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STREAM FLOW INVESTIGATIONS

NOTES ON METEOROLOGICAL PHENOMENA WITH REFERENCE TO GOVERNMENT POWER AND STORAGE INVESTIGATIONS OF THE BOW RIVER—FROM REPORT OF M. C. HENDRY, CHIEF ENGINEER.

THE various relations which exist between precipitation, altitude, run-off, temperature, evaporation, etc., make the study of stream flow exceedingly complex. While the influence of each is not in all cases a direct one it is frequently of such magnitude that to regard it lightly leads to inaccuracies of serious nature. In hydro-electric development work all factors influencing the discharge of the river or stream demand closest investigation over a period of years in order that question soon reveals the fallacy of this assumption, for the relationship is anything but simple, being influenced by a great many physical features of a rather indeterminate nature.

The collection of precipitation data all over the country has been carried on for a comparatively long term of years, whereas data regarding the run-off of streams are rather meagre. If, therefore, some general relation can be established between rainfall and run-off, the study

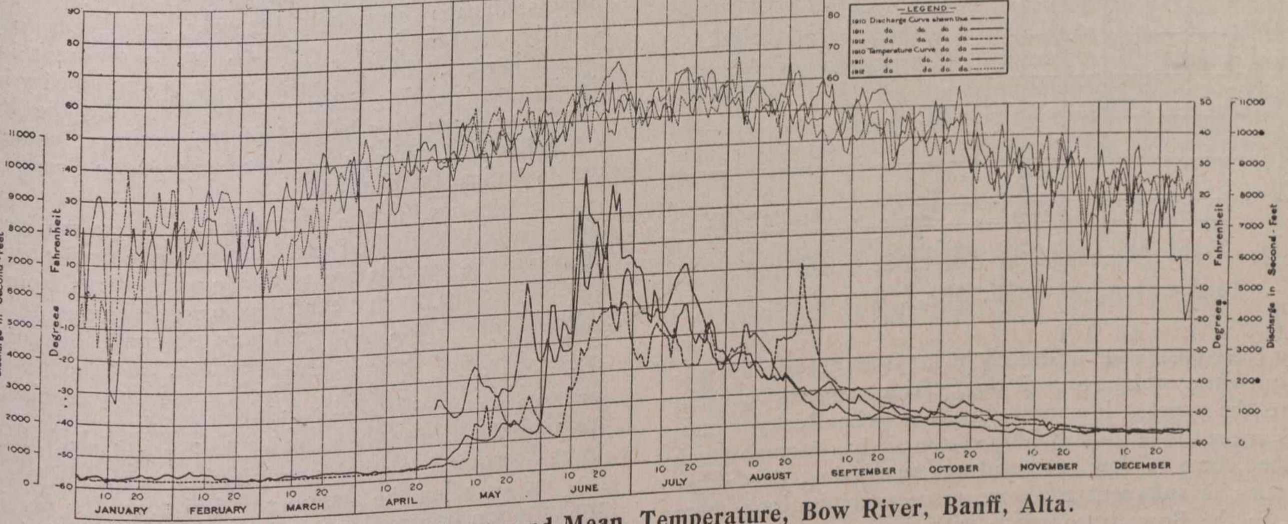


Fig. 1.—Daily Discharge and Mean Temperature, Bow River, Banff, Alta.

their valuable characteristics may be measured to a degree providing mathematical limits within which lie the data to form the basis of the proposed design. The value of an exhaustive study of these physical characteristics and their causes, is rightly emphasized by Mr. M. C. Hendry in his recent report on the power and storage investigations of the Bow River. These investigations were made by him under the direction of Mr. J. B. Challies, Superintendent of Water Powers in the Dominion. In our issue of last week the work which the Water Power Branch has accomplished on the water resources of the Bow River basin was chiefly outlined. The following notes respecting meteorological phenomena are from the above report.

The importance of a study of precipitation in connection with the flow of streams cannot be emphasized too much; its influence on stream flow is a very direct one and, without study, the erroneous conclusion is reached that the relation between precipitation and run-off is a simple one. A little time spent in the study of the of the streams from the standpoint of power production can be placed upon a more satisfactory basis. In the West, run-off data have been collected for a very short term of years, and only during the last three has a continuous record of the discharge been kept; thus the importance of a general relationship between recorded precipitation and run-off is all the more apparent.

The distribution of rainfall in any district or part of the country is not uniform. The records throughout Canada, generally, except in the eastern provinces, do not extend over a sufficiently long period, nor are the stations widely enough scattered to define areas in which certain amounts of rainfall may be expected. In the West, an examination of the available records seems to indicate a general conformation to conditions found to the south, in the United States; that is, that the lines of equal rainfall are generally north and south, or roughly parallel to the mountain ranges. There are, of course, divergences due to local influences.

Relation of Precipitation to Altitude.—Generally speaking, precipitation decreases with the increase in altitude. It has been found in travelling westward away from the Atlantic that as the country rises, the rainfall decreases. This general rule, however, does not seem to apply to the precipitation in the valley of the Bow River; in fact, the direct opposite is apparently the case in practically all the territory forming the eastern slope of the Rockies. An examination of the records will show that as the altitude increases on the eastern slope, the precipitation increases. Special local influences are at work here, however, the mountain ranges in which are situated the sources of the rivers, causing this reversal of the general rule.

The warm, moisture-laden winds from the Pacific are first intercepted by the mountains of the Coast range and deflected upwards to mingle with cold air currents or to come in contact with land at a lower temperature; becoming chilled below the temperature of saturation, they deposit some of the moisture as snow or rain as they pass over the mountains, giving rise to the heavy precipitation near the coast, the greatest recorded on the continent.

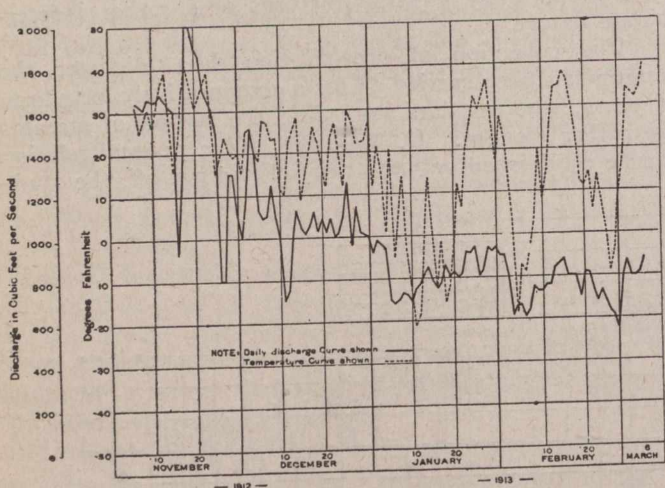


Fig. 2.—Daily Discharge (at Horseshoe Falls) and Mean Temperature (at Banff, Alta.), Bow River.

They then pass over a stretch of low-lying land, depositing but little moisture until the Selkirk range is reached, where the process is repeated. When the Rocky mountains are reached the humidity of the air has become much reduced, but the low temperatures reached at the higher altitudes is sufficient to cause more precipitation; therefore, in the Bow River basin, with which we are dealing and which is on the eastern slope of the Rockies, it is at the higher altitudes that the greatest precipitation occurs. The alteration of mountain ranges with stretches of country of low altitude is accepted as the cause of the arid and semi-arid regions to be found to the east of the continental divide.

Value of Records.—In making a study of rainfall in any district, it should be borne in mind that the average precipitation gives only a relative view of the question, as great variation from the average annual precipitation may occur at different points in the district. In this regard no general law can be made to apply. The number of conditions contributing are so great and variable that, for special purposes, a detailed study of the rainfall in the locality is necessary.

When studying precipitation records extending over a given period, it is necessary to know what value may be attached to them. Sir Alexander Binnie has given this question careful consideration in a paper published in the proceedings of the Institution of Civil Engineers (Vol. 109, pages 89 to 172). He reached the conclusion that for records extending over a period of 25 years, the mean obtained would be within 2 per cent. of the true mean. The conclusions reached by Mr. Rafter in a discussion of this paper were: that, for a period of 5 to 10 years, the probable extreme difference from the mean would be 15 per cent., and of 10 to 15 years, 4.75 per cent. Other authorities have expressed the opinion that it is necessary to have records for a period as great as 40 years in order that the mean may represent the true mean precipitation within 5 per cent.

Accuracy of Records.—In Canada, the recording stations are all under the direction of the Meteorological Service, and a standard method of obtaining the records is adopted. It is to be noted, however, that the placing of the recording instruments can have a very great influence upon the accuracy of the records. To arrive at the average precipitation upon a district, it is necessary that as many records as possible in the area to be considered should be available, as conclusions based upon records from a limited number of stations are liable to be considerably in error. An ideal condition under which to study rainfall data would be attained if the stations were uniformly distributed over the territory, or placed along each branch of the stream of which the relation between run-off and precipitation was to be established.

Distribution of Precipitation.—A study of the periodical distribution of the rainfall is interesting. Generally this distribution throughout the year, from year to year, is fairly constant in any district, but is different in different districts. For instance, there is a similarity in the distribution in the different localities along the Pacific coast; the same may be said of the territory to the east of the Rockies, while that portion around the Great Lakes has its typical distribution.

Tables showing the fluctuation in the annual precipitation recorded at Banff and Calgary have been prepared. At Banff, the records are available at intervals from 1890 to 1896, from which year they are continuous to date; during that period, the maximum precipitation occurred in 1902, 30.59 inches being recorded, and the minimum was 10.33 inches in 1903. The mean yearly precipitation for twenty years is 19.13 inches. At Calgary, the records are available from 1885 to date, during which interval the lowest recorded annual precipitation occurred in 1892, 7.91 inches being the amount; and in 1902, the maximum precipitation occurred, 34.57 inches being recorded. The mean yearly precipitation over the period of 27 years is 16.10 inches.

Owing to the scattered location of the recording stations in the district—at Banff, Calgary, and Jumping Pound (from the latter, only partial records are available)—they do not truly represent the conditions obtaining in the basin.

