, due to the rigid connections, are P′, R and P″.

P″ represents the radial tension that may be developed by the steel reinforcement connecting the bottom with the inclined deck. The value of P″ may reach 5,000 lbs. per lineal foot, or 52,900 lbs. per buttress, without injury to the structure.

R represents the reaction of the bottom on the supporting wall. This may also attain 3,400 lbs. per lineal foot or 35,900 lbs. per buttress.

The pressure—P′—under the assumptions made, amounts to a maximum of 2,585 lbs. per lineal foot of circumference, or 31,600 lbs. per buttress.

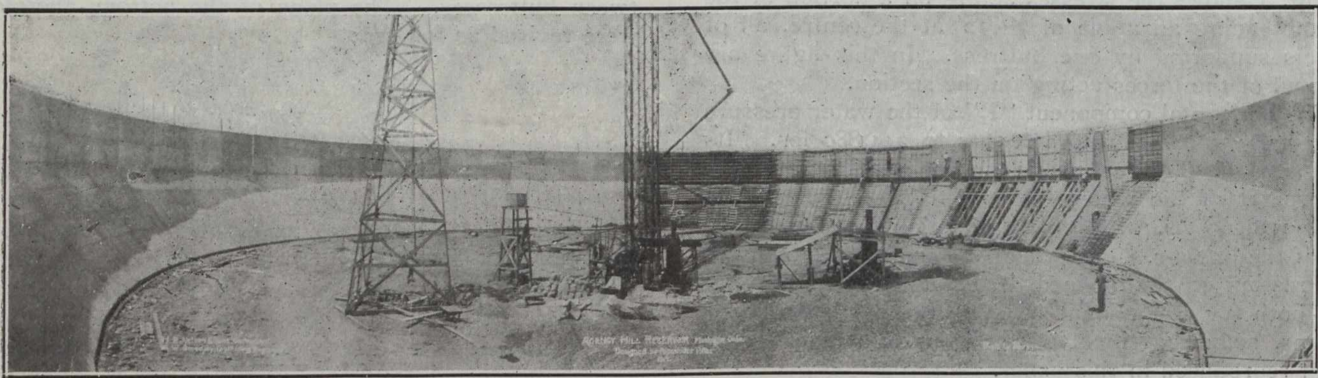

Fig. 3.—Interior of Reservoir During Construction.

Taking moments about the point "e" of all the forces acting on the section, under Case B we have:

P = 244,880 × 15.92	+ 3,898,490	
W′ = 218,560 × 7.26	+ 1,586,700	
W″ = 191,000 × 14.60	+ 2,788,600	
P′ = 31,600 × 20.35		— 643,060
P″ = 52,900 × 7.00		— 370,300
	+ 8,273,790	— 1,013,360
	— 1,013,360	

$$\Sigma M' = 7{,}260{,}430 \text{ ft. lbs.}$$
$$\Sigma V' = W' + W'' + R = 445{,}460$$
$$z = \frac{\Sigma M}{\Sigma V} = 16.31$$

Under Case B, the pressure line cuts the base 16.31 feet from the heel, well within the middle third. This gives a foundation pressure ranging from 4,962 to 2,544 pounds per square foot.

The foregoing computations show that the pressure at the toe of the buttress footing may range from 4,962 to 6,727 pounds, and the minimum pressure at the heel from 29 to 2,544 pounds. These pressures are conservative for the character of the foundation upon which the footings are placed.

The buttresses, which are radially spaced, are 15 inches in thickness. At the point where the inclined deck starts, there is considerable tension on the side of the buttress nearest the water. This tension is taken up by three ⅞-inch square bars at a unit stress in the steel of 9,000 lbs. per square inch, making full allowance for the weight of the section; ignoring this, the stress in the steel will be 15,000 lbs. per square inch. Two ⅞-inch square bars are carried up along the face of the incline of the buttress to take care of any possible tensile stresses, especially at the upper end of the incline where these stresses may be considerable.

The face of the buttress upon which the deck rests, is corbeled out to 30 inches. The corbel is reinforced by two ⅝-inch square bars tied together by ⅜ square ties spaced 12 inches centres. These ties serve both the purpose of reinforcing the corbel against cantilever action developed by the deck resting on the outer ends of the corbel and preventing the splitting of the buttresses.

When the structure was about half completed, the writer discovered an error that had crept into the plans which called for ⅜-inch square bars in the spread footings of the buttresses in place of ¾-inch square bars as required by the computations. The footings as constructed do not give, in the opinion of the writer, a sufficient factor of safety in adequately distributing the pressure over the area assumed in the design, and it was therefore deemed highly advisable to reinforce the spread footings.

The method suggested for reinforcing the footings required the cutting out of a section of each buttress already constructed, and placing upon the footing a reinforced concrete beam 3 feet wide on the base and about 27 inches deep under the buttress and 12 inches deep at its outer end. This beam was to be reinforced with six ¾-inch square bars.

To obtain a good bond between the old buttress and the new work, it was proposed to maintain a head on the semi-liquid concrete so as to force it into the buttress and to maintain this head until the new concrete had obtained its final set.

It is regrettable that the city officials failed to appreciate the importance of strengthening the footings, which could have been done at a nominal cost and would not have added more than one per cent. to the total cost of the structure. In thus refusing to comply with the plans, they have assumed all responsibility for the structure. Although it is strong enough as built to withstand all the pressures that may come upon it, there is always a possibility that one of the buttresses may settle sufficiently to impair the usefulness of the structure as a reservoir. The cost of repairing this defect may exceed many times the cost of reinforcing the footings in accordance with the plans. Had the suggestion been carried out, it would have effectively reinforced the spread footing so as to enable it to properly distribute the pressure over the foundation.

Construction of Deck.—The deck, with the exception of the top, is not tied into the face of the buttress by steel reinforcement. The vertical portion of the deck is 10 inches thick. The thickness of the inclined portion varies from 12 inches at the top to 15 inches at the bottom. The steel reinforcement is stressed to an average of 5,200 pounds per square inch in the vertical portion of the deck, and to 10,000 pounds in the lower or inclined portion. The deck of the reservoir is constructed as a monolith; no expansion joints are used. This type of construction throws additional tension upon slab reinforcement, especially in its upper portion. Provision has been made, in the design, for this additional stress by using a somewhat lower working tension in the slab reinforcement than is otherwise necessary. A widening of the diameter of the tank at the top, of as much as an inch, will increase the stress in the circumferential reinforcement to 17,200 lbs. per square inch.

Attention is called to the connection of the inclined to the straight portion of the deck. This joint, which is naturally a weak one, has also been made a construction joint. It has been strengthened by a 12-inch by 16-inch concrete beam reinforced with four ¾-inch square bars.

Hydrostatic Uplift.—In this article, no mention whatever has thus far been made of the possibility of hydrostatic pressure developing either under the concrete bottom or against the curtain wall, and thereby affecting the stability of the structure. This is guarded against by underdraining the spherical bottom with four and six-inch tile drains. Five 4-inch lines of drains are laid radially and drain to a sump at the centre of the reservoir. From this point a 6-inch drain is carried radially outward to a free outlet on the hillside. A circular line of 4-inch tile drain is laid entirely around the outer edge of the spherical bottom just above the footing of the 24-inch circular cutoff wall.

Fig. 4.—Nearing Completion, Exterior View.

With these provisions, it is almost impossible to conceive of hydrostatic pressure developing to an extent to make it necessary to take it into consideration in the stress analyses. Under the worst possible conditions, with all the underdrains clogged, the hydrostatic uplift is limited to the bottom of the reservoir and the footing of the 24-inch wall, and even then the effect of it on the stability of the structure is negligible.

Architectural Treatment.—The city bought the property immediately adjacent to the reservoir to convert it into a park. To improve the appearance of the structure, the buttresses are widened out to three feet at the back, and between them a concrete curtain wall, four inches thick, is carried up for a distance of four feet above the finished grade. Between the tops of the buttresses, concrete arches are sprung. Each arch has a rise of three feet and a clear span of three feet less than the distance between the buttresses. The recess thus formed is filled at a depth of 12 inches with a thin curtain wall of stucco placed on hy-rib. At intervals of 5 ft. 7 ins., the hy-rib is supported by reinforced concrete beams. A concrete walk, 2 ft. 8 ins. wide, extends entirely around the reservoir. On the outside of the walk, a concrete railing in conformity with the architectural treatment of the reservoir is built. The false construction just described gives the reservoir a pleasing appearance of massiveness.

A driveway, 33 ft. 6 ins. over all, extends entirely around the reservoir.

Piping and Drains.—The water enters the reservoir through a 24-inch line. The outlet is located at the centre of the reservoir and is of the same size. Circulation is maintained by two check valves, one in the inlet and the other in the outlet, so arranged that the direction of the flow in these pipes cannot be reversed.

The overflow is located 18 inches below the top of the tank. The overflow pipe is 10 inches in diameter. A 10-inch cast iron pipe with its inlet in the lowest part of the spherical bottom and its outlet on the hillside, drains the reservoir.

Monolithic Construction.—Some question may be raised as to the economy of constructing a reservoir of the size described without expansion joints. The principal advantage that can be gained by monolithic construction is a general increase in strength. In a large structure, this increase in strength is by no means as great as a casual inspection leads one to believe. It is obtained only at a sacrifice. The stresses in the deck, when built continuous, are no longer static determinate quantities, and their amounts cannot be ascertained with any degree of accuracy. The stresses developed in the deck acting as a beam are also increased a more or less indeterminate amount by the expansion of the shell under pressure. For these reasons, comparatively low unit stresses must be used in designing the deck. The gain in strength due to continuity of deck construction, practically decreases as the square of the diameter in a structure of the type described. The increase in strength due to continuity of deck construction in large tanks is therefore very small.

Watertightness of the Structure.—Under ordinary conditions, the writer is opposed to the use of waterproofing ingredients or waterproofing applications, as both add considerably to the cost of concrete work. It is far better to put the value of the waterproofing materials into the concrete work itself by adding more cement. In general, the use of waterproofing ingredients or application tends to poor construction work, the contractor counting upon the waterproofing to materially help out careless construction.

The only waterproofing called for in the specifications under which the reservoir was constructed, was two coats of neat cement wash to be applied with a whitewash brush on the inside of the basin. The second coat must be applied before the first one has had time to get very hard.

Before the final acceptance of the work, the contractor is called upon to render the structure watertight if leakage develops in the basin in excess of five gallons per minute. The reservoir has been filled for a number of months to within ten feet of the top, and the leakage, as measured at the outlet of the underdrains, at no time has exceeded half a gallon per minute. No leakage whatever is visible on the outside of the shell.

Horizontal construction joints are used freely. The unfinished surface of these was always left in as rough a condition as possible, but was never roughened up after the concrete had partially set. The writer's experience has been that this roughening often loosens the stones in the partially set concrete, but not sufficiently so that the loose stones can be removed by brushes, a condition which is apt to impair the watertightness of the structure.

To start a day's work, the old concrete surface was thoroughly cleaned with wire brushes and water, and a semi-liquid mortar mixed in the same proportions as the mortar in the concrete was poured over the old work to a depth of half an inch. This method has given good, watertight horizontal construction joints.

Vertical construction joints were permitted only over the buttresses as such joints are very difficult to make watertight.

Cost of the Structure.—The following is an approximate estimate of the materials required for the structure, together with the contract unit prices:—

7,271 cu. yds. excavation, including grading, @ $0.55	$ 3,999.05
100 cu. yds. rock excavation @ $1.70	1,700.00
965 cu. yds. 1:2:4 concrete masonry @ $9.00	8,685.00
1,739 cu. yds. 1:3:6 concrete masonry @ $7	12,173.00
3,400 bbls. cement @ $1.50	5,100.00
189,900 lbs. steel reinforcement @ $0.0425	8,070.75
650 lin. ft. parapet wall @ $1.40	910.00
196 lin. ft. 24-in. cast iron pipe @ $5.40	1,058.40
215 lin. ft. 10-in. cast iron pipe @ $2.00	430.00
110 lin. ft. 3-in. cast iron pipe, drain, @ $0.50	55.00
12,300 lbs. cast iron specials @ $0.05	615.00
Two 24-in. check valves @ $200.00	400.00
One 24-in. gate valve @ $240.00	240.00
One 10-in. gate valve @ $25.00	25.00
880 lin. ft. 4-in tile-drain @ $0.12	105.00
160 lin. ft. 6-in. tile-drain @ $0.20	32.00
90 lin. ft. 12-in. vitrified pipe @ $0.70	63.00
One strainer 24-in. outlet pipe @ $7.50	7.50
630 lin. ft. 1-in. pipe railing @ $0.40	252.00
500 lbs. wrought iron @ $0.05	25.00
20,300 sq. ft. of stucco on hy-rib @ $0.15	3,045.00
Total contract price	$46,991.30

The reservoir was built on the summit of a hill about a mile from the nearest railroad station. All water used for concreting had to be carted up the hill, a distance of about a mile.

The final estimate exceeded the bid price by a very small percentage. The contractor's profit on the work approximated twenty per cent., indicating a reasonably economic reservoir, yet one which presents a very attractive appearance.

THE PENETRATION METHOD IN MACADAM ROAD CONSTRUCTION

By W. W. Crosby, C.E.,
Chief Engineer to the Maryland Geological Survey.

In last issue of *The Canadian Engineer* a paper by Prof. A. H. Blanchard, dealing with the progress that has been made in America during the past three years, in bituminous paving by the mixing method was given. In connection with it, should appear a paper by Major W. W. Crosby, consulting engineer, Baltimore, Md., on the essential points of modern practice in America in the construction in open country of macadamized roads, bound with tarry, bituminous, or asphaltic materials, by the penetration or grouting method. The following is a crystalization of Major Crosby's paper, as read at the Third International Roads Congress in London:

Foundation and Drainage.—The necessity for firmer and stronger foundations, and, to this end, for the best possible sub-drainage, seems to be fairly widely and generally accepted, especially by those whose vision into the future is keen enough to permit them to recognize the probable increase in the demands on the foundations, to be brought about by better surfaces and by the consequent growth in both the amount and weight of traffic as well as in its severity. This necessity is even more apparent when the penetration method of constructing the crust is used because of the fact that such a crust appears to have frequently less inherent rigidity than many built by the mixing method.