As has been mentioned before, the precipitation increases in this locality with the altitude. The altitude of the station at Calgary is approximately 3,400, that at Jumping Pound about 4,200, and at Banff 4,525 feet, and an examination of the records will show a greater precipitation at Banff and Jumping Pound than at Calgary, that recorded at Banff being the heaviest of the three. The sources of the Bow River and its tributaries are at much greater altitude than is the gauging station at Banff; in fact the greater part of the drainage area above Kananaskis Falls lies above this altitude, so that the stations are by no means representative of the greater part of the drainage basin.

Relation of Precipitation to Run-off.—If the records of precipitation are compared with those of the run-off on the basin, it will be found that the recorded run-off exceeds the precipitation as recorded at Banff, by as much as 25 per cent. This condition is by no means uncommon for mountain districts. Mr. John R. Freeman, in his report on the Hetch Hetchy water supply for San Francisco, says:—

"In regard to the excess of run-off over precipitation, the fact that depth of run-off exceeded depth of rainfall at outlet simply proves that the average precipitation for the catchment as a whole was far greater than at this comparatively sheltered spot of lower altitude at the outlet of the valley."

This condition holds in the Bow basin, and emphasizes the need of more stations for the recording of precipitation.

On account of the short period over which complete run-off data are available, and the few precipitation recording stations in the catchment area, no definite relation can be established between run-off and precipitation. The only conclusion that can be arrived at from a study of these data is that for the water years from 1909 to 1911, the mean precipitation has been nearly equal to the mean yearly precipitation for the last sixteen years, as recorded at Banff. It is fair, therefore, to assume that the run-off during the same years represent approximately the mean run-off conditions during a like period.

Division of the Year.—In considering the relation of precipitation to run-off, a period known as a "water year" is made use of, instead of the calendar year. This period for the Bow Basin district may be assumed as extending from October 1 until September 30, for practically all of the water is obtained from the mountains, and from October 1 on, the precipitation in the form of snow is stored in the mountains to be held until the warm sun of the following early summer releases it, to form the summer freshets which occur during May, June and July.

Temperature.—Temperature in the Bow River drainage area is one of the great factors influencing the discharge of the river. In the upper part of the catchment area there is not a month in the year in which frost cannot be expected. The range of temperature is great, the range of mean temperature at Banff is from 56°.9 in July to 13°.7 in January, or 43°.2 of difference; at Calgary, the range of mean temperature is from 70°.7 in July to 14°.2 in January, or a range of 66°.4; and the maximum and minimum temperature greatly exceed these. From these two records it will be seen that the one at the higher altitude registered the lowest temperature. At the higher altitudes it is to be expected that low temperatures will be encountered, and that the period during which conditions of low temperature obtain will be longer than at the lower levels. The records are taken at an altitude which is low, considering the drainage area of the Bow River as a whole, and hence do not represent truly conditions in the upper part of the valley of that river. They give, however, an indication of the conditions to be found and, upon study, reveal some interesting facts with regard to the bearing of temperature upon the discharge of the river.

Influence Upon Evaporation.—The influence of temperature upon evaporation is one which is constant and unmistakable, but is one for which, so far, no relation has been established. Sufficient data are not available for a study of the question in the district, but in passing it seems well to note the work that has been done in this regard, and which is well summed up in a paper by Mr. Rafter, published by the United States Geological Survey. In this paper Mr. Rafter had made a careful analysis of the available data, and he reached the conclusion that no definite relation exists between evaporation and temperature, but that the influence is a constant one, and cannot be disregarded.

Influence of Temperature on Discharge.—There is no other single condition which plays such a vital part, or has such a direct influence upon the discharge of the rivers of the district as temperature. A diagram (Fig. 1) has been prepared, showing graphically this relationship—the daily discharges of the Bow River at Banff have been plotted continuously, and on top of this has been plotted the mean daily temperature as recorded at Banff from April, 1910, to December, 1912. Another diagram (Fig. 2) has been prepared for the period November 6, 1912, to March 6, 1913, showing the mean daily discharge for the Bow River at Horseshoe Falls, and the mean daily temperature as recorded at Banff.

A study of these diagrams will reveal how direct is the influence of temperature upon the discharge of the river; during months of low temperature the discharge is shown to be low. On the other hand, high temperature corresponds to large discharge, although within the limits of the record, the highest temperatures occur in the month following the highest discharge. This can be explained by the fact that, except upon the mountains permanently covered, the snow has nearly all been melted during June and the early part of July.

The second diagram shows clearly that the influence of low temperature on the discharge is unmistakable. The period selected is that covering the low-water stage of the river, which corresponds to the period during which extreme low temperatures are most encountered throughout the interval covered by the curve. It will be noted that the mean temperature is above freezing on only eighteen days, consequently it affects not only the source of the river but also the actual flow in the river itself.

PORT ARTHUR WATER SUPPLY.

The new water supply for the city of Port Arthur, Ont., was turned on last week. The installation includes two 24-inch steel intake pipes supported by piles and extending from a point in the lake 2,550 ft. from the shore, and in 45 ft. of water, to a well at the pump house. The intake is 10 ft. above lake bottom. The plant is equipped with 3 pumps each of 2,880,000 gallons per day capacity. Each pump is operated by a 250 h.p. motor. Two 24-inch mains extend from the pump house to the corner of McDougall and Algoma Streets, and from here the water is conveyed by 12-inch pipes to the city mains. The 24-inch pipes provide for ample extension of the distribution system as future needs may require.

The system is equipped with a chlorinating plant. As to the quality of the water, the provincial board of health reports it to be free from bacteria, and in every way satisfactory.

The total cost of the work has been $585,000. It was divided into a number of contracts, the chief of which was awarded to the Thunder Bay Construction Co. This contract included the construction of the pumping station, the laying of the intake, and the driving of a 530-ft. tunnel through rock between the pumping site and the lake.

The work has been executed under the supervision of Mr. L. M. Jones, city engineer.

PUBLIC WATER SUPPLY FOR CITIES—SOME GENERAL CONSIDERATIONS.*

By W. H. Dittoe,
Chief Engineer, Ohio State Board of Health.

IN the modern sense the waterworks of a city includes the source of supply and the equipment required to deliver the water through a distributing system to the point where it is utilized. The development of public water supplies in accordance with this interpretation has been of comparatively recent occurrence. In the United States there were only 53 public water supplies in 1850. Since that date, however, the installation of public water supplies has been general and it is estimated that at the present time there are fully 6,000 public water supplies. Prior to the invention of pumping machinery for lifting water the development of water supplies was practically nil. In 1582 in London the first pumps for water supply purposes were placed in operation. An important development in assisting the installation of public water supplies was the introduction of the steam pump in London in 1761. An impetus in water supply development came in the latter part of the 18th century when cast iron mains were introduced as a means of distributing the supply. Previous to that time wooden pipes only had been used.

In the early development of water supplies little attention was given to the quality of the supply. It was not until 1829 that serious consideration was given to the quality of the water. In that year the first filter was installed for the East Chelsea Water Company at London. About 1850 the germ theory of disease was seriously advanced and it was at this time the claim was made that typhoid fever was caused by a specific organism transmitted in sewage. This marked the beginning of the use of filters as a sanitary precaution in the improvement of water supplies, although definite proof of the existence of the typhoid germ was not secured until 1880 and 1881. The early development was the so-called slow sand filter which is still now extensively used in European countries and also in the United States. It was not until 1893 that studies were made leading to the development of the so-called mechanical or rapid sand filter. This process is known as the American system of filtration, although its origin was in England. At the present time it is estimated that there are 350 municipalities in the United States utilizing mechanical or rapid sand filters to purify their water supplies. The slow sand filters have not met with such favor in this country due no doubt to the fact that they are less suitable in the treatment of muddy water. At the present time there are about 50 municipalities using slow sand filters in the United States.

Sources of Water Supply.—The original source of all water is the rainfall which precipitates upon the surface. A portion of this rainfall is absorbed by the soil and percolates into the underlying formations. Another portion flows from the surface through streams and rivers to their points of discharge. An appreciable amount is lost by evaporation and another portion is utilized in the support of plant life. The portions in which we are interested for water supply purposes comprise that which percolates into the soil, becoming a source of ground water supplies, and that which passes off into the streams, becoming a source of surface water supplies.

Ground water may be obtained by means of wells, springs, or collecting galleries. Depending upon the elevation of the ground water with relation to the surface of the ground, it will require one or two sets of pumps to deliver it into the mains. The quality of ground water is dependent upon the formations from which it is obtained. Thus, by passage through a limestone formation the water will absorb hardness. If it comes in contact with iron salts, which are almost always present, it will absorb the iron by solution. It may also take on objectionable tastes and odors due to the absorption of sulphur compounds. In general, ground waters are less desirable than surface supplies, judged from their mineral characteristics.

Surface water supplies are derived from streams, lakes or reservoirs. With lakes or large rivers it is unnecessary to provide storage of raw water for a continuous supply for the pumps. With small rivers and creeks, however, it is frequently necessary to construct impounding reservoirs to store a sufficient portion of the excess flow of the stream to serve during dry weather. The quality of surface water supplies is dependent upon numerous factors, the most important of which is the density of population upon the drainage area. Theoretically every dwelling on the drainage area contributes to the pollution of the stream. The degree of pollution is, therefore, determined by the population. It is, of course, possible to reduce the extent of pollution by proper disposal of sewage. Regardless of the treatment of sewage, however, it is generally conceded that no surface supply collected from a catchment area which is populated is safe for drinking purposes without purification. This is particularly true in Ohio and in other densely populated localities where the streams are almost universally used as carriers of sewage.

Conditions Governing Choice of Source of Water Supply.—Statistics of public water supplies of United States show that a large percentage of the supplies are obtained from ground water sources. Practically all of the villages and small cities of Ohio obtain their supplies from wells, springs or collecting galleries. As the population increases, however, it is found that the ground water supplies will not furnish a sufficient quantity of water. Of the cities in Ohio with populations of 25,000 or more, five obtain their supplies from wells and nine are provided with water supplies of surface origin. Four of the well supplies are inadequate and two of them are supplemented by surface water. The indications are that unless unusually favorable conditions are encountered a city of more than 25,000 population must depend upon a surface source of water supply. In any case the most serious consideration must be given to the question of quantity in determining the choice of a ground or surface source of water supply.

It may be stated generally that the fundamental condition governing the choice of the water supply is the quantity available. It is obviously unwise to develop a source of supply which within the life of the installation will fail to furnish a sufficient amount of water. In determining upon the quantity available assumptions must be made to estimate the growth of the city and the increased use of water. The quantity thus determined must be supplied during the most extreme dry weather conditions which can be anticipated. It is not enough to supply a sufficient quantity of water for 350 days of the year and meet a deficiency during the remaining short period.

Of almost equal importance to the question of quality is the quality of the supply. Having two supplies pro-

*Read before Conference of Health Officers, Ohio State Board of Health.

posed equal as regards quantity available, the quality consideration will determine the selection. Troubles associated with poor quality are not confined to surface water supplies but are also experienced in water from ground sources. With the established modern methods of water purification it is probably true that improvement of the quality of surface water supplies is more easily accomplished than is the improvement of quality of an objectionable ground water supply. In the consideration of quality it is well to give attention to the value of pure water. It has been shown that improvement of the hygienic quality of the water supply fully repays the community in many ways for the expenditure incurred in the establishment of a water purification plant. The saving of lives and reduction of morbidity from typhoid fever alone will reduce the expenditures of the citizens of the community to such an extent as to repay within a few years the financial outlay for a plant. Thus it can be shown that the city of Columbus has saved for its citizens over $500,000 per year since its water purification plant was established. Cincinnati has saved for its citizens $1,750,000 per year by purifying its water supply. In like manner it can be shown that it is economical to provide a soft water supply for a city even at a greater expense than would be incurred in the development of a water supply containing objectionable hardness. Modern standards of purity of a water supply require that its physical hygienic and chemical properties be satisfactory. Using this standard a pure water supply is an asset and an impure water supply an expense to a community.

Another consideration to be given in selecting a source of water supply is the cost of its development. It frequently happens, however, that a source of supply costing more to develop is the more economical selection. It will readily be seen that a supply cheaply developed which does not furnish an adequate quantity is really an expensive selection. It is well to keep in mind that the cost of development is purely relative, and within the financial limits of a community consideration of cost must be subservient to those of quantity and quality.

Purification of Water.—Having decided upon the development of a water supply which is not of satisfactory quality in its raw state, some means must be provided to produce a water of good quality. If the water is obtained from wells it may require aeration, softening and iron removal. The softening of water is expensive in proportion to the original hardness. Few attempts have been made in this country to soften well water supplies of municipalities. Aeration and iron removal are, however, well recognized methods of water treatment to improve the quality of ground water supplies. In Ohio we have about six plants for the purpose of reducing an objectionable iron content.

The purification of a surface water supply may be brought about by one or both of two general methods, namely, filtration and disinfection. Purification by storage and sedimentation has been advanced as an efficient means of correcting the pollution of water supplies but thus far has gained little recognition. Filtration improves the physical quality of the water as well as its hygienic quality. Disinfection removes the pathogenic organisms but does not affect the appearance of the water. It will, therefore, be seen that the field of disinfection as the only treatment is confined to water supplies of good physical quality. There are two well-known methods of filtering water. The first and older process is the so-callled slow sand filter and the other, a more modern method, is the so-called rapid sand or mechanical filter. As has been stated, the slow sand filter is a development of the early part of the nineteenth century, while the rapid sand filter has come into use during the past thirty years. The slow sand filter is more applicable to the treatment of a moderately clear water while the rapid sand filter can successfully treat a very muddy or turbid water. The slow sand filter consists of a watertight basin usually one acre or less in area, provided with suitable underdrains over which is placed the filtering material. In the northerly climates it is customary to provide a roof for the filter. The filtering material comprises three feet or more of sand, resting upon gravel surrounding the underdrains. The water to be purified is applied at the surface of the filter. It fills the voids of the filtering material and stands to a depth of about three feet above the surface of the sand. Its flow through the sand is controlled so that it passes downward at a rate of 0.4 foot per hour, corresponding to 69 gallons per day per square foot of area or 3,000,000 gallons per day per acre of area. This is a low rate of filtration. The water passing through the filter is stored in a reservoir from which it is pumped to the distributing system of the city. The mechanical or rapid sand filter differs from the slow sand filter in the preliminary treatment of the water as well as in the rate of filtration.

The rapid sand filter is a development of the last thirty years. It first attracted attention in 1885, when a plant of this type was constructed for the treatment of the water supply of Somerville, New Jersey. For the first fifteen years it was principally used in the treatment of water supplies for industrial use, such as paper mills and allied industries. In 1902 the first large municipal rapid sand filter plant was constructed for the East Jersey Water Company at Little Falls, New Jersey. Since that time the development of rapid sand filters in the United States has been very important. Among the largest plants in the country may be mentioned those at Cincinnati, New Orleans, Louisville, Columbus, Toledo, Harrisburg, Minneapolis, and Grand Rapids. The cities of Cleveland and St. Louis are now constructing plants of the rapid sand type.

The rapid sand filter plant differs from the slow sand plant in many respects. With the use of a rapid sand plant the water is always given preliminary treatment by a coagulant. It is passed through filters of much smaller area at much higher rates. Roughly speaking, the rate of filtration is forty times that used for the slow sand filter. The filtered water is received and stored in a covered reservoir in the same manner as is the case with slow sand filters. The cleansing of the rapid sand filter is accomplished by a reverse current of filtered water passed upward through the sand removing the layer or silt and coagulant collected at the surface. This differs from the cleaning of a slow sand filter, which is usually accomplished manually or by mechanical means.

The principal features of a rapid sand filter plant are the intake and low lift pumping station, the primary sedimentation basins, the coagulation basins, the filters and the clear well. The raw water is received through the intake, elevated to the primary sedimentation basins by the low lift pumps, and from this point passes by gravity through the plant to the clear well.

Primary sedimentation is required for turbid water carrying large quantities of silt. Thus the Cincinnati and Louisville plants have large basins where the water is allowed to settle for several days before it is passed through the purification plant proper. The use of primary sedimentation basins is not always required.

The coagulation basins are provided with a two-fold purpose, namely, to furnish a period for the reaction of the coagulant in the water, and for partial sedimentation of the suspended matter. The chemicals generally used as coagulants are alum and copperas. Alum, or aluminum sulphate, is readily soluble in water and if applied in proper proportion to the ordinary surface water will form a sticky gelatinous precipitate called the floc, which in its formation collects the suspended matter and bacteria into heavy masses which readily precipitate. The action of copperas, or sulphate of iron, is quite similar, but this compound requires the addition of lime or soda ash to bring about coagulation. Where alum or copperas are used a portion of the coagulant will pass through the coagulation basins to be removed from the water at the surface of the sand in the filters. Coagulation basins are designed to furnish an ample period for the formation of the floc and an additional period for its partial settling. The necessary time required for this purpose varies with the character of the water to be treated. The modern plants which have been installed in Ohio provide periods ranging from three to twelve hours in the coagulation basins.

The water containing a small portion of the floc next passes through the filters. These are generally constructed as rectangular concrete boxes. A 1,000,000-gallon per day unit will have an area of about 360 square feet. Large plants are laid out with units having a capacity of from 2,000,000 to 5,000,000 gallons. The bottom of the unit is covered with a strainer system over which is placed a layer of graded gravel which supports the sand layer with a thickness from 30 inches to 3 feet. The water is applied at the surface of the sand over which it stands to a depth of two to four feet. It passes downward at the rate of 16 feet per hour, which is equivalent to 2,880 gallons per square foot per day or 125,000,000 gallons per acre per day. The rate of passage of the water through the filter is of prime importance in securing proper efficiency. This rate is regulated and controlled by the use of apparatus which prevents excessive rates of filtration, still permitting the use of the head necessary for operation. The efficiency of the rapid sand filter depends largely upon the collection of the floc at the surface of the sand. This gelatinous substance forms a mesh through which the suspended matter and bacteria contained in the water cannot pass. The resultant effluent from the filter is therefore purified, clear and sparkling. After the filter has been in operation for a certain length of time, depending upon the condition of the applied water, it becomes clogged and will no longer pass the proper quantity of water without excessive loss of head. It is then necessary to wash the filter. This is accomplished by passing purified filtered water through the strainer system and upward through the sand at a velocity of vertical rise of 15 inches or more per minute, the overflow being carried from the filter box through a gutter and connection to the sewer. The washing requires about five minutes and in large plants entails a loss of water of about two per cent. of the water filtered.

Whatever method of filtration is used, the purified water must be stored in covered and watertight receptacles to protect it from secondary pollution. It is customary to construct a clear water reservoir adjacent to and as a portion of the filter plant, where the purified water may be stored before it is pumped into the mains. The size of these clear wells is dependent upon (1) the relation between the capacity of the filter plant and the daily consumption, (2) the period of pumping, and (3) the storage provided on the distributing system.

What Filtration Accomplishes.—The filtration of a public water supply accomplishes beneficial results which can be with difficulty measured. The apparent result, which is appreciated by the citizens of a community in general, is the greatly improved appearance of the water. Instead of a muddy and often foul liquid a clear and sparkling fluid is drawn from the tap. The ordinary operations of the household are facilitated and the people are generally well satisfied, whereas frequent complaints against the previous condition of the water had been received. The most important result of filtration of a public water supply is the improvement in health conditions. Normally it may be expected that the introduction of a filtration plant will accomplish a reduction of 75 per cent. in the mortality from typhoid fever. The reduction at Cincinnati has been over 90 per cent. and at Columbus over 80 per cent. Accompanied with the reduction in deaths from typhoid fever there is also a noticeable reduction in deaths from general causes. It has been universally observed that the reduction of typhoid fever immediately follows the installation of a filtration plant.

Of lesser importance than the benefit to public health the financial advantage resulting from the purification of a water supply receives some recognition. With a water supply of good appearance and of satisfactory quality the inhabitants of a city will use it universally. This will increase the income of the waterworks department and will in turn decrease the cost of furnishing water. Each individual who uses a purified water supply will derive a financial advantage over the use of a polluted and muddy water. The saving resulting from the improvement of the physical quality of the water is also important and will in time assist in paying for the treatment of the supply. It has been previously shown that the saving of lives by the reduction of typhoid fever is amply sufficient to pay for the cost of purifying the water. Considering the question from a financial aspect alone and without regard to humanitarian considerations, a city provided with a water supply of poor quality can ill afford to maintain it without improvement.