Sizes and Shapes of Broken Stone for Bituminous Bound Surface Crusts.—While the mixing method may require a combination of different sizes of broken stone for the best results, with the penetration or grouting method under discussion, this is not the case. The unscreened product of a crusher is often used quite satisfactorily for the bottom course of the crust, though this course is frequently just as satisfactorily built of the coarser portions of this product. The choice depends on local conditions. It is considered inadvisable, however, to allow any particles over 3 ins. in length in this course.

In the second or wearing course, it is the best practice to pay considerably more attention to the screening and sizing of the stone particles. Very good results have been obtained by the use for the second course of cleanly screened stone passing a 1¾-in. round opening and not able to pass a ¾-in. Apparently better results have been secured by the use of pieces passing a 2-in. and retained on a 1-in. screen, and very good results seem to have been secured, where the pieces were most cubical, by the use of stone passing a 3-in., and retained on a 2-in. screen. More uniformity of grouting, together with longer wear, seems to be secured by the use of the larger sizes, and, further, a surface built of the larger sizes seems better able to withstand without damage the crushing strains of the heaviest loads carried on hard tires.

It has not been the best practice to permit too great a difference between the sizes of the screens used for separating the material for this course, about 1 in. being the customary difference in diameters of holes and 1½ ins., the maximum. A great difference seems to contribute toward lack in that much to be desired uniformity of grouting and this is especially noticeable in stone breaking into scaly pieces.

The writer believes that with a fairly cubical broken stone the best results have been obtained by the use of screens 2½ ins. and 1½ ins. in diameter of openings and that in the case of shaley rock 2 ins. and 1 in. have given the best results.

Reference has been made to "cubical" and "scaly" or "shaley" stone. There is general agreement that stones breaking cubically, without glassy fracture—that is, with fairly rough surfaces—and with sharp angles are most desirable.

The Use of Partially Worn Materials in Bituminous Bound Surface Crusts.—From the foregoing it will be seen that partially worn materials are usable for the bottom course of the crust, and they are frequently so used. Experience shows that such use should be accompanied by proper regard for the segregation, by harrowing or screening, of the fine material and detritus generally present with the coarser sizes. But the use of even the carefully separated coarser sizes of the old worn material is not generally permitted for the upper course of the crust as it is considered dangerous to successful results.

Thickness and Composition of the Strength Crust and of the Super or Wearing Crust Under Different Conditions.—So much depends on the particular conditions of the individual case that a general statement on this point is, with difficulty, made of any value. In addition to what has already been stated regarding sizes and shapes of the pieces of stone, it may be further said that the bottom course varies from a minimum thickness of perhaps 2 ins. to a maximum of 8 ins., measured after compaction. The average is probably from 4 to 5 ins.

This course is built both with and without the addition or presence of fine material (passing a ¾-in. or ½-in. screen) as local conditions seem to determine though it seems that the proper use of a moderate amount of the smaller material generally produces a firmer and stronger first course.

Occasionally the completed bottom course has been given a coat of pitch before spreading the upper course stone, but ordinarily this use of the pitch is not followed, nor does it generally seem to be considered necessary to endeavor to secure any penetration of the pitch to the bottom course through the upper course stones.

The super or wearing course, it may be said, is generally from 2 to 3 ins. in thickness after rolling. For the proper penetration and adherence of the bituminous material or pitch of whatever nature, it is now generally agreed that the particles of stone must be clean and free from coats of stone-flour, dirt or dust. Apparently a general preference exists that they should also be dry but there is still much discussion on this latter point, and it is by no means determined what lack of dryness can be permitted without detriment to the results. A very few have even advocated the presence of a certain amount of moisture on the stone before the application of the pitch, but the writer prefers a dry condition, though he agrees that, in most cases, a moderate amount of moisture is not as objectionable as dirtiness or dustiness.

Another most important factor affecting both the courses of a bituminous as well as of a water-bound road crust is the sufficiency of the rolling given them. So generally is it now accepted that with water-bound macadam the utmost possible compaction and interlocking of the stone by rolling is necessary for first-class results, that the truth of the saying that "Rolling is the life of the road" is everywhere recognized. With bituminous macadam built by the penetration method, the concordance on this point seems to be as yet less complete. Some road-builders actually insist on a minimum of rolling before the application of the pitch and others do not require a maximum. With the writer's work, however, there is no question but that the quality of the results has been in direct proportion to the amount of compaction or interlocking secured by proper rolling, and it is his opinion that results generally show the proper rolling of the stone before the application of the pitch is of the greatest importance.

Relative Advantages and Use of Tar, Tarry Compounds, Asphalt, Bitumen and Other Materials.—The proper selection of the bituminous material or pitch for use under the penetration or under any method is a most serious one and is influenced by many conditions other than method of use. Such, like price, soil, weather and traffic conditions, desires of users of, and abuttors on the road, the conditions likely to prevail regarding after-maintenance and cleaning, etc., etc., are largely local, and are probably not germane to the discussion in this paper.

Confining the statements to the above subjects and considering only the penetration method of use, it may be said:

The use of unrefined tars has been found unsatisfactory and has been practically abandoned. The extent and character of the refining seems to depend largely on the peculiar conditions to be expected in any case of the use of the material, but some points in this connection are still unsettled. It seems generally agreed that the presence in the tar of more than a minimum of water or ammoniacal liquor renders it undesirable for this method of use; that certain amounts of "light oils" are necessary for giving to the pitch the desired fluidity in handling; that a generous proportion of "middle" and "heavy" oils —especially the latter—is demanded in order that the tar may retain the longest possible "life" or elasticity after use and under the ageing or weathering effects of weather and traffic as well as for giving the "body" to the pitch demanded by this method; and that a limited amount of "free carbon" may be advisable in order to help to give body to the tar and to assist in reducing its susceptibility to changes in temperature. This "free carbon" (matter insoluble in carbon bisulphide) may be either the natural fraction of the tar or it may be added foreign material such as Portland cement or finely powdered limestone. Some crusts built by the penetration method with a low carbon tar have seemed to improve as fine material was supplied by traffic.

At first an opinion existed widely that the value of a tar for road work was in inverse proportion to its percentage of "free carbon" content, but the writer was loath to accept this view because of his knowledge of the proved great value of certain tars in which this fraction was unusually high. Results of practice with the penetration method to date seem to indicate that it is not the simple proportion of the "free carbon" fraction to the whole tar which was of use as a criterion in passing on the value of the tar for the penetration method but rather the ratio between the "free carbon" fraction and one or more other fractions (the heavier oils) on which depends the worth of the whole tar.

The use by the penetration method of tars with a "free carbon" content of less than 2 per cent. has resulted in an objectionable susceptibility of the road surface to summer heats, while the use of tars whose "free carbon" fraction was greater than the percentage of the heavier oils in the same tar has shown a too great hardness or friability under extreme cold.

In the use under the penetration method of the native asphaltic materials and of the oil residuums, a certain amount of "light oil" seems desirable for the sake of fluidity, and a limited amount of "middle" and "heavy" oil fractions for the sake of "life" and elasticity. The "pitch" fraction, being the base in those cases, must possess the desired characteristics of adhesiveness, cohesiveness, lack of brittleness and resilience. The proper proportions of the lighter fractions depend on the characteristics, in those particulars at least, of the "pitch" as well as upon the conditions of traffic, etc.

Early practice under the penetration method condemned the use of "cut back" products,—i.e., those artificially prepared by the addition of oils to previously reduced pitches—probably because in many cases such pitches had not been carefully prepared with this end in view but were by-products or wastes from processes arranged for the production from the raw material of the portions other than the pitch.

The writer believed that not only was it possible to make satisfactory road compounds for use under this method from a pitch by cutting it back with lighter materials, but also that it was quite possible that, in many cases, a far more satisfactory product could thus be obtained than by simple reduction, to the desired consistency, from the raw material.

Subsequent experience has seemed to confirm this theory and some of the most satisfactory results under the penetration method have been secured by the use of pitches compounded by adding the necessary oils to a previously and purposely prepared, fairly hard, asphaltic pitch.

In such cases, the harder pitch possessed all the usual qualities of a good asphaltic paving pitch and the flux, those of a proper flux for making asphaltic cement, except that perhaps more volatile oils were included to permit of easier and better use under the peculiarities of the penetration method. Experience seems to have proved that there is a limit to the amount of "greatness" that can safely be permitted in the flux so—as above—used and that an excess of this characteristic may ruin the results under this method by permitting, if not encouraging, the internal motion between the coarse particles of the crust, especially in the usual case of a deficiency of the smaller sizes.

In the use of the materials referred to, so much depends on the peculiarities of the local demands that brief general statements are again somewhat difficult. A few such may, however, be justified. For instance, experience has seemed to prove that in the use of tars or tar-compounds under the penetration method, better results have been secured where the softer materials have been used provided such softness was not secured by an excessive proportion of volatile or light oils. This seems especially true when considering the tendency of certain pitches to produce surfaces slippery in wet or cold weather.

As regards asphaltic materials (including oil residuum) it seems that in many cases where softness has been given by a generous amount of the middle oils (non-volatile) the resulting surfaces under this method have shifted under traffic in warm weather and evidenced "lubricating" rather than the necessary "binding" characteristics of the pitch compound.

Regarding the quantity of pitch to be used under the penetration method while the character of the wearing course (as to sizes, kind, etc., of the material) will affect the decision, it may be stated that ordinarily the successful amount of bituminous material per square yard of surface seems to have been between 1½ and 2 gals. The writer has built entirely satisfactory work with as low as 1¼ gals. per square yard, but under exceptional conditions. He has also seen instances where as high as 4½ gals. per square yard of tar was used, but with little dissatisfaction with the resulting surface. In fact, the main objection that appeared in those latter cases came from some bleeding of the pitch over the road surface during the first summer after construction, and this was readily obviated by one or two additional coatings of stone chips.

It has been suggested that an excess of pitch in the crust, provided it is located well down in the latter, may be of some decided advantage in that it may furnish a reservoir from which additional life will be given to that pitch exposed on the surface to deterioration by traffic and weather. However, penetration of the pitch to the bottom of the larger sized stone in the surface seems ordinarily to be sufficient for success.

Practice has varied in the application of the pitch under the penetration method, some applying the bulk (say, ¾ of the total amount) at first and then, after spreading a coating of chips and rolling, applying the balance with another coat of chips and more rolling. Others apply all the pitch at once. The writer concludes from his observations and experience that the latter way generally gives more satisfactory results.

With the mixing method, where the quantity of pitch may be reduced to a minimum, certain conditions may render advisable a "flush coat" of pitch and chips. But "in open country" where even slight dustiness may not be objectionable and where slipperiness may be decidedly offensive, the omission of the flush coat is generally, under the penetration method, better because of the longer freedom from unnecessary smoothness. And the writer has not found that the omission of the flush coat has, where the road crust was properly built by this method, rendered the crust visibly more susceptible to the destructive effects of either horse-drawn vehicular or motor traffic.

It seems generally admitted that with the penetration method the use of a "flush coat" is mainly for "insurance," i.e., to overcome or make good any defects from previous poor workmanship or inequalities in the earlier processes.

Uniformity of grouting has been referred to as desirable, and is now generally so recognized. Toward this end as well as for the sake of economy, efforts have been made to supplant the early system of hand-pouring by some mechanical distribution of the pitch. Some very successful machines have been devised for the purpose and it seems generally agreed that the best results under the penetration method are secured by the use of such appliances distributing the pitch under pressure of from 20 to 70 lbs. per square inch.

Cost Data.—The usual variations in cost, resulting from different local conditions, have been omnipresent with the penetration as with any other method. However, it may be stated that with labor at 15 cents, single horse carts at 27½ cents, two-horse carts or wagons at 50 cents, foremen at 30 cents, per hour, stone at $1.75 ton delivered on the work, and pitch at from 7 cents to 10 cents per gallon delivered at a railway station within one mile of the work, the cost for building by the penetration method a pitch-bound macadam using from 1¼ to 2¼ gals. of pitch per square yard averages between 15 cents and 25 cents per square yard over and above the cost of building water-bound macadam under the same conditions. A decrease in this cost has quite steadily occurred and it seems may be looked for further as proficiency in practice and as mechanical appliances for the work are developed.

BUREAU OF MINES' BULLETIN ON EXPLOSIVES

"The Analysis of Black Powder and Dynamite" is the title of Bulletin No. 51 recently issued by the United States Bureau of Mines.

This bulletin outlines the methods of analysis that are used by the Bureau of Mines in the examination of certain classes of explosives. The present form of most of these methods has been worked out in the Bureau's explosives laboratory. The methods employed by Pro. C. E. Munroe were taken as a basis, and were elaborated to meet the demands incident to the treatment of complicated mixtures and to the development of the explosives art. A subsequent bulletin will discuss the methods of analysis of "permissible" explosives, many of the latter being of decidedly complicated character and requiring special treatment. This bulletin presents the methods of analysis of "Ordinary" dynamite, and the ammonia, gelatin, low-freezing, and granular dynamites, and the common grades of black gunpowder and black blasting powder. The bulletin is published by the Bureau for the information of all persons interested in explosives and their safe and efficient use in mining work.

As the term "ordinary" dynamite, though much used, has no conventional meaning, and may be used to cover a wide variety of compositions of matter, it may be noted that the standard dynamite used at the Pittsburgh testing station is a good example of the "ordinary" dynamite known in this country. This testing station dynamite has the following composition:—

Composition of Pittsburgh Testing Station Dynamite.