SOOKE LAKE WATER SUPPLY.

The engineering staff of the Sooke Lake waterworks project for Victoria (see *The Canadian Engineer*, July 23rd, 1914), reports that a length of 6 miles of the 10¼-mile steel pressure pipe line has been laid, and that the most difficult portion of the route has been dealt with. It is expected that the whole pressure main from Humback reservoir to Smith's Hill service reservoir in the city will be completed in January.

The reinforced concrete flow line, 27.3 miles in length, has been laid for a length of 14 miles, or over half its distance. By the end of the year it is expected that the contractors, The Pacific Lock Joint Pipe Co., will have another four or five miles in position. To date the rate of laying has averaged 3½ miles per month.

The tunnel work within the city limits has progressed very favorably, the third tunnel being practically completed.

REPAIRS TO RIDEAU CANAL.

The Deputy Minister of Railways and Canals has announced that improvements to the extent of $50,000 will be made by the government on the banks of the Rideau Canal. The canal will be unwatered at an early date for this purpose.

THE CONSTRUCTION OF DAMS.*

By A. E. Walden,
Chief Engineer, Baltimore County, Water and Electric Co.

THERE are many things to be considered in designing dams, and especially one of the commonly called "gravity type," or, rather, of the solid masonry type, which will be here called the mass type; the gravity type will be that as constructed by Beardsley and Ambursen and Ransome.

In making examination of a dam site, test pits or borings should be made for a good distance above the dam site to determine the composition of the soil or strata under the dam, the trend of the stream, if on rock, noting if these are at right angles to the stream or with the stream, and if the stone is subject to water holes; also the character of the ledge, whether seamy or not, and if it shows rapid disintegration where exposed to the atmosphere, and if under water, that it is easily worn away by the action of the water, as in some limestones.

In some cases it will be found that in the bed of the river there are two classes of stone, one portion of which is soft and the other hard.

A careful examination of the banks should be made for suitable abutments and abutment foundations, and the quality of the soil composing them; also the slope of the underlying rocks, so that steps may be taken to prevent seepage through and eventually a washout.

There are several ways that have been employed by engineers in determining the proper length of crest, all of which are more or less efficient when properly applied,

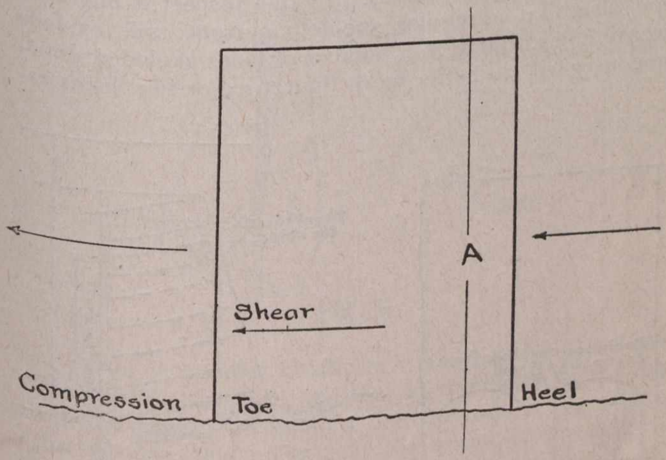


Fig. 1.

as are also certain empirical rules, where run-off data cannot be obtained, such as basing the run-off on a certain number of feet per second per square mile, certain instances of which will be given here.

In one case that came to the writer's notice the dam was constructed on a basis of three feet of crest per square mile of area which is hilly and steep, based on a rule that there should be on normal conditions at least one foot of spillway length for each square mile of drainage area, and this multiplied by three can take care of flood conditions. This dam failed many times, causing great property damage, but was finally constructed so that the spillway section would have a crest equal to taking the run-off at 20 cu. ft. per sq. mile at a velocity of one foot, and dividing this result by an assumed depth at the crest, considering it as a rectangular section, no allowance being made for the well-known weir action and of velocity of approach over such a crest. No trouble has since been experienced. This determination was made after an examination of the stream's banks for height of water, its depth at this point as compared with the width and depth of water at other points and for several hundred feet above and below; also noting the heights to which débris had landed; from information given by people living along the stream as to flood heights; from the drainage area and from rainfall data which had before for some

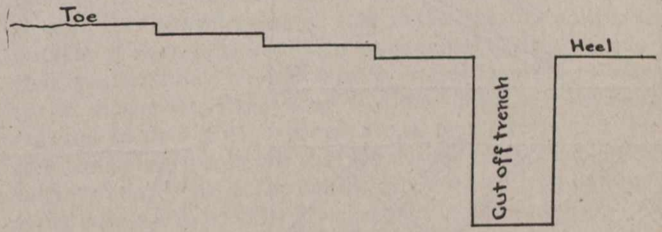


Fig. 2.

reason given results too small, to some extent probably due to the character of the drainage area, its topography, and the condition of the soil at certain times.

With 20 cu. ft. at a velocity of one foot per second and the banks 5 ft. high, it was assumed that the water reached 5 ft., but with 20 cu. ft. used as a basis and the dam lengthened to 146 ft., and estimating a crest depth under these conditions of 3 to 4 ft., this stream has since been measured for surface velocity during high water and an average velocity, on the surface, of 10 ft. per second obtained, with a depth of 20 in. at a point far back of the crest so that the increased velocity of the water at the crest of the dam did not affect it. Undoubtedly the velocity of the water varied at various depths, but this could not be obtained.

Assuming the average velocity at 10 ft. per second, and a sectional area of 146 ft. by 20 in., the approximate discharge per square mile in this case was 99 cu. ft. per second, and the greatest depth of water so far noted on the crest of this dam has been 3 ft. It is possible under these conditions that the velocity was from 15 to 20 ft. per second, but this could not be measured at the time, on account of lack of preparation.

In another case a dam was constructed for a crest depth of 5 ft. for a drainage area of about 300 sq. miles. This dam was 200 ft. long at the spillway, with about 1,000 ft. of earthen embankment about 18 ft. higher than the spillway section. The 5 ft. depth at the crest has been exceeded many times, and the gauge has shown a depth of 11½ ft. on the crest, which was beyond data based upon the government report's gauge readings at that time, and would be about on the approximate basis of 7 cu. ft. per second per sq. mile.

From an examination of many streams, watersheds, and dams, it would seem that one may expect to find that the run-off will vary from 50 to 100 ft. or more per second, and in some cases it has been considerably more than the maximum amount noted for a hilly section, that will give a quicker crest rise than a flat section will do, owing to the fact that the water cannot spread over any large area.

It may be assumed that a certain portion of the flood reaches the crest in the first hour, a certain portion in the second hour, and so on to five or six hours, or more, but this cannot be accurately determined beforehand with the data we have to-day.

Every effort should be made to obtain data from other dams on the same watershed, if any, or on similar water-

*From a paper read before the New England Waterworks Association, September, 1914.

sheds in the vicinity, as to the rise in a given length of time after a heavy rainfall, so as to determine the lapse of time between either the beginning or the maximum rainfall and the maximum crest rise. Rainfall data show that a maximum rainfall of 4 in. in one hour may be looked for, and from 8 in. to 10 in. in twenty-four hours. On this basis there would fall for each square mile in the first hour, 9,288,800 cu. ft. (1 in. equals 2,322,200 cu. ft.). Then the question would arise as to what part of

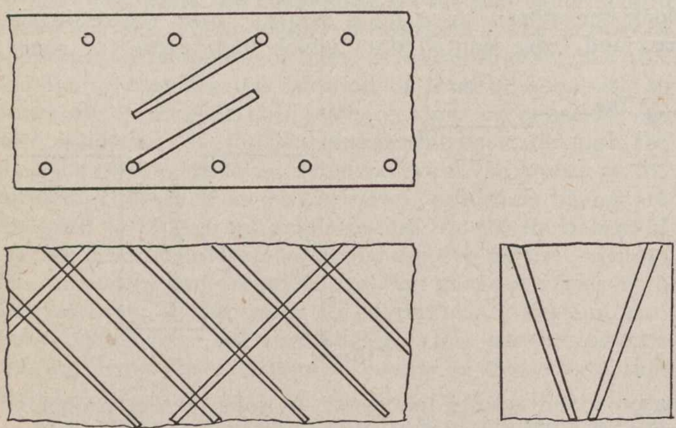


Fig. 3.—Method of Drilling.

this reaches the dam the first hour, and each succeeding hour until the maximum crest height is reached, and the effect the condition of the soil and the ground water content has on this. From J. B. Francis' records, the indication would seem to be that a depth of rainfall varying from 6 in. to 11 in. or more, with rates about as follows, may be looked for: 4 in. in two hours, 6 in. in about twenty hours, and 9 in. to 10 in. in thirty hours, etc.

For the rainfall and flood conditions, Fanning's formula has been much used, as well as others, but must be applied with care for the particular location, the period of the year in which the rainfall occurs, as on frozen ground or with a light fluffy snowfall it requires 15 in. or 20 in. to equal 1 in. of rainfall. While assuming 4 in. to 5 in. of wet soggy snow to equal 1 in. of rainfall, the rainfall combined with the water from the melting snow with the frozen ground underneath will give quite sudden changes in the flood conditions, which will exceed any rainfall obtained from hourly rainfall records; recording gauges at dam, however, would show this.

The effect of impoundings or pondage in reducing flood conditions, if the area is sufficient, where there is one or more dams above the one to be designed, should be considered. The crest of the dam under design should be proportioned to care for the failure of at least one, or more, of these dams in addition to that of flood conditions, depending on the location of towns and villages below, and the property value and loss of life likely to occur in case of such failure.

In the design of a dam of the mass or solid section type, as shown by section, Fig. 1, the dam may be considered as a beam fixed at one end and having an uniform load, and as such may have shear at the joints, tension in the upper face and at the heel, with compression at the toes, etc.

Then to care for tension in the upper face, steel may be provided, but its calculation would be to some extent theoretical. In any event, if securely anchored to the rock formation in drilled holes, and the steel provided with split ends and wedges, and afterward grouted in carefully, this method would certainly add to the stability of the dam, especially when the dimensions were properly proportioned to care for shear. Steel bars may be embedded at an angle of about 30 degrees, as shown in Fig. 4, or some other angle, with the horizontal so that the steel will take tension as far as it is possible to make it do so under these conditions.

In preparing the foundation, care must be taken to remove surface rock that has deteriorated, to a depth that test holes show to be safe, and then the surface under the dam should be roughed, either toothed or sawtoothed, or in a similar fashion, so that pressure will tend to force the dam downstream and against the toothed or roughed surface, as shown.

This work should be carefully performed, either by the use of dynamite or steel points and wedges. But dynamite should be used in the hands of an experienced man, who understands placing shots. Especially is this true of the cut-off wall at the heel, for if such placing is done it should be carried out in the manner described.

Care should be taken to so set the upper drill holes to line for a narrower cut than is required, then removing the shattered stone by wedges and points, as it is necessary that the cut-off wall should not be shaken to such an extent that there will be liability of leakage to the downstream side.

A careful note should be taken to see if seams run at right angles with the stream, or partially with the stream; also the character of the stone and of any change in the composition, as there are cases where there are one or two different rock formations in the same river bed.

One or two test holes should be exploded with various charges, at some other point, to determine the proper charge to be used, but vertical holes should not be used, unless absolutely necessary. In this respect it might be said also that a regular 500-volt current will explode twenty holes, and such a number of holes exploded simultaneously will do better work than three or four holes ex-

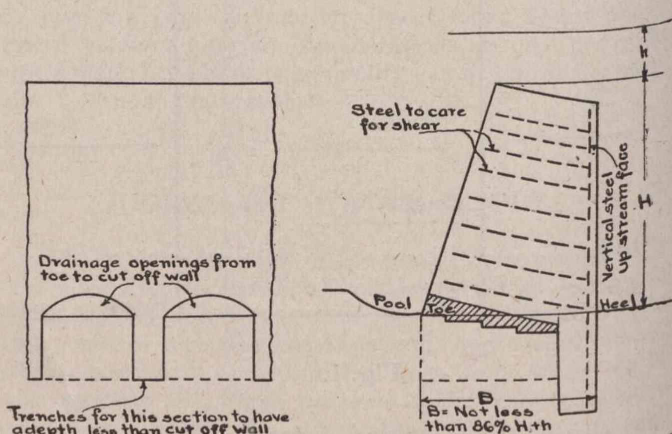


Fig. 4.—Solution of Solid Dam Showing How the Arch Can be Used for Drainage from Cut-off Wall to the Toe.

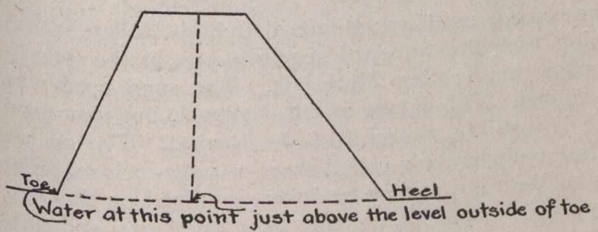
ploded at a time. Holes may be placed as described below:—

Holes running with trench on each side, about 4 ft. apart and at an angle of 45 degrees, with extra holes at each end at same angle, looking the other way. The depth of these holes will depend on the depth of trench required and the width of the same. In addition to this, holes may be drilled from side to centre as shown in the end section, Fig. 3.

The writer has seen trenches cut in this manner, by men who understood tunneling and channeling, that would meet the conditions required in every respect.

Test holes should be drilled to sufficient depths, 10 to 20 ft., more or less, to be sure that no seams or underlying strata of clay underly the rock, and tested with compressed air or water to at least 100 lb. pressure, and pressure maintained for such a time as will surely determine the condition in these test holes. Shale formations are liable to large seams; overlying strata of clay and limestone formations to water channels or recesses. The holes should be drilled from 10 to 15 ft. apart, more or less, depending on the conditions found to exist.

There seems to be no reason why solid section dams should not be constructed in the form of arches that extend from the toe to the cut-off wall, and the spaces under these arches would effectually care for any uplift due to water seeping through or under the dam, supports to the arches, or haunches of the arches, of course, being carried sufficiently below the surface to effectually protect them from wash and undermining, and would be more satisfactory than large pipe placed 8 to 10 ft. apart, more or less. Or 10-in. split tile may be employed for this purpose, which would be more satisfactory than a solid tile, but in any event should be covered with loose stone so as to allow free access to the tile from all sides.



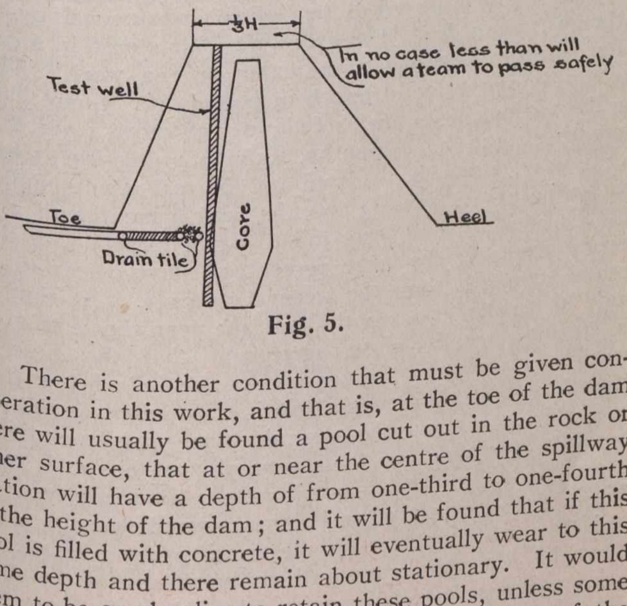


Fig. 5.

There is another condition that must be given consideration in this work, and that is, at the toe of the dam there will usually be found a pool cut out in the rock or other surface, that at or near the centre of the spillway section will have a depth of from one-third to one-fourth of the height of the dam; and it will be found that if this pool is filled with concrete, it will eventually wear to this same depth and there remain about stationary. It would seem to be good policy to retain these pools, unless some other method were taken to care for the action of the water at this point. Some types of dams would probably be less affected than others.

The solid dam may be reinforced and tied to bedrock in the cut-off portion, as described before and as shown here, and thus would take tension in the upstream face of the dam, in addition to which the diagonal bars at some angle would tend to take the tension due to sheer and prevent any tendency to sheer in the horizontal plane, or where new work was tied to old, in case that the joint was not properly cleaned.

The trenches for the haunches for the supports of the arches should have a depth at least equal to the pool and the cut-off wall, preferably somewhat below this. These arches should extend back to the cut-off wall, which should be made sufficiently strong for the purpose, and will give a more efficient drainage than it will be possible to obtain with pipes of any kind.

Referring to the earthen embankment as employed at the abutment ends of some dams, the following construction was employed by the writer, and tests carried on every day for several years to see if there was any increase of the water in the test well (Fig. 5) but no increase was found.

Again, from the core out to the toe every 20 ft., double lines of porous drainage tile were laid from the double line of tile that skirts the core to the double line that skirts the embankment just under the toe and to the outside of the embankment to some suitable disposal plant that would allow of the amount of water running to waste to be measured, from time to time, these drains being covered in turn with crushed stone to a depth of 6 in.; the reason for this being that the writer excavated on one such embankment to the centre of the same, the embankment being composed of a gravelly soil, and found no water until the centre of the embankment, or core, was reached, showing that the drainage kept the embankment dry from a point above the centre to the outside.

As before stated, the surface or foundation on which the dam or embankment is to be constructed should be excavated either in trenches or as shown, as this gives the foundation a greater frictional or sheering resistance.

Table I. gives data on dams, the depth and velocities of waters at the crest for which these were designed; and the actual depth obtained will give an indication of the conditions as they actually exist.

TABLE I.

1	4,185	8.5	9	16.5	1,000	50
2	4,475	8.5	13.5	14.4	1,000	50
3	3,085	...	16.4	18	1,000	..
4	1,545	8	8	9.5	890	60
5	7,000	...	6	....	318	..
6	19,600	...	12 and 5	....	1,500	..
7	66,000	...	12	10	700	..
8	1,380	...	7	2.2	400	..
9	5,760	...	15	12	1,078	..
10	400	...	5	3.6	120	..
11	3,560	...	(Could stand 9; stand flood of 50,000 sec. ft.)	4.4	1,108	..
12	15,800	...	15	....	480	..
13	16,600	...	15	....	500	..
14	1,270	...	5.5	8	260	..
15	.....	...	...	....	....	..
16	26,766	...	17.5	....	2,350	..
17	300	...	5	11	200	..
18	320	...	5	8	119	..

Dam No. 18 was designed to care for 4,400 sec. ft.; had a total crest length of 450 ft. and a spillway section of about 120 ft., and under flood conditions water rose 8 ft. above spillway section and 3 ft. over the crest, the estimated discharge being 14,500 sec. ft.

There is one other point in the case of gravity dams (Fig. 6) in that the factor of safety of 4 for deck loads has been used, but consideration should be given the following sketch (Fig. 6), also the cost of such work. It is manifestly certain that no load will ever be obtained that would stress the deck to call for a factor of 4, or even a factor of 2, and that a factor of $2H$ would be amply safe even for ice, as with a sloping deck such a factor would protect it from floating blocks or a plane of solid ice, as the blow would be glancing; and again, the silt which fills in on the deck would act as a cushion. Then again, floating objects are most apparent at flood when the water on the crest is deepest, which would tend to carry these floating objects safely over the crest. And in any event, the stress in the material would not exceed the normal load stress effect. It may be said that load stress is uncertain. This may be true of some dams.

Now, the writer is not advocating a construction that would be unsafe under any consideration, but that more careful consideration be given these conditions on account of cost in a safety factor for loads that would be both safe and economical in so far as the cost of material and construction were concerned, but without going to extremes for a condition that will never be reached.