	Per cent.
Nitroglycerin	40
Sodium nitrate	44
Wood pulp	15
Calcium carbonate	1

As most permissible explosives contain only the constituents found generally in the various types of ordinary dynamite, the chemist will usually find it possible to analyze such explosives either wholly or partly by following the general methods of analysis here given for the type of explosive that seems most closely related to the one under examination. The methods of extraction with ether, with water, etc., outlined in the bulletin are general methods which are applied with equal success to all classes of explosives, and therefore by the use of these general methods, following a thorough qualitative examination, little difficulty should be met except with those classes of permissible explosives that contain large amounts of salts holding water of crystallization, such as alum and magnesium sulphate, or those containing an unusual number of uncommon constituents. Even with such explosives, however, if the information desired is principally in regard to the percentages of explosive ingredients (nitroglycerin, ammonium, nitrate, etc.), the methods outlined in this bulletin may be satisfactorily followed.

The Third International Congress of Refrigeration is to be held at Chicago in September next. It will be divided into six sections, dealing with: (a) Liquified gas and units; (b) the design, construction, operation, and method of testing refrigerating machinery and insulating materials; (c) the application of refrigeration to foods; (d) the use of refrigerating apparatus in the industrial arts; (e) refrigeration in railway and steamship transportation; (f) questions relating to legislation and administration. The secretary-general is Mr. J. F. Nickerson, 431 South Dearborn Street, Chicago. The first Congress was held in Paris in 1908, and the second in Vienna in 1910.

THIRD INTERNATIONAL ROAD CONGRESS, LONDON.

On the 23rd of June, at the invitation of the British Government, and under the patronage of His Majesty King George V., in Central Wesleyan Hall, Westminster, was convened the Third International Road Congress for the deliberation and discussion of matters relating to the world-wide movement for road reform.

That the movement is world-wide is shown by the fact that some 39 countries were officially represented and in all about 3,000 delegates attended. Canada was ably represented by Mr. W. A. McLean, engineer of highways for Ontario; H. S. Carpenter, superintendent of highways for Saskatchewan; W. G. Tretheway, of the York County Highway Commission, and others.*

That the meetings weie destined to be eminently successful was evinced by the large number of men, of high rank in public affairs in their respective countries, who had assembled to give their experience in matters so vital to the interests of the community—the improvement of highways.

The opening meeting was presided over by the Right Hon. the Chancellor of the Exchequer D. Lloyd-George, who expressed his deep interest in and the sympathy of the government with the objects of the congress. For some years past there has been in Europe a distinct movement in road reform. This movement found expression in the formation in Paris in 1908 of the Permanent International Association of Road Congresses. At that meeting some 400 men, eminent in professional, scientific and administrative work, chiefly from France, Germany and Great Britain, assembled to discuss matters relating to the movement. This was followed by the Brussels Congress in 1910, at which about 1,000 delegates attended, and the impetus, largely given by the association, is shown in the extraordinary attendance at this, the third congress.

Since the second congress concluded its labors in Brussels the movement in favor of road reform has made immense strides, and the past three years have been a period of constant activity and improvement. The problem of treating roads with bituminous materials has been advanced from the experimental to the practical stage, and has now attained an assured position. Experience has proved that roads can be built of bituminous material which are not only practically dustless but are also capable of carrying the heaviest ordinary traffic.

The manner in which the programme was arranged and carried out in every detail reflects great credit upon the Organizing Committee and the chairman, Sir George S. Gibb. In dealing with a matter of such wide scope, very thorough and systematic arrangement becomes essential and the plan adopted in this instance was as follows:

The papers that were to be submitted were sent in some months previous to the meeting. These were placed in the hands of sub-sectional committees for criticism. The sub-committee reported on the salient features and added recommendations or resolutions. Thus, every paper came before the congress in a predigested form and the resolutions only were discussed. A glance at the following list of subjects of the programme will give some idea of the scope and import of the deliberations of the congress, and when it is considered that many papers were submitted in each case, an estimate can be made of the volume of pre-convention work performed by the committee.

The programme comprised the following:

1. Planning of Streets and Roads.
2. Types of Surfacing to be Adopted on Bridges, Viaducts, Etc.
3. Construction of Macadamized Roads Bound With Tarry, Bituminous or Asphaltic Materials.
4. Wood Paving.
5. Lighting of Public Highways and Vehicles.
6. Observations Noted Since 1908 as to the Various Causes of Wear and of Deterioration of Roadways.
7. Regulations for Fast and Slow Traffic on Roads.
8. Authorities in Charge of the Construction and Maintenance of Roads, Functions of Central Authorities and Local Authorities.
9. Finance of the Construction and Upkeep of Roads.

The exhibition connected with the congress was most interesting and instructive, especially the exhibit of the Road Board, in which many types of construction were shown by portions that had been taken from actual roads, a full description being given in each case. There was also an excellent display of materials, machinery and appliances.

The arrangements for road excursions were fully satisfactory. The writer had the opportunity of going over the Berkshire roads in company with the chief surveyor, and we found them in excellent condition, combining in a high degree all the essential qualities of a good road. The district is almost entirely agricultural, and the roads are subjected both to heavy traffic and that of fast-moving motor-driven vehicles, and meet all the requirements admirably well. There appears to be no reason why we, in the older parts of Canada at least, should not have roads that would meet our conditions as well as these do the conditions that obtain in England. One was most favorably impressed with the manner in which all points were discussed and the manifestly good spirit which prevailed throughout the entire congress. Men of high attainments and character unselfishly gave the best of their services in the promotion of one object, that of making the world a little better for having lived in it.

The impetus given to the movement will be difficult to measure, but one can feel assured that those from Canada will return fired with new zeal for the promotion of that upon which so much of our future depends—highway improvement.

A. T. LAING.

London, June 28th, 1913.

*[The University of Toronto was represented by the writer of this article and by Professors J. McGowan and P. Gillespie.—Ed.]

Some practical rules laid down by the American Foundrymen's Association for obtaining castings resistant to corrosion are as follows: (1) Use white iron if possible. (White irons are especially useful where any acidity is to be encountered.) (2) If not practicable to use white-iron castings, chill those surfaces which are to be in contact with corrosive conditions. (3) If grey iron must be used, get dense, close-grained castings through the use of steel scrap or otherwise. (4) Avoid oxidized metal; use pigirons of good quality, together with good cupola practice. If possible, use deoxidizing agents; for example, titanium or vanadium. (5) Keep the sulphur as low as possible.

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CONTENTS OF THIS ISSUE.

THE INTER-ATTRITION THEORY OF ROAD WEAR.

At no time in its history has road building received such attention as the road associations are devoting to it this season. Certainly many discussions, long pending, should be settled and many points scientifically gained as a result. Highway construction and maintenance has sufficient technical knowledge now connected with it to prevent further profuse expenditure upon methods not the most suitable.

A theory gaining ground among road engineers in England, and which has to do with the wear of roads, attributes the chief destructive tendencies to an internal movement among the stones at some depth below the surface, producing an abrasion which results in a gradual rounding off of angles and corners and impairs their interlocking and resisting power. According to a Times' correspondent, the dustlessness of roads, especially if they are made with tarred material, and not merely tar painted on the surface, arises in a comparatively small degree from the fact that the surface is protected from wear. The real saving lies in the fact that between the stones, which are packed together in close association below the surface crust, there is little or no wear, owing to the oily nature of tar or bitumen as a binder, which prevents the faces of the broken stones from actually grinding against each other under rolling weights. The surface wear of an ordinary non-tarred road is, except in cases of heavy continuous traffic, a comparatively negligible factor, and it is undoubtedly heavy weights which are the chief cause of road wear seen above and unseen below the road crust. It thus comes about that the heavy traction engine, even though its tires may be broad and the diameter of its wheels large, from its mere weightiness, apart from any question of speed, causes irresistable crushing of the road surface and the inter-attrition of the stones beneath it. This produces more dust and more mud than the passage of thousands of smaller vehicles even though they may travel at a rapid speed; for light vehicles affect only the part of the road near the surface.

Ordinary tar-macadam or tarred slag, where slag from blast furnaces is used instead of stone, laid in a layer several inches and afterwards rolled, forms a homogeneous foundation for the surface crust, in which the stone probably forms about 75 per cent. of the total volume, and the combined material—that is, small, broken stone and tar, or some compound of it—forms the remaining 25 per cent. of it. When this is rolled together the inter-attrition of the stones is reduced to a minimum, for every angle of every stone is bound together firmly or is coated with an oily surface. The beneficial result extends far beneath the surface of the road itself; so that when these stones move, if they ever do, under the influence of heavy traffic, all that happens is that a certain proportion of superfluous tar or bitumen may be forced to the surface, and ordinary mud, such as is produced by the grinding together of two plain surfaces, does not appear.

Other forms of bituminous binding that meet this intersticial wear, and confine it largely to the upper surface of the road, include several patented surfacing preparations, to be applied to ordinary water-bound macadam road. Tar grouting, where the tar or bituminous mixture is poured upon freshly laid dry macadam immediately after laying and rolling, or a modification of it using standardized pitch, or a further modification, in which a layer of a fine mixture of tar and concrete is laid, and upon which dry macadam is spread and rolled, are among the processes that are meeting with fair success.

At any rate, the advisability appears now to be practically demonstrated of laying down roads with bituminous material for a depth of several inches, rather than merely painting the surfaces with tar, and leaving the untarred stones underneath to grind against one another, inevitably producing mud and dust.

ENGINEERS AND LITERATURE.

The study of literature in connection with an engineering course is frequently quoted as being decidedly out of place. The fact remains that many young engineering graduates find the writing of intelligent, comprehensive reports upon the work which is in their charge to be one of the hardest problems with which they have to contend, likewise the most disliked and generally the least satisfactorily fulfilled of all their duties. The failing has often been attributed to engineers in general, until one is forced to admit that it is something with which the matter of training has to do and, therefore, which reflects upon the engineering course.

Against the contention that the study of literature is beyond the horizon of the engineering school are the opinions of a great majority of the older followers of the profession—men whose rank and affluence followed the cultivation of a breadth of reading, the necessity of which they recognized in their early problems. The subsequent study of literature brought them into the possession of a better working knowledge of engineering English, which soon reflected itself in what literary work their profession required of them.

To the engineer of to-day it does more. A study of literature means a study of men, of human character, of selection and adaptation, and ability to deal with men. A study of the writings of others enables him to write, furnishes him with more than a meagre share of a knowledge and appreciation of the best in literature, and enables him to converse, with intelligence and equality, with other cultured men in his and other professions. It broadens his scope of society and business, it means recreation, relaxation and inspiration to him. Finally, the most potent thinkers of the world are, one and all, students of literature. A study, then, that has so much to do with the establishment of a man's standing among his fellow-men, should have prominence in any educational course, and to few courses does it apply more materially than to the engineering course.

EDITORIAL COMMENT.

The American Waterworks Association, at its thirty-third convention, held recently in Minneapolis, announced a membership exceeding 1,000. A new constitution was adopted, its chief feature being provision for the establishment of local sections throughout the country. The convention in 1914 will be held in Philadelphia.

* * * *

The first official statement of the new manager of railways for the Dominion Government discloses the intention of creating a 6/10 grade on the Intercolonial, from Montreal to Halifax and Sydney. The change will be affected at the rate of about 100 miles per year, short lengths of the line having to be entirely rebuilt. This remedying of grades, which are in some instances excessively heavy, will greatly increase the effective hauling power of the I.C.R. locomotives.

Mr. Gutelius further announces the intention to double-track the Intercolonial. A section some thirteen miles in length, between Levis and Chaudiere will be completed this season, and other sections will follow. At present the line from Moncton to Pansac Junction and from Halifax to Windsor Junction is under double track.

* * * *

The world's greatest drydock, to provide accommodation at Levis, Que., for the largest ocean liners, is about to be constructed as the first of a series of drydocks and ship repair plants under contemplation by the Department of Public Works. Others will be located at Esquimalt and Vancouver on the Pacific and Sydney, St. John or Halifax on the Atlantic. The contract has just been awarded for the Levis drydock, the cost to approximate $2,600,000, construction to be commenced at once, and to be ready for use in 1915.

LETTERS TO THE EDITOR.

The Road Congress.

Sir,—The International Road Congress held last week in old London was about as cosmopolitan a gathering as one could hope to see anywhere. There were forty countries or states officially represented, and the list of delegates included the best, socially and professionally, that those countries could furnish. His Majesty the King was Patron. The list of honorary presidents included five of his Majesty's ministers. The presidents of six leading engineering societies of Great Britain were among the the vice-presidents, and served, with others, on the organizing committee. It may be of interest to remark that Germany and France were officially represented by the two largest delegations—men, in the main, whose official positions and scientific attainments would lend distinction to any gathering. The proceedings were carried on simultaneously in four different halls adjacent to Parliament and Great George Streets, within a stone's throw of the House of Commons and Westminster Abbey, and in a neighborhood rich in historic associations. The sectional meetings were conducted mainly in English. The remarks of those who contributed to the discussion were invariably abstracted and translated by interpreters for the benefit of those who understood only one language. Generally, the arrangements were satisfactory, and the few disappointments that did occur were usually due to contingencies very difficult to foresee and still more difficult to provide for.

An instructive exhibition of materials and appliances was in progress during the week. This included machinery for the preparation of materials and the construction of roads, proprietary, and other articles and samples of types of highway construction taken from actual roads. Each booth had its demonstrator, usually in frock coat and silk hat, who was gracious and courteous, but not offensively aggressive; who was tolerant of competitors, and who gave one the impression that he understated rather than overstated the merits of his goods. For the Britisher is thorough if he is anything, and depends on the excellence of his article first, and the fairness of his business methods second, to create a market for his products.

Of the actual road sections exhibited, probably none were of greater interest than those supplied by Mr. J. A. Brodie, city engineer of Liverpool. These had been cut from the streets of that city and some of them had seen many years of service. One of these, I recall, consisted of six-inch Welsh granite setts above a six-inch concrete base, the two being separated by two inches of sand filler. The joints between adjacent setts appeared to be filled with grout. This road, subjected to constant heavy traffic, had stood for 41 years and appeared to be still in good condition. Another, of somewhat similar type, except that the binder between the individual setts was asphaltic instead of grout, had stood quite well under what was reported as medium traffic since 1883. Other samples gave evidence of remarkable wear in treated wooden blocks. One section consisted of creosoted dial blocks on an 8-inch concrete base. The blocks appeared to have been originally separated from each other in rows by tiny horizontal wooden strips. This road was in fair condition and had been in service since 1893. But the most ancient of all was the Roman road, discovered in 1897 at Rochester. The construction was substantial beyond doubt, since below the seven-inch paved roadway were: gravel, 9 inches; small flints, 7 inches; chalk, 5 inches, and large flints, 42 inches. Below this, finally, were timber caps and piles, the highway having doubtless been constructed across a marsh. The aggregate depth, exclusive of the timber, was 70 inches. John Bull has undoubtedly some substantial prototypes for his guidance when he turns his attention to the building of highways.