Records should be kept of the depths of the waters on the crest of the dams at all times, and the cost of an efficient instrument for this purpose is small. Such records, together with the records for rainfall, depth of

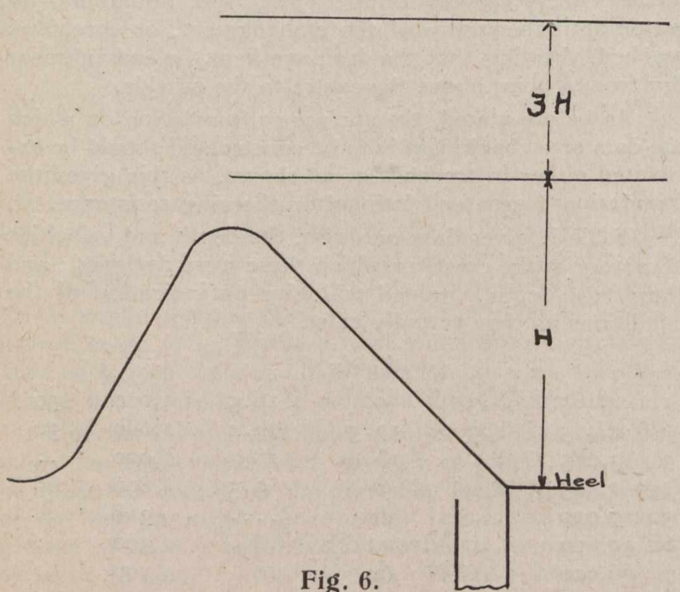


Fig. 6.

rise on the crest of the dam and the time relative to the maximum rainfall, would give data that would be invaluable, in a short time.

Records should also be kept of the soil strata through which excavations for test pipes and test holes pass.

The question of frost at times may have to be considered.

Every available record should be used to determine the run-off from the rainfall on a given watershed, as the run-off and the time of the maximum run-off are affected by so many conditions that there should be as few guesses as possible, and even the records should have a reasonable percentage added.

IMPROVEMENT WORK IN VANCOUVER.

The following is a summary of the street work during the past year in the city of Vancouver, according to a recent report of Mr. F. L. Fellowes, City Engineer. The various works are given in miles:—Pavements, 6.98; concrete sidewalks, 8.78; curbs and gutters, 1.44; curbs, 2.54; gutters, 4.41; clearing and rough grading streets, 11.79; clearing and rough grading lanes, 8.93; clearing and rough grading boulevards, 0.33; grading streets, 20.65; grading lanes, 3.26; grading boulevards, 11.89; rocking streets, 12.24; rocking lanes, 4.45; planking streets, 16.19; planking lanes, 5.87; three-plank walks, 18.03; sanding and oiling streets, 46.88.

BLAST FURNACE SLAG IN CONCRETE.

With the rapid growth of concrete construction, the advantage of blast furnace slag as an aggregate in reducing the dead weight has made a strong appeal to many engineers. The result has been that the building codes of several large cities have permitted the use of furnace slag equally with any other material ordinarily used for aggregate. An extended series of tests involving the manufacture of five hundred 6-in. cubes, 100 of these to be crushed at each of the several periods, 28 days, 3 months, 6 months, 9 months and one year, has been recently undertaken. Commenting upon these tests the Iron Trade Review states that as the work progressed, results were such that the number of cubes tested at the 9-month and one-year periods was reduced to 50 each, and it is proposed to crush the remaining 100 cubes at 6-month intervals up to 6 years, 10 cubes at each period. The materials used in the test were all produced commercially, and the work of making the specimens was no better than under ordinary field conditions of construction. Thorough mixing was assured, the work being done by hand.

The cement used was standard Lehigh Valley brand, complying with the standard specifications of the American Society for Testing Materials. The sand used was Jersey gravel. This is not an ideal gravel, but was used because it was the material of the market. The coarse aggregate commercially called three-quarter-inch material all passed the 1¼-in. sieve and were retained on the 1½-in. sieve. All material was in the proportions one part cement, two parts sand and four parts coarse aggregate. The concrete was mixed to the ordinary work consistency, rather wet than dry. The cubes were air stored in a dry cellar, being sprinkled with water once a week. The average compressive strength in pounds per square inch for the various tests are as follows: 28 days, 1,561 lb.; 3 months, 1,952 lb.; 6 months, 2,589 lb.; 9 months, 2,841 lb.; 1 year, 2,797 lb. A study of the test results shows that while at 28 days, 3 months and 6 months, if the number of individual tests fail to agree closely with the general average, the large percentage show considerable greater strength than the general average. A similar study of results at 9 months and one year shows that of the results not in close agreement that the general average, a somewhat larger percentage falls below this general average than runs above it. However, as the results which are above the general average are much more above the average than the low results are below, it may be assumed that the average results are conservative. This is more evident when it is considered that the sand used was not what could be considered as first-class material. Also, the comparatively small size of the slag aggregate must have lowered the strength of the concrete.

The findings seem to point that slag may be employed as an aggregate in competition with broken stone or gravel, since the crushing strength of broken stone or gravel concrete, made under ordinary field conditions, will not generally average much over 1,500 lb. per sq. in. at the age of 30 days. From the actual strength of the concrete developed in these tests, its weight per cubic foot, the recognized solubility of slag which permits it to act as a puzzolanic material, its alkaline nature which is especially conducive to rust-proof in the case of reinforced concrete, and from the relatively high combined percentages of silica, alumina and iron, which make for permanency of the resulting concrete, the conclusion is that slag is satisfactory for use as an aggregate in concrete.

ROAD ECONOMICS.*

By J. E. Pennybacker,
Chief of Road Economics, U. S. Office of Public Roads.

ROAD economics may be defined as that branch of economic science which treats of the cost and use of a road as a public utility. Cost and public utility, in a comprehensive interpretation, are the determining factors with reference to the amount of money to be expended, the method of its procurement, the liquidation of any indebtedness incurred in connection therewith, the location of the improvement, the character of the work, economy in the management of the project, and the utilization of the completed road for the economic benefit of the public.

The subject is logically comprised in two divisions, the first of which deals with those larger questions of legislation, finance, organization, road classification or selection, the utilization of collateral agencies, and the management of the road as a completed project. The second division of the subject, although more limited in scope than the first division, is important from the standpoint of economy and efficiency, as it relates to the various activities in connection with the actual work of construction. Examples under this division would be the lowering of cost by the intelligent use of labor-saving machinery; the keeping of adequate and efficient cost records so as to detect extravagance, incompetence or dishonesty; the systematic purchase of materials, and the use of such other measures as would serve to produce a satisfactory road at the lowest practicable outlay.

Legislation, to be effective, must be economically sound, and it is necessary to the intelligent framing of road laws that the economic considerations applicable to the subject should be known and accepted by the legislators. A system of financing road improvement is largely the outcome of legislation, but is often modified by the exercise of administrative discretion. Organization, like finance, is to a great extent prescribed by statute, but here again the personal equation enters largely in the determination of efficiency or inefficiency. The utilization of collateral facilities of the state, such as convict labor and the aid of state institutions for investigative and educational work is largely determined by law, but here again administrative discretion and the personal equation play an important part. The classification and selection of roads for improvement, although resting upon legislative enactment, are much more largely an administrative question that those to which I have already referred, and the same holds true with reference to the use of the road after completion so as to best serve its purpose as a public utility.

It is thus evident that these basic factors should be correlated and that the undertaking as a whole should conform to those economic considerations which may be regarded as fundamentally sound. I have, therefore, formulated ten fundamental propositions which I hold to be incontrovertible and so self-evident as to be axiomatic. I shall, therefore, first submit these ten axiomatic propositions, and then endeavor to explain to you their practical application.

1. That all who share in the benefits of road improvement should share proportionately in the burdens.

2. That the degree of improvement should be proportionate to the traffic importance of the road improved.

3. That the rate of payment or the rate of accumulation of the sinking fund on any public debt contracted for road improvement should approximately equal the deterioration of the improvement.

4. That road building and maintenance comprise work requiring special qualifications on the part of those who direct it.

5. That responsibilities should be definite as to persons.

6. That continuous employment is more conducive to efficient service than intermittent and temporary employment.

7. That the specialists who direct road work should be appointed instead of elected; and that they should hold office during efficiency instead of for a fixed term.

8. That no road is wholly permanent and that it requires continuous upkeep, for which financial and supervisory provisions must be made.

9. That cash is a much more satisfactory form of tax than is labor.

10. That all agencies at the disposal of the state, capable of use in works of public improvement, should be so used, rather than in such commercial production as would conflict with private enterprises.

The practical application of these ten axiomatic propositions does not involve intricate or impracticable procedure. Under the first proposition, that burdens and benefits should be shared proportionately, I would call attention to the fact that the country road is no longer a mere local utility. The product of the farm is absolutely essential to the existence of the city population, while, conversely, the product of the city factories finds its way to the most remote country districts. There is an interdependence which should carry with it a co-operative sharing of the burdens incident to improving the facilities of transportation between country and city. Legislation should, therefore, be framed so as to provide for city taxation in aid of country road improvement. Automobile owners should individually pay a material portion of the cost of our public roads, and they are already cheerfully doing so in many of the states. Last year the state revenues derived from automobiles amounted to about eight million dollars applicable to roads, out of a total from all sources, state and local, of about $205,000,000. The exact method of apportioning the road taxes is a detail which can readily be worked out by each individual state.

The second proposition, which calls for the improvement of roads in proportion to their traffic importance, strikes at the very root of our present method of apportioning road improvement. Too often have we seen examples of costly improvements distributed according to the dictates of a few influential citizens or according to some arbitrary arrangement of political units or for sentimental reasons, or through a cheerful, haphazard indifference. It is now generally believed that four-fifths of the traffic of this country is carried on one-fifth of the road mileage. It should be manifest that the most heavily traveled roads should first receive attention and should be improved in the most substantial manner. It is entirely feasible to make an expert study of a county road system and indicate graphically the traffic areas for each important road, much as you would show drainage areas for waterways. The yield and the probable traffic in ton miles for these traffic areas can be readily determined so as to establish with reasonable exactness the amount of outlay which the traffic would justify. The relative cost of such a determination would be almost negligible if in-

*Paper read at the Fourth American Road Congress, Atlanta, Georgia, November 9-14, 1914.

curred as a preliminary to a large outlay for actual construction.