Finally, let me point out, the International Road Congress affords to the observer, mainly by contrast, a view of some of the anomalies of present-day civilization. Mr. John Burns, presiding at the final banquet of the Congress, held at the Hotel Cecil, on Saturday evening, June 28th, in moving the toast to the "International Road Congress," asserted that to the modern road was due the wonderful diminution of infantile mortality and infantile diseases, and that the lack of roads and communications had led to estrangement, hostility and misunderstanding between nations. This great International Congress, composed of representatives of the sober thought of fifty nations, goes somewhat farther and shows how the constructive arts afford a common meeting ground, prevent misunderstanding and promote good-fellowship and international good-will. But this all happens in a week when the Imperial Chancellor of Germany is asking his Reichstag for six new cavalry regiments "for the protection and security of the Fatherland," when the French populace are being forced into universal military service, and when in England the First Lord of the Admiralty has announced that because of the action of the Canadian Senate in rejecting the naval bill, the construction of three dreadnoughts will be accelerated. It is interesting to observe that he too makes use of that hoary fiction, "the safety, not of our trade, but of our lives." Meanwhile, the innocent citizen is perplexed to understand whose concealed hand is working the puppets. That the better spirit of the land is in some degree becoming disgusted with the whole sordid business is evidenced by an incident that happened at Sheffield during the week. A large number of the Roads Congress delegates were the guests of the Hadfield Steel Manufacturing Company at that city on the occasion referred to, and had been given an actual demonstration of the power of the modern projectile in penetrating armor plate. Sir Robert Hadfield, head of the great firm, in addressing the gathering, remarked significantly on its cosmopolitan character, and hoped that when the Congress again met in England his firm would not be engaged in this kind of work. The anomaly of our present civilization is that while efforts looking toward the betterment of the race, its health, its comfort, its education and its happiness, were never more active than they are to-day, the perfection of engines for its destruction was never so complete.

PETER GILLESPIE.

London, July 3rd, 1913.

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Long Distance Measuring With a Stadia.

Sir,—In traversing with a stadia it may seem incredible to some that distances of 3,000 to 4,000 feet are reported to be read or measured. Where precise measurement is required this is not possible at a single setting, but when fairly close approximations are sufficient, such long traverse sights are not infrequently taken. The method used may be of interest.

In these cases only half the wire interval is employed, that is, a 13-foot rod may be read over a distance of 2,600 feet. In some transits the two half wire intervals are not precisely the same, and in cases where the wires are attached, it is impossible to properly adjust them for this work unless they are sent to a repair shop for alteration.

In reading half the wire interval the centre wire is focused on the top of the rod, and the lower wire is marked on the rod with a target, at, for example, ten feet from the top, corresponding here to a distance of 2,000 feet. In such long distances it will, of course, be impossible to read the rod directly, and one must depend upon the rodman for its measurements. A target can easily be seen through the transit from a distance of 2,000 or 3,000 feet.

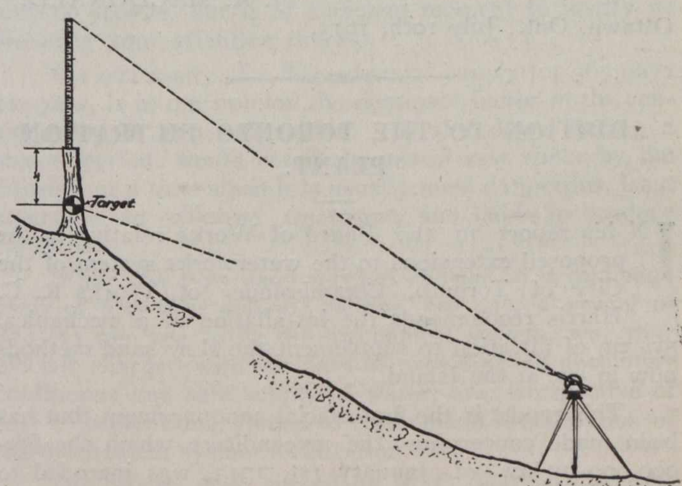

Fig. 1.—Showing Method for Use in Sights of Unusual Length.

The writer has taken many sights of this length in traversing lakes, no effort being made to read the rod, the position of the target only being viewed with the lower wire. As stated, the middle wire was focused upon the upper end of the rod and the reading was made downwards. Thus the target makes it much easier for the transit man, although its use is not required for shorter distances of, say, 500 to 600 feet.

The average 13-foot rod will read up to 2,600 feet in this way. When longer sights are required the accompanying illustration shows a convenient method to pursue.

The rod is held on the top of a tree stump as shown. It is sometimes necessary to cut a tree for the purpose of securing a stump of sufficient length when longer distances are in use; for example, 3,500 feet or upwards. With the rod in this position the target, whatever it may be—a field book or a page of white paper—is read on some part of the stump. By this means the writer has taken sights of 4,000 feet on several occasions when absolutely necessary, as in the case of an intervening lake. The transit might be set up on one shore of the lake and a sight to the opposite shore might necessitate readings through such a distance. I have known sights of one mile in length to be taken on a lake. These are rare instances, however, and conditions must be suitable, for telescopes are few through which a target can be satisfactorily read at a distance of a mile. Extreme difficulty is experienced in focusing the wire upon it even at a distance of 4,000 feet, it being almost impossible to see the target unless a little ingenuity is used in distinctly outlining it.

Such long-distance sights, provided proper precautions are taken, have great advantages in traversing. One accomplishes more, and again, a single long-distance sight is more correct than two of short distances. The longer the sight the straighter the line. This is well exemplified in chain measuring where the transit man who strives to run a perfectly straight line knows the value of a single sight of, say, 2,400 feet in comparison with two sights of 1,200, or four sights of 600 feet each.

On land, of course, these distances are frequently impossible owing to divergencies of contour; but on the water and in some parts of the western provinces very long sights may sometimes be taken. In the case of the latter, however, level or open prairie work is no longer abundant, the major portion of the unsurveyed west being covered with bush and muskeg.

J. A. MACDONALD.

Ottawa, Ont., July 10th, 1913.

ADDITION TO THE TORONTO FILTRATION PLANT.

In his report to the Board of Works relative to the proposed extensions to the waterworks system of the City of Toronto, Commissioner of Works R. C. Harris recommends the installation of a mechanical system of filtration to supplement the slow sand methods now in use at the Island.

This report is the first official announcement that has been made concerning the expenditure which the $6,000,000 by-law of January 1st, 1913, was intended to cover. During the past six months the Works Department has given the situation most careful study, and the scheme of extension now advocated is the result of a very thorough investigation. As intimated in the June 26th issue of *The Canadian Engineer*, the Commissioner of Works had decided it advisable to base his report upon the experience and careful investigation of the city's own engineering staff, rather than merely to accept the report of the board of experts appointed previous to his administration.

The new report in full is as follows:—

Gentlemen,—We beg to herewith submit report re addition to Island filtration plant.

There are two standard methods of filtration, viz., slow sand and mechanical, both of which are capable of giving equally effective results.

In the former system, the raw water, without chemical treatment, is passed through beds of sand and gravel at the rate of from three to five million gallons per acre per day, and the effluent is carried by gravity to a clear water reservoir, from which it flows to the distributing pumps.

In the mechanical system, the water is pumped from the source, and a coagulant, usually in the form of sulphate of alumina, is applied before entering a coagulating basin, where sedimentation takes place for several hours. The water is then passed through rapid sand filters at the rate of from seventy-five to one hundred and fifty million gallons per acre per day, then flowing to a reservoir for distribution by pumping.

The slow sand process is particularly adapted to purifying water without color and with comparatively little suspended matter. The mechanical process will successfully handle any type of water, regardless of color of turbidity, and operates at maximum efficiency when raw water conditions are worst.

Ordinarily, the first cost of a mechanical filter installation is considerably less than that of slow sand, and occupies but a fraction of the area required by the latter, while the operating costs are considerably higher than the slow sand method, due largely to the necessity for using coagulant.

For the purpose of acquiring information to enable us to advise the administration, we visited mechanical filter plants at Montreal, Que.; Little Falls, N.J.; Cincinnati, O.; Toledo, O.; Columbus, O., and Niagara Falls, N.Y. We also viewed the slow sand plants at Philadelphia, Pa.; Pittsburg, Pa., and Washington, D.C.

At each of these cities the type of plant used was giving satisfactory results.

At Philadelphia, we found that pre-filtration was necessary before admitting the water to the slow sand beds. This pre-filtration was accomplished by what is known as a "roughing filter," which is in effect a mechanical filter without the use of coagulant, and which removes from the water the greater portion of the suspended matter, thereby enabling the slow sand beds to be used at a rating much above normal.

At Pittsburg, they were having considerable trouble with the water, and were making plant additions to overcome same. This, however, was not due to any demerit of the slow sand method, but is accounted for by the chemical quality of the raw water.

At Washington, the water travels many miles from the source before it reaches the filters, sedimentation taking place in the channels and in certain basins en route.

The mechanical filters above referred to were also giving excellent satisfaction. Especially good results were obtained at Cincinnati, which may, in a measure, be accounted for by the fact that the water is allowed to settle for several days in reservoirs, prior to entering the plant.

The works at Montreal are the most recent in point of construction.

The Medical Officer of Health and Alderman Rowland, chairman of the local Board of Health, also visited a mechanical plant at New Orleans, La., which is giving excellent results.

The plants of both types visited were handling river waters.

The slow sand plant located on Toronto Island, consists of twelve beds, having an area of .8 acres each, designed to handle a maximum of five million gallons per acre per day, or four million gallons per filter, making a maximum of forty-eight million gallons per day. However, it is necessary to have at all times at least two filters out of operation for cleaning purposes, making the average output of the plant forty million gallons per day. As a matter of fact, we have, for a considerable time, been operating at the rate of forty-three to forty-eight million gallons per day—considerably in excess of its designed rating.

To make provision for a maximum daily capacity of one hundred million gallons, Mr. Allen Hazen, the expert retained by the city, advises an addition of thirteen slow sand beds, each having an area of .8 acres, which would guarantee an average daily output of sixty-seven million gallons, after making allowance for the beds inoperative because of cleaning operations. For short periods this output could be increased to ninety million gallons per day.

This addition, together with the necessary pumping plant and appurtenances, would cost approximately one million dollars. The cost of operation per million gallons, excluding pumping and capital charges, is estimated by Mr. Hazen at $1.83. This seems to be a fair figure.

A mechanical filtration plant, capable of delivering a maximum of sixty million gallons per day, would cost approximately one million dollars—equal in amount to the slow sand addition.

While we have hereinbefore stated that the first cost of a mechanical filtration plant is considerably less than that of a slow sand, it does not hold good under local conditions, where very expensive foundation work must be provided owing to the sand formation of the Island.

The first cost of each type of plant being practically identical, the annual charges on capital account are not included in the comparisons following.

In mechanical filtration, an additional head is required to operate the filters, over and above that requisite in the slow sand method. Making provision for this additional lift, Mr. Hazen estimates the cost of operation per million gallons, exclusive of capital charges, to be $4.80, which, having regard for our investigation, appears a reasonable figure.

For the purpose of illustration, assuming the average daily pumpage for the year 1914 to be fifty-five million gallons, handled exclusively by slow sand filters, the approximate cost, excluding pumping and permanent charges, would be $36,737. If thirty-two million gallons were filtered through the present slow sand beds (their average normal rating), and twenty-three millions through mechanical filters, the annual cost would approximate $61,670, showing a difference of $24,933 in favor of slow sand. In later years, if the proportion of the total supply through mechanical filters largely increased, as it naturally would, the cost difference in favor of slow sand would be greater.

From the foregoing, you will observe that, from point of operating cost, the slow sand process is very much cheaper than the mechanical.

We have found in the operation of the Island plant that, at times of easterly storm, the suspended matter carried from Scarboro', and particularly the fine sand carried in the water, has rendered the filters almost inoperative. Our experience in 1912 showed this condition to obtain for four periods, and while by dint of great effort, we have never come to the point where actual cessation of filtering operations was necessary, we feel that a long continued easterly storm would probably so clog the filters as to render the use of raw water necessary.

Again, from the inset of frost in the fall until the advent of warm weather in the spring, it is not possible to wash the sand scraped from the filter beds, by the methods provided, inasmuch as the pipe lines, etc., would freeze and burst, and the sand and water would be frozen during the washing process. To overcome this, it was found necessary last summer to build a storage sand bin in each filter, wherein the sand scrapings for the winter were held. We have been working night and day since spring to wash this accumulation, plus the sand from the beds in operation, and the quantity necessary for resanding.

The complete construction of a slow sand filtration plant would take approximately three years, while a mechanical unit should be installed and in operation within eighteen months.

We deem it unfortunate that the filtration plant should have been erected at Toronto Island. The ideal place for such installation would have been on Garrison Common, which is within a convenient distance of the main pumping station, and would have been the strategic point at which, if necessary, other than lake water could have been filtered.

However, the fact that upwards of $800,000 has been invested in the Island plant compels the retention of the Island as a filtration site, unless the present plant be abandoned, which we, of course, cannot advise.

The formation of the Island is such as to render it an undesirable location for permanent construction of this nature, and the very extensive dredging operations which the Harbor Commissioners purpose undertaking, may cause such changes as to imperil the present or any future installation which may be built thereat. This possibility may be remote, but is of sufficient moment to justify us directing your attention thereto.

The continuity of a filtered water supply for 365 days per year, is in our opinion the dominant factor in the consideration of this proposition. A shut-down during a storm period would entail the use of raw water by the citizens, at a time when it is usually most dangerous, least amenable to chlorine treatment, and liable to produce epidemic.

While the slow sand method shows, on a pumpage basis of fifty-five million gallons per day, a saving of $24,933 per year over the mechanical system, we, your officials charged with the duty of providing an absolutely continuous and safe supply of water, are, irrespective of cost considerations, forced to recommend the adoption of the mechanical system of filtration.

The report was signed by R. C. Harris, Commissioner of Works; Geo. G. Nasmith, Director of Laboratories, Department of Health, and Chas. J. Hastings, Medical Officer of Health, and was adopted by the Works Committee.

The International Congress of Mining, Metallurgy, Applied Mechanics and Practical Geology is to be held in London in 1915. Several preliminary meetings of the Organization Committee have already been held, and a decision arrived at that the sections of the Congress be divided into four groups as follows:—Group 1, mining; section A, coal mining; section B, metal mining; Group 2, metallurgy; section C, ferrous metals; section D, non-ferrous metals; Group 3, applied mechanics; section E, mechanical engineering; section F, chemical engineering; section G, electrical engineering; Group 4, geology.

THE INCREASING COMPLEXITY OF MUNICIPAL GOVERNMENT

INTERESTING HISTORICAL REFERENCE TO TORONTO'S DEVELOPMENT IN MUNICIPAL GOVERNMENT — A REVIEW OF THE EVER-WIDENING RESPONSIBILITIES WITH WHICH CIVIC AUTHORITIES DEAL.

By His Worship the Mayor of Toronto, H. C. HOCKEN, Esq.

THE subject which I have chosen for a brief paper is "The Increasing Complexity of Municipal Government."* It will be admitted, I think, by all who have anything to do, at the present day, with the government of our large cities that the contrast between the present and former days is a very striking one with respect to the range and importance of the matters which are dealt with in our municipal administration. In earlier days the administration was simple; in the present day it is complex, and is increasing in its complexity.

The Toronto *Globe*, in its issue of June 11th, 1913, contained the following paragraph:—

"When the late Dr. Goldwin Smith, a keen critic of public affairs, was asked why he did not take an active part as a municipal representative, he said he had to confess his lack of ability. He went on to point out that while honesty and common sense were sufficient in a small municipality, the great city's management called for special knowledge in a multitude of problems in such matters as finance, engineering, sanitation, hydraulics, transportation, and traffic management."

In these words the difference which exists at the present time between the government of a small municipality and that of a large one is very succinctly stated; and also, I think, the difference between the government of a large city in earlier days and that of the present day.

By way of illustration, let us consider the City of Toronto, which I have the honor to represent. The earliest printed financial statement of Toronto which I am able to find is that for the year 1858. The ordinary expenditure for that year may be set down under the following principal headings:—

Public hall, public markets, weigh houses; street watering, lighting, and repairing; fire protection, by a volunteer brigade; education—common schools and grammar school; police protection, and administration of justice; health protection—in a small way, including, it may be remarked, care of "cholera shed"; care of insane; public walks and gardens; care of poor, principally by the House of Industry; construction of sewers.

The financial statement for 1880 does not differ much in its scope from that of 1858. The principal changes are the substitution of a permanent fire brigade for that of a volunteer force, a larger proportionate expenditure for street watering and repairing, and in the interval the transfer of the care of insane persons to the provincial government. Parks in 1880 were given more attention, street cleaning formed a more important item, and there was some expenditure for a smallpox hospital and for vaccinations.

An examination of the estimated expenditure for the year 1913 reveals a vast difference in character and scope as well as in the magnitude of the figures. Under the headings "Works" and "Health" the change is a striking one. In former days the expenditure for protection of health was insignificant; to-day it is large. The Health Department, with a skilled and leading member of the medical profession at its head, is one with a large staff, combatting diseases of a contagious and infectious character, maintaining an isolation hospital and a smallpox hospital, and vaccinating people free. It tests milk and regulates its sale to see that the business is carried on under clean conditions. It sends its inspectors out to the country to examine the dairy farms and enforces compliance with sanitary regulations. It fights the white plague by sending out nurses to the houses of the poor to direct the care of those suffering from tuberculosis and to prevent others from being infected. It has a dental clinic which does a large work principally in treating the teeth of school children. It has a laboratory for contagious diseases, for testing milk, and for making a daily and continuous analysis of our city water. Plumbing construction and appliances are regulated and inspected, and house drains are supervised and regulated. In addition, a vast system of inspection is carried on to suppress insanitary conditions in houses and premises, and to prevent the growth of slum conditions. Food offered for public sale is also inspected, and the conditions surrounding its display, its handling, and its delivery are regulated. Perhaps in no department of civic government is the change so marked as in that of the care of the public health. It would be nearer the truth to say that this branch of our municipal government is altogether new. It has arisen out of the great advance made of late years in sanitary science and preventive medicine, and I think that in its detection of contagious diseases, in its limitation of them, and in its prevention of epidemics with attendant enormous loss of life and trade, the board of health is a paying insurance.

The people demand free libraries, and one was established in Toronto in 1883. The maintenance of our public library board takes one-quarter of a mill in the dollar of our annual taxation. Not only is there a large central library, but the residents of the outlying sections demand branches which are provided and maintained. Skilled and trained officials are in charge.

Children's aid societies, industrial schools for boys and girls, and a juvenile court for the discriminating and sympathetic treatment of boys and girls who commit offences which bring them into the hands of the police are among the new institutions of recent years with which we have to deal. The system of dealing with juvenile de-

*Read at the 13th Annual Convention, Union of Canadian Municipalities, July 15, 16 and 17, 1913.

linquents is largely preventive, and on the whole it is successful.

An industrial farm has been provided to which to send prisoners from the city jail, in order that regular and healthful work may restore them to physical vigor and enable them to overcome their craving for drink. Incidentally, they earn the cost of their maintenance.

A few years ago we established a public bath house. This has been so successful in a central location that baths have been demanded for other sections of the city.

The people call for band concerts in the public parks in the summer as well as free bathing facilities at the Island, and in the winter they call for skating rinks and toboggan slides in the parks.

We are establishing a public abattoir at a large expenditure for building and equipment.

In connection with street cleaning, the great area to be cleaned and swept, and the extensive system of garbage collection require the erection and equipment of incinerator plants at different points in the city, and a reduction plant outside the limits of the city where garbage is to be reduced and by-products utilized. The initial expenditure for all these plants will total about one million dollars.

Education is widening out. To the former common and high schools are added those for technical instruction, with a very large expenditure for building and equipment.

Public ownership of public utilities is the new order of the day. It began with the acquisition of the waterworks. It has extended to the establishment of a municipal electric lighting and power plant in close affiliation with the hydro-electric system of the province of Ontario, and the construction of street car lines by the municipality, and my hope is that before long we shall have ownership and control of street railway transportation and electric power distribution on every street and in every part of our city.

Main drainage, sewage disposal, storm overflow sewers, bridges and viaducts, waterworks problems and extensions, are all subjects which require careful thought and the employment of skilled engineers and experts. These are important matters with which the municipal rulers of earlier days were not required to deal.

All this increasing complexity of municipal government demands the service in the Council of men who have had some special training in municipal administration. It must be apparent to any thinking person that a man cannot approach this work, and render substantial service until he has had a chance of making a study of at least some of the problems with which a large city government has to deal in these days.

This ever-widening range of responsibility will compel the men who are elected to administer the affairs of the great cities, to specialize in the different departments of civic government. It is only by special application to particular problems on the part of a group of men sharing this responsibility that the best results can be attained.

When Toronto was a city of under 100,000 people, thirty-five years ago, one man was city commissioner and health officer. He inspected works in course of construction, and had charge of health, street cleaning, street watering, public markets, public halls, and other miscellaneous work. No city in Canada of a population of 100,000 would dream to-day of putting such a load on any official, because the duties of each branch have been so amplified that it would be a physical and mental impossibility for the official to carry the responsibility.

The people demand that our municipal government shall protect them and their property against criminals and fire. They ask for protection against disease, whether it comes from diseased persons or from food or water. They ask to be cleansed by public baths, and to be amused in summer and winter. They ask also to be provided with books and periodicals to read. In short, they ask to be guarded at almost every point, and as in the last analysis, they rule as well as provide the funds, their demands must be complied with. The experience of Toronto is, I believe, similar to that of other cities.

NEW HIGHWAY BRIDGE AT LYTTON, B.C.

The accompanying illustrations refer to a proposed structure to cross the Thompson River, just above its junction with the Fraser, at a site between the present bridge which is also shown, and the crossing of the Canadian Northern Railway. The new bridge will carry the main highway from Hope and Lytton in the direction of Lillooet and other northerly points.

The sub-structure is of concrete, and steel is being used in the superstructure, the whole resting on a good rock foundation.

Fig. 1.—Bridge at Lytton, B.C., Which is Being Replaced.

There will be 209 feet of timber trestle approach with a similar length of grading on the southeastern bank of the river. Over the bridge the roadway will be 16 feet in width, and will be constructed of 4-in. plank protected on either side by a 4-foot hand railing with posts 7 feet 7⅝ inches apart. The roadway plank will be supported on 6-inch joists of varying depth, according to camber, on steel I-beam stringers. A crowning one inch thick will be applied to the top of the floor.

The bridge itself will consist of a 250-foot truss span, 35 feet deep, together with two 70-foot plate girder spans, one on either side and an additional 50-foot plate girder span carried on steel bents and concrete abutments. The large truss span will rest upon concrete piers seventy feet above low-water, while the distance of the resting surface of the truss above the extreme high-water level will be 7½ feet.

The bridge is designed to carry a live load of seventy-five pounds per square foot on the 250-foot truss, and one hundred pounds per square foot on the shorter spans, together with a concentrated load of a 16-ton road roller.

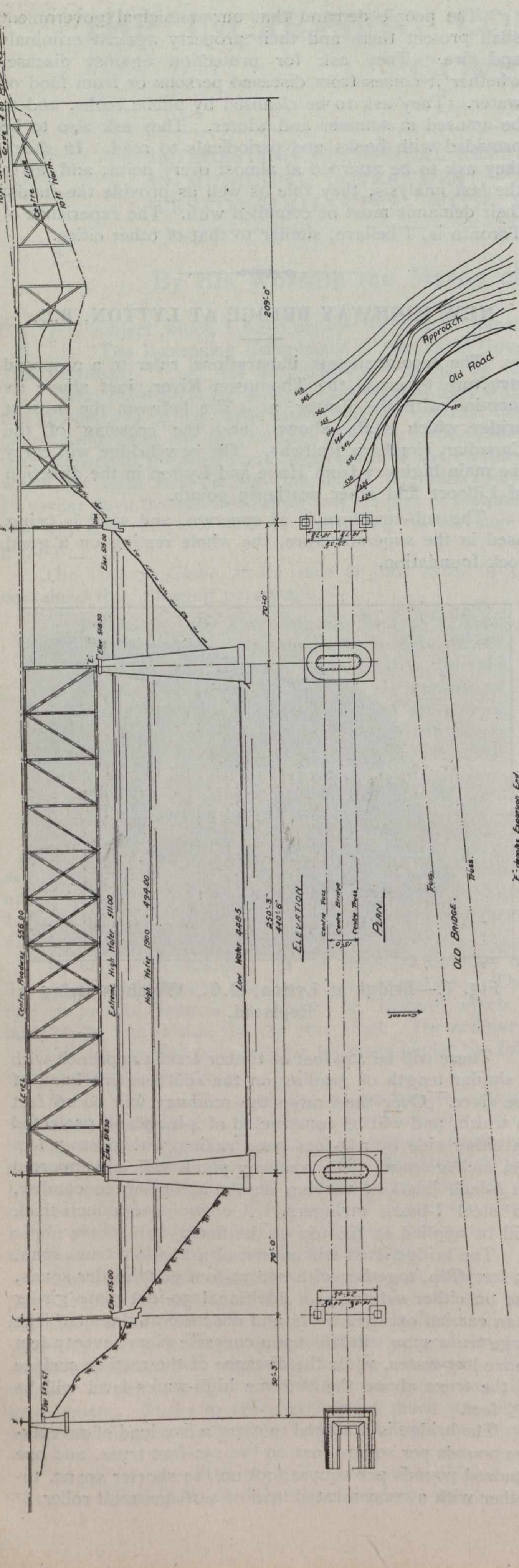

Fig. 2.—General Plan of Proposed Bridge Over the Thompson River at Lytton, B.C.

The level of the new bridge will be forty feet higher than that of the present structure, which is illustrated in Fig. 1. The 215 tons of steel will be fabricated by the Canadian Bridge Company, while the 2,000 yards of concrete, erection of steel, and the other work at the site

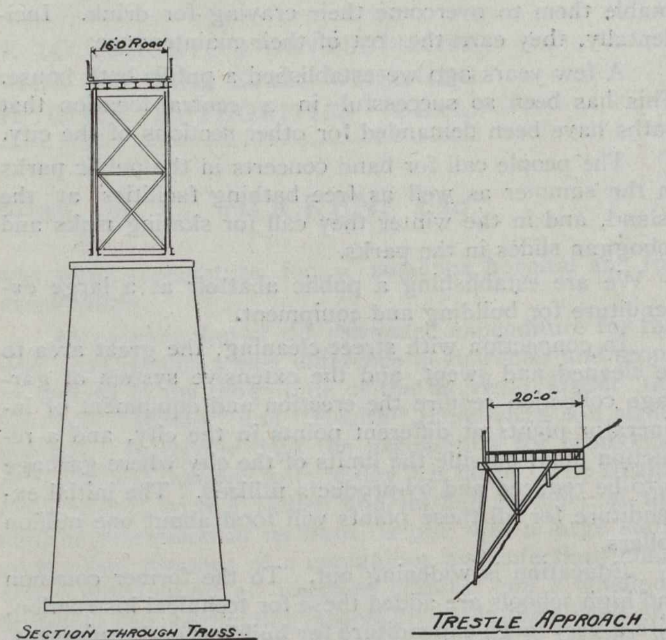

Fig. 3.—Sections at Abutment and Trestle, Lytton, B.C.

will be carried out by the Graff Construction Company. The bridge is being built by the Provincial Department of Public Works, J. E. Griffith, chief engineer, and was designed by E. A. S. Stone, M. Can. Soc. C.E., M. Inst. C.E., consulting engineer, Vancouver.