The third proposition, that debts should be liquidated in proportion to the deterioration of the road, is intended to prevent the incurring of a debt which will outlive the utility which it was designed to create. There are two extremes in the controversy which rages over this question of public debt. There is the one faction which either opposes debt in any degree, or contends for an indebtedness of such short term as to make it almost a cash transaction, and asserts that the road is entirely destroyed long before the debt becomes due. The other extreme faction contends for long-term indebtedness, on the theory that as posterity will reap the benefits it should bear the burdens, and that a road well maintained never wears out. As a matter of fact, location, if intelligently made, should be permanent; likewise all reduction of grades. The drainage features, if honestly and efficiently constructed, should be reasonably permanent. The road, except under extraordinary conditions, should, therefore, be considered reasonably permanent as to these features. As a general rule, the foundation of a road should not require renewal if the road is subjected to adequate and continuous maintenance. Avoiding any detailed consideration of the exact proportion of the total cost of a road represented by these features, I should say that in general the permanent features would average at least 50% of the total cost. So that, if the other 50% must be figured as perishable and subject to renewal, the debt should not cover a period longer than twice the length of this perishable portion. For example, if a macadam road is constructed at a cost of $6,000 per mile and has an estimated life of ten years, the bonds could run twenty years, because, at the end of ten years the depreciation is $3,000 and the actual value is $3,000. Another expenditure of $3,000 is made and at the end of twenty years when the bonds become due, there has been a total outlay of $9,000, against which should be credited the permanent value of the road at $3,000, making the net outlay $6,000, or the face amount of the bonds. This is merely an example and a generalization. It would be desirable to ascertain the permanent and perishable portions in each undertaking.

The fourth proposition, which calls for the employment of specialists in road work, is so nearly self-evident in its application as to require very little explanation. I should say, however, that if the laws of the state would require that all persons selected to have immediate direction of road or bridge construction and maintenance must possess practical knowledge and experience, and if this fitness should be tested by some sort of competitive examination to be prescribed by a state highway department, acting either directly or through a civil service commission, the net result would undoubtedly be the saving of many millions of dollars of road revenue and a wonderfully increased efficiency in our road system.

The fifth proposition, that responsibilities should be definite as to persons, is aimed at the elimination of our present complex and cumbersome system of road management. If all of this antiquated organization could be swept aside and in its stead one or a few officials endowed with authority and charged with responsibility in each county, the beneficial effects could not fail to be most marked. If the people, individually or in a representative capacity, could immediately place their finger, so to speak, upon the man responsible for the discharge of public duties we should have no more political juggling and the passing of responsibilities and duties onward in an endless chain.

The sixth proposition, that continuous employment is more conducive to efficiency than temporary employment, finds its antithesis in our present annual or semi-annual junket which we call "working the roads." It is so self-evident that a minor defect in a road can be repaired at its inception with little effort, and that if allowed to go on it may require the entire reconstruction of the road surface, that is seems scarcely necessary to urge the soundness of this proposition. If a small force of laborers with necessary tools and teams were employed throughout the year on the roads it would not cost any more money than to call out a small-sized army of road hands twice a year, and would not only result in quick repairs where needed but would also insure that the most work would be done at the places where it was most needed. The force would be small, mobile, trained, interested, subject to effective discipline and altogether infinitely more efficient than the unwieldly forces now employed.

The seventh proposition, which calls for appointment rather than election and for the holding of office during efficiency instead of for fixed terms, is designed to attract to the work men who look upon road-building as a life profession or occupation. A good engineer may be a very poor politician and a good politician may be a very poor engineer, but in a contest in which votes are essential the good politician will usually defeat the good engineer, although the position requires engineering ability rather than political ability. Do not spoil a good highway engineer or superintendent by making him cater to the popular fancy. If he is the right man in the right place, it is absurd to limit him to a fixed term, for his position is not a reward. The county is purchasing his services and is supposed to get value received, and it should continue to purchase so long as he delivers the goods.

The eighth proposition, that no road is wholly permanent and that it requires continuous upkeep, is intended to impress upon legislators and administrative officials the necessity for making adequate financial provision to care for roads, no matter how costly or efficient their construction. A house is not permanent without repair, a railroad track is not permanent without repair, then why should public funds in a large amount be expended in road construction which, without adequate maintenance, may deteriorate to the extent of 50% in a few years? It would seem almost a reflection upon your intelligence that I should urge upon you these conclusions which are so generally understood and accepted, were it not for the fact that their acceptance is very largely in theory and not in actual practice.

The ninth proposition, that cash is a much more satisfactory form of tax than labor, is put forward as a protest against the continued cherishing that old heirloom known as "statute labor." If A owes B $10 and B has the option of collecting that $10 in cash or taking the amount cut in labor which A shall select and which is totally unfamiliar with the character of work which B requires and which would be semi-independent of any control by B, we should consider it very unsound business judgment if B were to accept the payment in labor instead of cash. If you provide an efficient highway engineer or county superintendent with a modest amount of cash and let him select competent, efficient laborers, he can quadruple the effective results obtained by the same number of laborers under the old statute system. I know that there are sections of country where it is almost impossible to collect a cash tax. A certain amount of discretion might in such cases be entrusted to the county authorities to accept payment in labor.

The tenth proposition, that state agencies which may be used in works of public improvement should be so used, instead of in commercial undertakings, is directed partially toward the convict labor question, and is based upon the assumption that offenders against society owe a debt to society which should be paid in such form as will most benefit society, and the further assumption that honest labor should not be discriminated against through the sale or disposal of products created by criminal labor. The practical application of this proposition would mean the employment of convicts in road-building, the preparation of road materials, or in other works of public improvement so far as practicable. This proposition is intended also to emphasize the necessity for correlation of the states' various agencies in the interest of road improvement. For example, a state geologist should be helpful in the selection and location of road materials, the laboratories of state universities should be useful in the testing of materials, the university staff should be helpful in the givng of theoretical instruction and in many cases in practical extension work, state bureaus of statistics and agriculture should be helpful in accumulating essential data for the road improvement work in the state, and state civil service commissions should be of very great use in the inauguration and conduct of the merit system in the filling of positions requiring technical or practical qualifications and experience.

PROPOSED CAR LINE EXTENSIONS FOR TORONTO.

Four by-laws providing for the expenditure of $500,000 for transportation utilities are likely to be presented to Toronto ratepayers on January 1st. The works and expenditures involved are as follows:—

(1) Construction of civic car line on Lansdowne Avenue from St. Clair Avenue southerly to connect with the northern terminal of the Toronto Street Railway line on that street at a cost of $105,000.

(2) Construction of a double track civic car line to serve North Toronto, commencing at or near Yonge Street and Shaftesbury Avenue, easterly across the Reservoir Park ravine parallel to the C.P.R. tracks, northerly on a proposed street to the corner of Rosehill and Clifton Road, north on Clifton Road and Erie Street through Mount Pleasant Cemetery, on Alberta Avenue and Mount Pleasant Road to near Broadway Avenue at a cost of $320,000. The above definition of the route has not been definitely settled upon by the works commissioner and will probably be subjected to one or two minor changes. Before work on the line could commence the works commissioner has thousands of dollars of sewer work to lay on the proposed route and a road to construct through Mount Pleasant Cemetery. This road is to be permanent and must be sewered the whole length before the roadway can be constructed.

(3) Proposal to purchase all the tracks of the York Radial Railway from Queen Street within the city limits at a cost of $52,000. The company's franchise on this portion of the line ran out last year.

(4) A proposal to purchase $100,000 worth of motor buses to establish services at unspecified sections in the city.

M. Beatty and Sons, Limited, Welland, Ont., announce that they have opened a district office in Toronto with address 154 Simcoe Street, where they are represented by Mr. K. M. McKee, formerly of the head office. Previously this company has been represented in Toronto by H. W. Petrie, Limited.

ADMINISTRATION OF WATER RIGHTS IN BRITISH COLUMBIA.

By William Young,
Comptroller of Water Rights.

THE history of water administration of British Columbia for the past 50 years may be said to be the history of water administration of several of the Western States of the Union south of the International Boundary. From the time when the province became a Crown colony the ownership of the waters in the rivers and streams has been vested in the Crown, and in the circumstances, water rights were granted through a period of well over forty years, unfortunately in those early days in an unmethodical manner. The result is that there are streams that have been over-recorded many times, and again, many of these records are a hundredfold in excess of the requirements for which they were taken out. Although throughout these years there was a water law that provided for granting of rights, such law contained no machinery for administration afterwards. With this weakness in the law and the fact that records were granted by government agents in different sections without reference to a central authority, the final condition became one of chaos. Just as some of the states to the south have faced a similar condition and set things in order, so have we had to set about this work, a beginning being made in 1909 when steps were taken to terminate the growing confusion; but no organized effort was made until the summer of 1912, when the Hon. Mr. W. R. Ross called in able advisors to formulate a system and advise the best method of undertaking the work.

There is now nothing new to present in the administration of water rights in British Columbia. In taking up the many problems that confronted us we went about it in the same manner that the trained scientist undertakes some new field of research. An effort was made to ascertain what had been done in other countries. While amendments to the Water Act were made in 1913, the results of organized expert effort may be said to have crystalized in the amended act of 1914. We do not claim that this act as it now stands is perfect, far from it; for during the preparation of amendment of the act complete organization of office and staff has been well advanced, current work taken care of, an order of work established and the problem of handling the large quantity of work in arrears commenced. As regards investigating the work that other countries have done, it may be said that we have just entered on the border of a vast realm; for of all applied sciences irrigation may be said to be the oldest, not to say anything of water power or waterworks.

The foundation of our administration of water rights is our water law. What follows hereinafter is a brief analysis of this law, an outline of our order of work, and a few remarks with respect to administrative problems and of how the administrative staff deal with the work.

The basic principle of our water law is set out at the beginning in the declaration that all the unrecorded water in any stream is vested in the Crown in the right of the province. The purposes for which water rights may be acquired are there given. Organization and administration are next taken care of. Procedure in the acquirement of water rights follows, then the organization of communities, associations and municipalities, and lastly the Board of Investigation, its functions and procedure.