COPPER CLAD WIRE LITIGATION DISMISSED.

Important litigation in regard to copper clad wire which has been contending in the United States Court in Pittsburgh, Pa., for the past two and a half years between Duplex Metals Company of New York, complainant, and the Standard Underground Cable Company, Pittsburgh, Pa., defendant, was virtually decided June 25th, when the case came before the Court on motion made by complainant to dismiss the bill in respect to patent infringement. The bill as originally filed charged infringement of the patent and infringement of a trade mark. The motion made by complainant was to dismiss without prejudice; that is to say a dismissal leaving the complainant in a position to renew the suit at its pleasure. The motion was opposed, defendant contesting that the bill should be dismissed in this regard and a dismissal should be on the merits of the question. The Court so ordered, the order reading:—

"Complainant having admitted that defendant's product referred to in the proofs herein does not infringe the Monnot Patent in suit No. 893932, it is ordered and adjudged and decreed that the bill of complaint herein, in so far as it is based on alleged infringement of said patent be, and the same hereby is dismissed on the ground that defendants have not infringed said patent."

The Order of the Court directs that the complainant pay the costs. The only portion of the suit not thus disposed of is in regard to the right to use the trade name "Copper Clad" and which is expected to go to a hearing in the early fall.

ROAD RESOLUTIONS ADOPTED BY THE 1913 CONGRESS

CONCLUSIONS ARRIVED AT BY THE VARIOUS SUB-SECTIONS—THE NINE ROAD QUESTIONS AND FINDINGS RELATING TO EACH—A SUMMARY OF THE WORK OF THE THIRD INTERNATIONAL ROAD CONGRESS.

THE resolutions adopted as a result of the careful study relating to the nine questions before the International Road Congress are given below. The Congress included two sections, each of which were further divided into two sub-sections. The first section's investigation pertained to construction and maintenance. Sub-section A dealt with the roads outside of larger towns and cities, while Sub-section B had before it the consideration of roads in cities and large towns. The second section, on traffic and administration, consisted of Sub-section C, dealing with traffic and vehicles, and Sub-section D, on administration, finance and statistics. The discussions of each section were distinct from those of any other, and each had its own executive committee. In a number of instances, however, two sub-sections sat together.

First Question.—Planning of Streets and Roads.—This was dealt with by Sub-sections A and B combined. When the discussions were summarized the following resolutions were adopted:—

1. As a general principle, it is better that new main roads be constructed to pass outside rather than through towns, and that, where an existing main road passing through a town is unsatisfactory for through traffic, it is often better in preference to widening an existing narrow main road through the centre of a town, new roads should be planned according to the principles of the science of town planning.

2. Gradients on new roads should be as easy as possible, having regard to the physical character of the country through which they pass, and they should be easier where there are curves, trams, or a preponderance of heavy traffic.

3. The radii of curves in roads used by fast traffic should, where practicable, provide the best possible and an unobstructed view, and that where this is not possible, the curve being of too short a radius, means should be provided whereby the approach thereto is in some way clearly indicated.

4. Except where it is possible to provide special reserved spaces, tram tracks are best placed in the centre of the roads, and that where so placed it is desirable to provide space on either side for two tracks for vehicles.

5. The main traffic roads should be so designed that spaces are provided for tram tracks, fast and slow traffic, and standing vehicles; and in such a way that they can proceed without unduly intermixing. In fixing building lines along what may ultimately become main roads, regard should be paid to ultimate requirements. Adequate space should be provided between the buildings, and powers for enforcing this should be held by all authorities who decide the widths of roads.

6. That the planning of main road communication outside towns should be at once undertaken; it is a matter of national importance in regard to which some initiative should rest with a Central State Authority, and the action of Local Authorities should to some extent be regulated or supervised by Central State Authorities.

Second Question.—Types of Surfacing to be Adopted on Bridges, Viaducts, etc.—Sub-sections A and B sat conjointly concerning this question also, and the following are the resolutions which were passed:—

1. The choice of road surfacing for bridges depends on the nature and intensity of the traffic, the local conditions, such as permissible first cost, kinds of material readily available, and climate. For light bridges the choice is largely influenced by the weight of the surfacing. Public safety and convenience should be first regarded rather than questions of comparative cost.

2. On short bridges in town or country, it is desirable than the surfacing should be the same as that on the adjoining streets or roads.

3. In forming the roadway on bridges, special care should be taken to secure proper drainage, and to prevent the harmful percolation of water. With longitudinal gradients of at least 1 in 50, the cross section of the surface may be made nearly flat and the dead load thus reduced.

4. As a general rule, the surfacing of a bridge should be waterproof, capable of resistance to wear, durable, and of a weight appropriate to the structure of the bridge; it should also be as smooth as possible without being slippery.

5. Plank surfacing on bridges is light, and its first cost is low. Its cost of maintenance is, however, excessive, except where the traffic is light. Its extreme liability to damage by fire is a serious disadvantage. It should not be adopted, except in remote districts in which there is an abundance of cheap timber, and where a more desirable form of surfacing is not easily obtainable. Single plank floors are only suitable for very light traffic. For moderate or heavy traffic, two layers of planking, the lower of which is creosoted or otherwise protected from rapid decay, should be used.

6. Macadam, or ordinary broken stone surfacing, on timber planking, is not always satisfactory on account of its great weight and its permeability. Macadam is, however, quite satisfactory for massive bridges in rural districts, if the substructure has a proper damp course.

7. Macadam, bound with tar, or other waterproof and elastic material, is useful and economical for the surfacing of rural bridges with moderate traffic, when the spans are short or the structure is massive.

8. Wood paving block, 3 to 5 inches thick, is an ideal surfacing for bridges in most cases. It is light and durable and can be laid on concrete, or, when weight must be minimized, on a timber subfloor, which should be creosoted. Special care should be taken in the selection, treatment and laying of wood blocks for bridge paving, to avoid troubles due to expansion and contraction of the blocks or of the metal structure.

9. Asphalt, in various forms, is an excellent surfacing material for bridges with easy gradients,

on which the traffic is not confined to definite lines or very heavy.

10. Stone paving, carried out either with ordinary hand-dressed setts or with small setts (Durax; Kleinpflaster), laid on concrete and bound with cement or pitch, makes excellent and economical surfacings for bridges with heavy traffic. However, it is only suitable in cases where questions of the weight of the surfacing or of noise are of no importance. The thickness of the layer of sand interposed between the setts and the foundation will be decided in the same way as with an ordinary carriage-way, in town or country, as the case may be.

11. For movable bridges, and for non-rigid suspension bridges, the surfacing should be light and easy to attach to the bridge platform. The trials made in France and Belgium with old mine cables, or other fibrous substances of even less cost, and with such materials impregnated with tarry, bituminous or asphaltic materials should be encouraged.

Third Question. — Construction of Macadamized Roads Bound with Tarry, Bituminous or Asphaltic Materials.—Sub-section A dealt with this question and arrived at these resolutions:—

General Conclusions.—By the use of bituminous, including tarry or asphaltic binders, we may obtain a number of different forms of road crust, which may be employed with advantage, according to the various conditions of the road as regards traffic, locality, and climate.

The exact value and duration of life of these various road crusts, taking into account traffic, climatic conditions, and the methods of construction, remain to be determined.

For this purpose it is advisable to draw up a uniform system of tests, measurements and records, under the following headings:—

1. Physical and local conditions. (Plans, cross-section, slopes, camber foundations, subsoil.)

2. Materials employed, petrological analysis, dimensions, composition of the binding agent.

2a. Method of construction, date of construction.

3. Census of traffic on the section under review.

4. Climatic conditions affecting the road.

5. Periodical measurement of wear.

6. Periodical examination of the state of the road crust.

7. Actual cost of the road crust: (a) As regards cost of construction. (b) As regards maintenance cost.

The standard form in which the information is to be furnished will be drawn up by the Permanent Commission.

Particular Conclusions. — I. Foundation and drainage.

Confirming the conclusions adopted in 1910 by the second Congress (Brussels, 2 Question), which called attention to the advantages of a dry foundation and a sound subsoil, the Congress especially insists upon the great importance of efficient foundations in the case of road crusts bound with bituminous (including tarry or asphaltic binders) for the following reasons:—

(1) The road crust being expensive, it is important to give it a base which will increase its life.

(2) As the weight, speed and intensity of the traffic continually tend to increase on roads considered worthy of such a crust, it is best to provide a foundation which has been so constructed as to secure for the crust the best possible conditions of resistance to wear.

II. Dimensions and shape of metalling.

(1) When an ordinary macadamized road crust is constructed with a view to being tar-sprayed, it should be constructed of hard metal, with sharp edges, and broken as nearly as possible to a cube of the dimensions of from 4 to 6 c/m.

(2) In the case of bituminous including tarry or asphaltic macadam, carried out by the mixing process, the dimensions of the metal may be so selected and graded as to form a compact road crust with the fewest possible voids. The dimensions of the largest metal may vary according to the nature of the stone and of the traffic. When the process of construction employed requires more than one layer of material, the upper layer or wearing crust may be formed of smaller metal.

(3) In respect of bituminous including tarry or asphaltic road crusts constructed by the penetration process, the trials and tests now being carried out in various countries should be continued, taking care only to employ metal of as cubical a shape as possible, and with sharp edges, at any rate, for the portion of the road crust nearest the surface.

(4) It is understood that further experiments will also be carried out in the use of the other methods, and especially 1 and 2.

III. Employment of partially used metal.

By carefully eliminating all particles of mud and organic matter, it is possible to successfully make use of partially worn materials, on condition that they are not employed for the surface of the road crust.

IV. Relative importance of patching.

It is agreed that it is absolutely necessary to carry out repairs, in the case of all bituminous including tarry and asphaltic road crusts, immediately the necessity for them arises.

V. Permissible wear.

The complete renewal rendered necessary by wear must be carried out immediately the depth of the road crust is below a given limit of safety, or when its waterproofing qualities have become so poor that the road will unduly suffer from climatic conditions.

VI. Various means of employing tarry, bituminous and asphaltic materials.

In using these materials, both in the penetration method and the mixing method:—

(a) It is preferable to use dry stone in order that it may adhere well to the binder. In the mixing method the stone must always be dry, and if necessary it must be heated.

(b) One must never lay a top crust upon a soft or damp foundation. One should preferably carry out the work in fine weather.

(c) One must never employ too much binder, but only a sufficient quantity to bind the portion of the road which is being rolled.

(d) One must never employ road rollers which are too heavy.

VII. Tests and chemical analysis.

The advantages of analyses and methodical laboratory tests, and their necessity in the case of bituminous binders, are unanimously recognized.

It would be of advantage to obtain uniformity—

(1) As regards the specification of the principal characteristics of these binders.

(2) As regards the methods of testing for drawing up these specifications. The Permanent International Commission will be entrusted with the work of enquiring into the best way of standardizing the above.

VIII. Climatic effects.

It appears to be generally agreed that certain tarry, bituminous or asphaltic road crusts (as is also usually the case with all smooth and waterproof road surfaces) may become slippery under certain conditions of weather.

This may be remedied by strewing the surface with coarse, sharp sand; and in most cases a good cleansing of the surface will usually prevent the carriage-way becoming slippery.

IX. Effects on public health, etc.

Sufficient information is now available to enable engineers to select and specify bituminous binders which will have no prejudicial effect upon public health, fish life, or vegetation; but which, on the contrary, will conduce to conditions of considerable hygienic advantage.

X. Cleansing and watering.

It is recognized that carriage-ways properly treated with bituminous including tarry or asphaltic materials require less sweeping and watering than ordinary water-bound macadamized roads, and that they allow of considerable economy being effected under this head.

Fourth Question.—Wood Paving.—The resolutions which were adopted by Sub-section B are the following:—

1. Where gradients permit, wood block pavement is very suitable for streets where the traffic is great, but is not of the exceptionally heavy character usually existing on streets near docks or similar centres of industrial traffic. It should be used where a noiseless pavement is desirable.

It is of great importance that a concrete foundation should be laid of sufficient strength to carry the traffic passing over the pavement.

2. Great care is necessary in the selection of the proper timber for the purpose, and all soft wood blocks should be thoroughly impregnated with a well-proved preservative before being laid.

3. In view of the varying results given by wood pavements, according to local circumstances, it is desirable that further investigations and laboratory experiments should be carried out in connection with the selection of the timber and of the impregnating preservative.

4. Every precaution should be taken in laying the blocks to prevent, so far as possible, the entry of water through the joints.

4a. Hard woods give varying results according to local circumstances, and it does not appear desirable to recommend them for roads with intense traffic in large cities, unless some means are devised to effectively prevent the rapid destruction of the joints and the resulting destructive effect on the concrete below. If these woods are employed, it is desirable not only to prevent the percolation of water through the joints to the foundation, but also to consolidate the blocks as far as possible, so that they may not become rounded at the edges.

Soft woods obtained from suitable kinds of trees, and especially from resinous species, are equally suitable for roads with a comparatively heavy and intense traffic as well as for roads with a light and infrequent traffic. In the latter, however, the blocks are liable to rot if they have not been suitably pickled. It is also desirable to make the joints as small and watertight as possible. On the other hand, their comparatively rapid wear on roads with great traffic should encourage one to make exhaustive investigations into the best means of treating them, so as to increase their strength without prejudice to their elasticity.

5. Subject to certain precautions, such as impregnating of the wood, waterproofing of the joints and surface, frequent cleaning of the roadway, etc., there is no objection to wood pavement from the sanitary point of view.

6. The spreading of gritting is necessary under certain conditions and in certain weather (especially on hard wood paving) to prevent the surface becoming slippery, but the gritting should be done with suitable small gravel chippings or sharp sand, so as to avoid, as far as possible, any injury to rubber tyres.

Fifth Question.—Methods of Lighting Public Highways and Vehicles.—This was considered by Sub-sections C and D combined, and the following resolutions unanimously adopted:—

The section adopts the following resolution unanimously:—

I. For the purposes of a general determination of methods of lighting, highways may conveniently be divided into three classes as follows:—

(1) Important streets in cities, towns or other urban areas in which the traffic after dark is considerable in volume.

(2) Important suburban roads in the vicinity of large towns.

(3) Rural roads in open country, and having regard to modern conditions of traffic, it is essential that adequate lighting by means of fixed lights should be provided in classes 1 and 2.

II. As a general principle in the lighting of all highways which require to be lighted by means of fixed lights, the method of lighting to be adopted should be such as will provide an illumination as uniform and free from glare as possible. The amount of illumination and the position of lamps must be determined with reference to local circumstances.

III. It would be impracticable to light rural roads in open country generally by similar methods to those adopted in urban streets or suburban roads, and the lighting of vehicles running or standing on rural roads at night is, therefore, of the highest importance.

IV. Every vehicle, whether standing or moving, should carry a light of sufficient power at night which can, except when specially authorized, be seen from the rear as well as from the front of the vehicle.

(2) Every motor car must carry after nightfall, two lighted lamps in front, and one at the back; if it is able to move at a high speed it must be fitted in front with a headlight of sufficient illuminating power to light up the road or path for at least 50 yards to the front. In inhabited places where the ordinary lighting is sufficient to allow motorists to see their way and to be easily seen, the light of the

headlights must be limited to that of the ordinary lamp.

V. It is desirable that all obstacles across a road, such as gates, and particularly gates at railway level crossings, should be painted white and in other colors in alternate parts, and illuminated by fixed lights which are lighted at dusk.

(2) It is desirable to paint white paint or indicate by some other method all danger signal posts, direction posts and other posts, milestones, wheel kerbs, bridge abutments, etc., or other special features, the indication of which would aid travellers, or conduce to the safety and convenience of the traffic.

VI. One and the same color should be universally adopted as the color for danger signals.

The meeting also adopted the following resolution:—

1. It is desirable that each Government should do away as soon as possible with colored lights on automobiles.

2. The Congress expresses the wish that regulations should be made to compel drivers of herds of cattle to make their presence known.

Sixth Question.—Observations noted since 1908 as to the Various Causes of Wear and of Deterioration of Roadways.—Sub-section C adopted these resolutions:—

1. Weather conditions are amongst the most powerful influences which cause deterioration of roads, and that the destructive effect of weather can be minimized by effective waterproofing of the road surface, with suitable drainage for the foundation.

2. Any considerable volume of traffic, consisting of either heavy motor vehicles or high-speed light motor cars has a seriously damaging effect on water-bound macadam roads. The damage caused is effected by the balancing of the motor; the ratio between propelling power and adhesive weight; the weight of unsprung portions of the motor; the progressivity of action of the brakes; the system of springing; the type of tyres employed, the diameter of the wheels, the width of the rims, variation of speed and adherence, and other factors.

3. The damaging effect of heavy motor vehicles can be minimized by the use of wheels of large diameter; tyres of a width properly adapted to the weight of the axle load; rubber or elastic tyres and suitable springs, and that all reasonable means of reducing the damage to roads caused by such vehicles should be enforced.

4. Light motor car traffic does not cause serious or exceptional wear or damage in the case of properly made macadam roads which have been properly treated or bound with tarry, bituminous or asphaltic materials, except in sharp curves.

As regards horse-drawn vehicles, it is desirable also to study the relations between load, width of rims and diameter of wheels, and more especially the system of shoeing horses. It is also necessary that power should be given to Local Authorities to prevent the deposit of refuse from the fields and earth upon the roadway by the wheels of agricultural carts.

5. There is still a great lack of precise information in regard to the various causes of wear and deterioration of roadways, and that it is desirable to collect more information compiled on carefully devised scientific methods, standardized as far as possible for the purposes of comparison, and to make further systematic study of these causes.

Seventh Question.—Regulations for Fast and Slow Traffic on Roads—Sub-section C investigated existing regulations, and adopted resolutions as follows:—

1. That all regulations for the control of road traffic should be based on the principle of allowing the speed practicable for each different kind of vehicle consistent with public safety, general convenience, and the normal wear of the road.

2. That regulations for the conduct of fast and slow traffic should be as few and simple as possible, and should be such as can and ought to be universally adhered to and enforced.

3. That in all large cities there should be a Traffic Authority, on whom should be charged the duty of studying and dealing with street traffic problems, the powers of such authority and the co-ordination of such powers with those of other public authorities being matters of detail which must be settled by public authorities on consideration of the circumstances and conditions of each large city.

4. That there should be ample provision of traffic controllers (such as the police in London) with adequate powers to regulate the traffic, not only at congested points, but throughout the course of crowded streets.

5. That having regard to the increased danger which is necessarily created by the conditions of modern traffic it is important that drivers should be carefully and systematically trained, and that children should be specially taught how to provide against the dangers of the road.

6. That except where local circumstances render it absolutely necessary, no obstructions, such as lamp-posts, tramway standards, etc., should be placed in the centre of a road, except necessary refuges for pedestrians crossing.

7. No obstruction of the public highway should be permitted either by vehicles standing unreasonably, or travelling at an obstructing speed, or by things placed on the highway. Exception must, however, be made for depôts required for the work of maintenance or repair of the road, or for work being carried out by duly authorized and competent authorities, but in every case all necessary steps must be taken to ensure the safety of traffic.

The meeting unanimously adopted the following resolution:—

8. Regulations for roads and traffic must aim at defining the rights, duties, and responsibilities for each kind of traffic, in order to avoid the causes of accidents and damage and to ensure the maximum of order and liberty.

Eighth Question.—Authorities in Charge of the Construction and Maintenance of Roads. Functions of Central Authorities and Local Authorities.—Sub-section D passed resolutions concerning this question, which are as follows:—

The system of road administration in any country must be in harmony with the general system of government prevailing in that country, and the political genius of its people. It is impossible, therefore, to lay down any general rule of universal application as to the extent to which the road organization of any country should be centralized or decentralized.

In countries where maintenance of roads by local authorities has hitherto been the prevailing system, the modern engineering problems of road construction raised by the increased motor traffic are creating a demand for greater centralization in the belief that this will tend to greater expenditure on the roads, but in the opinion of this Congress it is not desirable that the maintenance of the roads should be vested in a central authority, but should be decentralized as far as is consistent with good administration, and that assistance should be given by the State contingent on the roads being maintained up to a prescribed standard.

In those countries where centralized systems of administration already exist, it is desirable that these systems shall be developed and perfected.

A principle that can be laid down as of universal application is, that the unit of highway administration shall be sufficiently large and command sufficient resources to employ and adequately remunerate a competent staff.

It is desirable that the engineering staff shall be organized on a national basis, and shall consist of:—

(a) Chief engineers, with powers of inspection, and report to the authority making grants.

(b) Divisional engineers in charge of administrative units.

(c) Assistant engineers, recruited by examination from engineering students who have received a practical training following upon a good general education, and an engineering education at some recognized engineering school or university. Promotion shall be by merit.

Ninth Question.—Finance of the Construction and Upkeep of Roads—Provision of Revenues.—Sub-section D decided as follows:—

1. The expenditure on the maintenance and improvement of:—

(a) The roads which serve as main routes of communication between important places in any country, or

(b) Roads which are used mainly by long distance traffic unless such expenditure is borne wholly out of the National Revenues under a system of State Administration of roads (which system is practicable and suitable in the case of some roads in some countries) should be mainly paid for out of National Revenues, whether or not such roads are locally administered and maintained, subject, where local administration prevails, to the supervision of a central government authority both as to efficiency and expenditure.

2. It is desirable to abolish, so far as possible, all tolls on public roads, but it is equitable that vehicles which, on account of their weight or weight combined with speed or any other exceptional circumstances connected with either the vehicle or use of the road, cause special damage to roads beyond the wear and tear of the ordinary traffic of any district, should be subject to special taxation, the proceeds of which should be earmarked for expenditure on roads.

3. Borrowing money for new road construction and for the periodic renewal of the surface coating of a road is consistent with sound financial principles, provided that the loan period in the case of loans for renewals, is kept well within the life of the surface coating.

HYDRO-ELECTRIC INSTALLATION, CITY OF TOKYO.

The unparalleled industrial boom Japan experienced during the last few years has brought with it an enormous increase in the demand for cheap electrical energy throughout the country and particularly in the city of Tokyo. In 1908 the Tokyo Electric Light Company completed their hydro-electric power station on the Katsura River about 100 miles from Tokyo, at this time the largest and most important power station in Japan. The total output of this plant was 27,500 H.P. developed by six Escher Wyss Francis turbines direct coupled to generators of Siemens make. One year later the company had sold the whole of the energy developed and a second plant of increased capacity had to be taken in hand. It was decided to develop a fall ten miles down stream on the same river, where 42,000 continuous horsepower could be obtained. The minimum flow of the river was measured to be 850 cubic feet per second, while the net head available varied from 368 feet to 396 feet maximum. By providing a reservoir of sufficient storage capacity the plant could deal with a peak load of 50,000 H.P.

With a total capacity of 75,000 H.P., not including the power required by the auxiliaries, this new installation is again the greatest power plant in Japan, comprising six main turbines of the same make, each of 12,500 H.P., including the oil pressure plant as well as the distributing piping with the necessary gate valves.

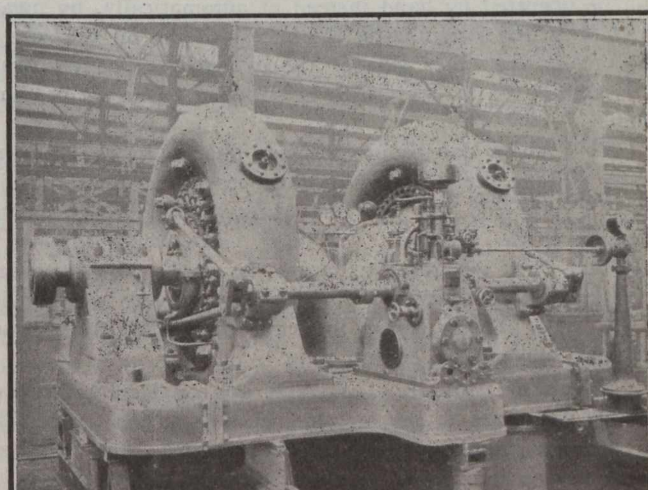

Fig. 1.—Turbines Used in Tokyo Hydro-Electric Plant on the Katsura River.

Regarding the layout of the plant it may be mentioned that the water is brought through a tunnel to the forebay and from there in six parallel pipelines of 700 feet length and 6 feet diameter to the turbines. Each turbine has its own pipeline, the exciter turbines being fed by a seventh pipe of smaller diameter.

The main turbines are arranged in two groups, each consisting of three units on both sides of the switchboard. The distributing pipes and valves are on the lower floor, thus leaving the engine room proper free and allowing for easy access and attendance. For the transformers and connections a second building is provided. The pipeline for each main turbine is connected by means of a conical pipe to a gate valve of 4 feet 7 inches diameter operated hydraulically by pressure water taken from the penstock. A cast steel Y piece and bend connect the turbines to the main gate valves.

The main turbines are shown in the illustration. They are Francis turbines of the twin spiral type with horizontal shaft running at 375 r.p.m., and are coupled direct to the alternators, the coupling flanges being forged on to the shaft. Each unit is mounted on a solid cast iron base plate grouted into the engine room floor. This arrangement ensures a very accurate and simple lining up on site, easy dismantling and remounting for repairs, and equal pressure on the foundations. The shaft runs in two ring lubricated bearings of ample dimensions mounted on pedestals. The bearing on the free end is fitted with thrust collars. The lower bushings of both bearings are hollow and water cooled. The runners are made in special bronze and screwed on to flanges forged on to the shaft. The spiral casings are made in cast iron reinforced by steel bolts and guide ribs cast in. The guide apparatus is arranged outside the turbine casing, thus making all links and bolts accessible. The guide rings and covers in contact with the water have cast steel linings, which are easily interchangeable in case of wear. To reduce the distance between the bearings the draft chest has an elliptical form on the bottom. An intermediate pipe connects this draft chest to the wrought iron draft tubes.

The turbines are regulated automatically by oil pressure governors of Escher Wyss and Co.'s patent, mounted on the same bedplate as the turbine. The governor is the largest size of Escher Wyss and Co.'s standard type, fitted with speed changing device from the switchboard, further with quick closing device in case of falling off of belt, thus preventing the running away of the set. The servo-motor can be operated by hand instead of automatically, by means of a hand wheel regulating the access of the oil pressure to the one or the other side of the cylinder. The necessary pressure oil for the governors is supplied by an oil pressure plant.

To prevent dangerous pressure shocks in the pipeline under sudden throwing off of load of the turbines a relief valve is provided for operated direct from the governing gearing of the turbine. The relief valve works in such a way that when the governor closes the guide vanes to a certain amount, the corresponding area is opened in the relief valve. To prevent losses in water the relief valve closes automatically after a certain time.

The exciter turbines of 460 H.P. are coupled by means of flexible couplings to the exciters running at 600 r.p.m. The turbines are impulse wheels with two nozzles, each regulated by an oil pressure governor mounted on top of the casing.

The oil pressure plant consists of three pump groups, each group of sufficient size to feed four generator turbines and governors. Each pump is driven by a small impulse wheel of about 25 H.P. running at 80-100 r.p.m. Regulation is done by hand by throttling the pressure in the needle nozzle. All parts exposed to water pressure were tested to a test pressure of 350 lbs. per square inch.

The installation is working since October, 1912 and has been a great success in every respect.

George S. Rice, chief mining engineer of the United States Bureau of Mines has dedicated to public use a patent just issued by the Government for a hoisting cage which is primarily for use in rescue work, but can be used for other purposes. In describing his invention, he states that it has for its object the provision of a novel cage which shall have peculiar advantages in regard to portability and ease of assembling and disassembling. He adds that although not limited to such use it is of especial utility in mine rescue work as an emergency cage.

COAST TO COAST.

New Westminster, B.C.—Under an arrangement which the Provincial Government and the C.P.R. are upon the eve of entering, it is now proposed to have the new government highway bridge across the Pitt River finished many months ahead of the time originally set for its completion. The Provincial Government authorities are at present conferring with the railway officials with a view of securing the steel superstructure of the present railway bridge across the Pitt and placing it upon the concrete substructure of the new Government bridge, which will be located several hundred yards above the railway bridge and about where the ferry landings now are.

Vancouver, B.C.—In order to facilitate the work of protecting the forests from fire, the Provincial Government is building a number of trails through the danger spots, to aid in concentrating the forest guards in emergency. Work is going on at present on a trail from Gordon Pasha Lake to Powell Lake; a trail from Campbell Lake to Salmon River Valley, and a trail from Bond Sound to Kingcom Inlet. Cabins are being built along the trails at intervals to form resthouses for the firewardens, and supplies are being packed in over the trails, in order to prepare for emergencies. Superintendent George D. McKay has ready a supplementary list of fire guards who will be set to work as soon as the weather gives any indication of proving conducive to forest fires.

Toronto, Ont.—Toronto is to have the proposed auxiliary service to the waterworks pumping station, filtration plants and sewage disposal plant, in order to insure the necessary supply in case of interruption in the electrical transmission lines to the city. Chairman Ellis, Mayor Hocken and General Manager Couzens of the Toronto Commission had a conference with Hon. Col. Hendrie, Mr. W. K. McNaught, M.P.P., and Chief Engineer Gaby, of the Hydro-Electric Commission, and after a full and careful discussion of the joint report of the Provincial and city commission engineers regarding the proposed auxiliary plant it was approved. The report, which is signed by Messrs. Gaby and Couzens, does not assume to be comprehensive in character, and suggests two plans, part of which reads as follows:—"The power required for the civic requirements as outlined is over 14,000 H.P., and there are two broad lines on which a permanent auxiliary electric service to operate the plant can be dealt with:—(a) By the installation of generating plant within the city, to be given by steam, gas or oil engines; (b) connection with the system of the allied electric companies. A comparison of these two methods shows, in our opinion, the following among other advantages, in favor of the former under present conditions:—Greater rapidity in picking up the load; less delay in transferring the load after resumption of supply; greater reliability; the whole Toronto system would remain under the direct control of the Toronto Commission, and, therefore, under the general Hydro scheme; lower capital cost; economy due to utilizing the steam plant for the reduction of peak loads; ability to use the plant in cases of emergency in accordance with the terms of the agreement between the Provincial Commission and the city of Toronto; greater possibility of expansion in accordance with the requirements of the system and service. We, therefore, beg to recommend the adoption of scheme (a) in general principle, when the details can be carefully worked out and a report submitted to the Toronto Commissioners with a view to considering the various commercial features which concern the undertaking under their control."

Montreal, Que.—Nearly seven million bushels more grain have passed through the Lachine Canal thus far in 1913, than for a similar period of last year. The exact increase is 6,911,919 bushels, or more than the total receipts for the month of May, 1912. Wheat, corn, barley, flax and oats are included in the shipments, which comprise a record for the Lachine Canal. The carriage of wheat alone is almost doubled this year, its total of something over ten million bushel being balanced against five million for 1912. Mr. Ste. Marie, canal revenue officer, predicts even a greater increase for the remaining months of the season. "The Fort William and Port Arthur elevators are not nearly exhausted yet," he said recently, "and the chief reason why shipments have not been even heavier than they have, is because Montreal elevators have not been able to cope with the onrush of grain that has been pouring into them since navigation opened late in April. When we have secured sufficient elevator accommodation at this port, Montreal will get all, or practically all, of the Canadian shipments from the West. The St. Lawrence route, besides being the shortest, is the most expedient for lake shippers, and we may expect to get more records broken when we supply facilities for handling the grain once it gets here."

Vancouver, B.C.—"The Burrard Inlet is a splendid place in which to locate a floating drydock. I should prefer a floating to a graving dock, which was in fashion forty years ago, but which has since grown too small or become unadaptable because the shipping centre has moved away. But Vancouver really needs a floating dock," said Mr. James Fowler, of Seattle, Lloyd's agent for the Pacific coast, to the sub-committee on harbor affairs of the board of trade when discussing Vancouver's requirements in the matter of docks. Mr. Fowler recommended the erection of a floating dock, 12,000 to 15,000 tons weight, for Vancouver harbor. It should be 600 feet long, and there should be at least 90 feet between the towers. Such a dock would satisfy the needs of this port for many years. A structure at Seattle, built for the Seattle Construction Company, approximately of this size, cost about $650,000. But it was built in sections, a method of which Mr. Fowler disapproved. "For Vancouver especially, where there is just now no centre of shipping, a floating drydock, which can be moved up the harbor as wharves are built toward the east, is vastly to be preferred to a graving dock," said Mr. Fowler. "It can be built in one-quarter of the time, and its proportionate cost is less. The vessels can be docked and undocked much more easily. Lloyd's will insure a floating drydock at rates as low as graving docks. The difference in cost of upkeep is offset by the additional advantages." Mr. Fowler also drew attention to the floating drydock being constructed by the Grand Trunk Pacific for Prince Rupert. This is to be 610 feet long with 110 feet between towers. The committee appointed the chairman, Mr. Stone, and Mayor Baxter to be a sub-committee to interview the authorities of Canadian Pacific Steamship Service and to ask what will be their share in the establishment of a drydock for Vancouver.

Montreal, Que.—The administration of the St. Lawrence ship channel is likely to be attached to the inside service at Ottawa by legislation to be introduced next session. At present it is a part of the outside service. Sir George Murray in his report on the public service suggested direct control from Ottawa of the staff and works, upon which millions are being spent, and it is wholly probable that it will be followed out. There will also be legislation abolishing the pilots' corporation at Quebec, as was recommended by a commission which last winter investigated the pilotage system. Its report came too late to be acted on last session.

Ottawa, Ont.—The application of the Canadian Pacific Railway Company to the Government for authority to increase the company's capital stock by a further issue of shares to the par value of $60,000,000 is likely to be granted. The application has been before the Government since last August, but was not pressed last year in view of the alternative adopted by the company of issuing new stock last fall under the provisions of its charter legislation in regard to stock issues against branch lines. It is understood that the company does not wish to exhaust this method of further increasing its capital stock without recourse to Government sanction, and consequently authority for the next issue will be sought from the Government. Justification for such sanction is urged on the ground that the company is now carrying out a program for main line and general improvements aggregating $100,000,000. It is known that several members of the Cabinet are in favor of granting the application made by the company last August and which has never been withdrawn. Hon. Robert Rogers has frankly stated that he is in favor of Government sanction for the sixty million stock issue. He takes the ground that the greatest need of western Canada is better transportation facilities to keep pace with the rapid development of the country. If the C.P.R. wants to raise sixty million dollars more to spend on the road he sees no reason why the application should be refused.

Toronto, Ont.—A summary of the total expenditure on county roads for the year, according to W. A. McLean, Provincial Engineer of Highways, in his annual report, is as follows:—Road construction, $407,547.90; permanent bridges, $213,162.41; superintendence, $15,764.73; machinery, plant and equipment, $39,946.22; special county grants to townships, towns and villages, $18,821.26; toll roads, $16,830, making a total for the year 1911 of $712,072.52. Provincial grants of one-third of the total expenditure, in accordance with the Highway Improvement Act, amounted to $237,357.50, payment being made during the Provincial fiscal year 1911-12. County expenditure, or the remaining two-thirds, was $474,715. The roads graded, drained and metalled with broken stone and gravel amounted to 240 miles. The expenditure included the construction of 281 tile culverts, 155 other culverts of less than 10 feet span; and 113 bridges of more than 10 feet span. Culvert and bridge construction was all of a permanent type, using concrete tile and corrugated iron for small waterways; principally concrete for culverts of a larger size; and steel and reinforced concrete for bridges, piers and abutments being of solid concrete. Bridge and culvert construction largely proceeds in advance of actual road improvement, as in many cases, the immediate rebuilding of old and decayed wooden bridges on the designated county roads is imperative in the interest of public safety.

Traffic through the American and Canadian canals at Sault Ste. Marie for the 1912 season is recorded as follows: The total freight traffic of both the American and Canadian canals was 72,472,676 tons for the season of 1912, an increase of 36% over 1911. All items of freight show an increase when compared with the season of 1911, except coal, salt, copper and building stone. The total number of passengers was 66,877, a decrease of 13,074, and the passages through both canals numbered 22,778, a gain of 22% over 1911. Traffic through the American canal was 45% of the total freight, 55% of the total net registered tonnage, and 44% of the total number of passengers carried. Through the Canadian canal traffic was 55% of the total freight, 45% of the total registered tonnage, and 56% of the passengers carried.

CANADIAN PRODUCTION OF CEMENT.

The production of cement in Canada during the past few years, though all classed as Portland, has included an output of Puzzolan cement, made from blast furnace slag at Sydney, N.S., and a small production of "natural Portland," made at Babcock, Manitoba, 75 miles southwest of Winnipeg, on the Canadian Northern railway, according to the annual report of mineral production in Canada by John McLeish, B.A.

The total quantity of cement made in Canada during 1911, as per reports received from the manufactures, was 5,677,539 barrels of 350 pounds net each (993,569 tons), as compared with 4,396,282 barrels (769,349 tons) made in 1910—an increase of 1,281,257 barrels, or over 29 per cent.

The total quantity of Canadian Portland cement sold in 1911 was 5,692,915 barrels (996,260 tons), as compared with 4,753,975 barrels (831,946 tons) in 1910—an increase of 938,940 barrels, or nearly 20 per cent.

The total consumption of Portland cement in 1911, including Canadian and imported cement, was 6,354,831 barrels of 350 pounds net (1,112,095 tons) as compared with 5,103,285 barrels (893,075 tons) in 1910—or an increase of 1,251,546 barrels, or nearly 25 per cent.

The cement industry has been rapidly growing in importance, and its output is now exceeded in value amongst non-metallic products by coal and clay products only.

An average of 3,010 men were employed in 1911, the total wages paid being reported as $2,103,838.

The increase in annual production since 1905 has been nearly four-fold. The production per capita in 1911 was about 278 pounds, as against only 79 pounds in 1905. The approximate consumption per capita has increased during the same period from 115 pounds to 310 pounds.

A similar rapid increase in both production and consumption has taken place in the United States, where the annual production now exceeds 75,000,000 barrels.

PERSONAL.

Mr. A. N. BEER has been appointed assistant waterworks engineer of Ottawa, to succeed Mr. Storrie.

Mr. ALEXANDER LARIVIERE, who for some time has been connected with the Montreal Harbor Commission, recently resigned and has joined the staff of the Department of Roads, Province of Quebec.

J. T. HOWARD, B.A.Sc., has become associated with the F. W. Thorold Company, consulting engineers and contractors, as engineer. Mr. Howard is a graduate in structural engineering of the University of Toronto.

Mr. F. T. BOWRING, of Winnipeg, was a visitor at the office of *The Canadian Engineer* this week. Mr. Bowring is on an extended trip through the eastern provinces. He is a member of the municipal engineering firm of Bowring and Logan, Winnipeg.

W. CHASE THOMSON, M.Can. Soc., C.E., has opened an office in the new Birks Building, Montreal, as consulting engineer. Mr. Thomson will make a specialty of bridges and other steel structures. His experience in bridge and structural designing covers a period of twenty-three years, during which time he has spent three years with the King Bridge Company of Cleveland, Ohio; seventeen years with the Dominion Bridge Company, Limited, of Montreal; and the past three years as manager for Canada, with the Cleveland Bridge and Engineering Company, Limited, of Darlington, England. Mr. Thomson has contributed several articles to the engineering journals and has written two books: "Bridge and Structural Design" and "The Design of Typical Steel Railway Bridges," both of which are extensively used, both in colleges and engineering offices, throughout Canada and the United States.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.

The sixth semi-annual meeting was held at the Engineers' Club in Boston, Mass, June 25-28. Papers were presented on "The Power Plant," by Perry Barker, of Arthur D. Little, Inc.; "Relation of the Manufacturer to the Patent System," by Dr. W. M. Grosvenor; "Depreciation and Obsolescence," by R. K Meade; "Legal Control of Dangers to Health in Factories," by Dr. C. F. McKenna; "Some Peculiar Functions of the Retained Expert," by Dr. W. M. Grosvenor, and other papers.

COMING MEETINGS.

THE INTERNATIONAL GEOLOGICAL CONGRESS.—The Twelth 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 ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Sixth General Annual Assembly will be held at Calgary, Alberta, September 15th and 16th. President, J. H. G. Russell, Winnipeg, Man.; Hon. Secretary, J. W. H. Watts, R.C.A., Ottawa, Ontario.

CANADIAN PUBLIC HEALTH ASSOCIATION.—Annual Meeting in Regina, September 16, 17 and 18, General Secretary, Major Drum, Ottawa; Local Secretary, Dr. Murray, Regina.

AMERICAN ROAD CONGRESS.—Annual Session will be held in Detroit, Michigan, from September 29th to October 4th. Secretary, J. E. Pennybacker, Colorado Building, Washington, D.C.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Twentieth Annual Meeting to be held in Wilmington, Del., October 7th to 10th. Secretary, A. Prescott Folwell, 15 Union Square, New York.

UNITED STATES GOOD ROADS ASSOCIATION.—Convention will be held at St. Louis, Mo., November 10th to 15th. Secretary, J. A. Rountree, L021 Brown-Marx Building Birmingham, Ala.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Tenth Annual Convention to be held in First Regiment Armory Building, Philadelphia, Pa., December 9th to 12th. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

NATIONAL ASSOCIATION OF CEMENT USERS.—Tenth Annual Convention to be held in Chicago, Ill., February 16th to 20th, 1914. Secretary, E. E. Krauss, Harrison Building, Philadelphia, Pa.

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

THE WESTERN CANADA IRRIGATION ASSOCIATION.—Meeting to be held at Lethbridge, Alberta, on August 5th and 6th, 1913. Secretary, Norman S. Rankin, Calgary, Alta