Under the chapter "Organization and Administration," the law briefly authorizes the appointment of the comptroller of water rights, and the Board of Investigation, each with specific powers; the appointment of district engineers, also with specific powers; the division of the province into water districts and the appointment of water recorders. The law then sets out the administrative duties and powers of the minister, also those of the Lieutenant-Governor-in-Council. With respect to the latter, one of the most important powers is the making rules and regulations for the carrying out of the spirit, intent and meaning of the law. With this basis to work on, the organization is elaborated.

The comptroller of water rights issues all licenses and administers the act in accordance with the rules and regulations in their application to the various purposes in which water may be used. He is also empowered, with the approval of the minister, to carry on such topographic or hydrographic surveys and other engineering investigations as may be in the public interest. The Board of Investigation was formed for the purpose of hearing claims, determining old rights and adjudicating thereon. The Lieutenant-Governor-in-Council or minister may, however, refer any matter, question or thing to the board for the purpose of obtaining information or making any enquiry thereon. As constituted, the board normally consists of three members, two of whom shall form a quorum. The comptroller of water rights is a member of the board in all matters excepting those pertaining to old records.

The division of the province into water districts is in the interest of efficient administration and the engineers appointed to supervise such districts have stated powers to enable them to enforce "beneficial use" of water and settle disputes; in other words, the district engineers represent and are deputies for the comptroller of water rights. The water recorders, usually the government agents, act as representatives to the comptroller to the extent of receiving applications for water rights, such applications are advertised and then filed with him, so that the neighbors of the applicant may have an opportunity of ascertaining if their interests are affected. The rules and regulations deal particularly with petitions, surveys, plans, fees and rules covering the use of water rights.

It is not the intention at this time to enter into any description of how water rights may be acquired for the reason that there is a marked similarity to the procedure that obtains in many of the water laws of other parts of North America. Suffice it to say, however, that the procedure is now simplified in the interest of the settler so that it is no longer necessary for him to call in a lawyer. Already this feature has proven a boon to many a pre-emptor or small owner to whom a lawyer's fee would be a charge he could ill afford.

The purposes for which water rights may be acquired are fourteen in number and, although they are all important, three great purposes stand out with prominence:

(1) Irrigation, whether by individual, community, company or municipality;
(2) Power;
(3) Waterworks.

A broad distinction in purpose may be said to exist: "Purposes that affect the public interest" and "purposes that affect the individual." Around these groups our administrative machinery may be said to be constructed and in their light the department is in a process of organization for effective and efficient administration.

The creation of the organization we now have may be said to date from 1910, when the administration was centralized in Victoria. During 1911 and 1912 considerable progress was made in the creation of a system adapted to the business of administration, in expert investigation of conditions, and in formulating an order of work. 1913 witnessed the division of the province into water districts, the opening of branch offices and the appointment of district engineers; also a united effort in the preparation of rules and regulations for the administration of the act, and important amendments to the act, among which may be mentioned a chapter dealing with irrigation, whether by community, company or municipality. Very important amendments to the Railway Belt Water Act were also made, whereby the administration of water rights in the railway belt finally passed from the Dominion to the province, and as an outcome of this the British Columbia Hydrographic Survey was organized for systematic work throughout the province.

The effective work of administration may be said to have begun in this year, and that there might be uniformity of effort, the order of work referred to as having been adopted in 1912 was slightly revised to meet the conditions. This order is as follows:

1. Investigation of old records.
2. Systematic and continuous work in stream gauging.
3. Study of the proper duty of water.
4. The prevention of wasteful use of water.
5. Policing of streams.
6. Economic distribution and delivery of water.
7. Inspecting water systems to determine their efficiency and safety.
8. Determination of storage possibilities.
9. Investigation of water powers.
10. Investigation of source of domestic water supply.

This order of work involves the three great groups of purposes referred to, and which are, in each particular district, of greater or less importance.

Investigation of old records comes first, and necessarily so, for the very good reason that effective administration was quite impossible until the chaos of almost 50 years had been cleared up. Under these circumstances the efforts of our district engineers have been largely concentrated on engineering investigation of those records, although every line of work has been given more or less attention. There are about 8,000 of these old records, practically all of which have now been reported on. These preliminary reports have been of great value to the Board of Investigation. The hearings now held by the board are very different to those first held without such preliminary engineers' reports. The success resulting from the efforts of this tribunal during the past two seasons is as much due to these reports as to anything. Decisions on 2,000 records have been rendered, and to date but five appeals have been filed, two of which are now in default. We are hopeful this measure of success will continue. In some of the districts the board work is complete, and we are now fortunately in a position to follow more fully and carefully the various other lines of work, with results that have been most encouraging.

I have referred to three great purposes as being of public interest, *viz.*: Irrigation, water power and waterworks. Since the difficulties met with in administration centre around these, we will refer to them in due order.

The Administration of Water for Irrigation.—Prior to 1914 there was no provision in the law that would enable the officers to cope with the conditions that already existed, and under the circumstances their hands were practically tied. The Water Act of 1914, however, included new sections which involved basic principles and made administration for irrigation possible and effective. These principles are:—

(1) "Limiting the quantity to beneficial use," that is to say the quantity of water used per acre shall be limited to such quantity as experience may from time to time indicate to be necessary for the production of crops in the exercise of good husbandry.

(2) "Rotation in use," when a number of water users may arrange a system of rotation that will best meet the requirements of growing crops and at the same time secure an economic use of the water.

(3) "Consideration of the particular crop grown," a provision which opens the way for adjustment that is in the interest of the community as a whole.

As to what kind of crops should be grown, I do not consider myself qualified to discuss such an important subject; but as regards these principles and their administration I am reminded of a statement credited to Sir William Wilcocks in reference to the control of use of water in the prevention of deterioration of land: "In this respect the government is autocratic and can and must enforce the regulations devised by its experienced advisors. It need not await the slow education of the great body of water users before adopting those practices which experience has shown are necessary for the general prosperity."

For the administration of these principles the powers of the district engineers were enlarged, and in carrying out "rotation in use" they may arrange when necessary for the appointment of water bailiffs whose duties are clearly set out in these sections and whose authority is backed up by the Police and Prisons Act. These principles and the provision for their enforcement are not new. In referring to the history of irrigation, particularly in countries where it has been practiced for centuries, we are told that the water that irrigates your field has to flow in a channel which passes the field of all your neighbors and cannot be maintained in a state of efficiency unless all do their duty, and it is easy to understand how method, order and obedience to a properly constituted authority very soon developed themselves. We are also told how autocracy was introduced into a free community of irrigators on small, independent canal systems and in times of difficulty the irrigators chose from among themselves a dictator for the whole period of scarcity of supply and his orders are obeyed and respected as though he were an absolute monarch, and further, that they invariably chose a good man."

In short, success here may be said to depend upon the human equation and we have kept in mind these facts of old-world practice in the appointment of bailiffs, insisting upon these men having the confidence and respect of the communities in which they reside. The result of the introduction of these principles in some districts where water feuds have existed for years has been most encouraging. Irrigators have again become friends and neighbors, realizing that their individual success and prosperity meant the prosperity of the community. In one particular instance where an order of rotation of water was instituted, as the water became scarce it was found that some of the prior record holders had ditches that absorbed all the water in the creek before it reached their land. As this state of affairs became obvious the bailiff eliminated these record-holders from the order of rotation in the use of the creek, and to the credit of these men it may be said that, although in other years they had caused trouble, they now acknowledged the justice of the bailiff's ruling, they could not make beneficial use of the water, and it was not in the interest of the community that they should prevent others from doing so.

Then there are other important features in the interest of irrigation that permit of effective administration and encourage organization that will mean not only development, but greater co-operation among farmers. These are:—

(1) The organization of water users communities;
(2) Organization of mutual water companies;
(3) Organization of public irrigation corporations, or irrigation municipalities.

Time will not permit of reference to these, other than to state that enterprise has been stimulated in different farming sections. Irrigation communities are being formed and the department have now under consideration a number of petitions for the formation of irrigation corporations in respect of which the preliminary engineering work is well advanced. It is expected that the various conditions required by the act as regards organization and management will be fulfilled during the coming winter, and that another year will see several irrigation corporations or municipalities in operation.

Administration of Water Rights in the Development of Power.—This purpose and its administrative requirements has received quite as much consideration as the purpose of irrigation. Recent amendments to the act in this respect were but few, but of great importance. It is no longer possible for a company to organize with the minimum of capital permitted by the Companies Act for the purpose of carrying out an undertaking requiring several millions of dollars. It is now impossible for a purely speculative element to secure and hold indefinitely a valuable franchise. The administration in this respect is largely governed by rules and regulations that the Lieutenant-Governor-in-Council may from time to time make for carrying out the spirit, intent, meaning and purpose of the act. In respect of power, these rules deal with surveys, construction, the operation period and fees. In regard to the companies now operating the determination of the fees to be charged is now occupying our attention. How such fees should be arrived at is clearly set out with an alternative; this alternative being that the fees may be based on a reasonable station output. For the present, we are taking this as the average daily horse-power arrived at from the total output in kilowatt hours at the power house switchboard. As the old records are eliminated and licenses substituted therefor and the organization for effective administration progresses, we shall in due course go more fully into the question of fees, basing such on the several factors set out in the rules rather than on the basis which has been adopted for the current year.

Hydro-electric power is essentially a specialty and to deal with it in a proper way, a section of our staff will, in due course, give its whole time to its administration and study.

The problem of water power administration and policy is one of economic importance and the question that confronts us is to what extent should the Crown become interested. On the one hand we have the example of the Hydro-Electric Commission of Ontario, the progress of which we must carefully follow, analyzing the reports and criticisms pro and con. Then there is, on the other hand, the necessity for encouraging investments of private capital, subject, however, to the principle that public utilities as natural monopolies must be under regulation by the Crown. What the ultimate result will be only the future can tell.

As the province must know something of its assets in water powers the work of stream investigation has been taken up. This work for the season now closing has been more especially in the Okanagan Valley and, comprises topographic work, and stream investigation for power, reservoir investigation, stream gauging already having been arranged for. Small powers are not overlooked. It is only necessary that data be made available in some instances to bring about development, as a small power may mean an important industry to some community.

Administration of Water Rights for the Purpose of Waterworks.—Administration in the issue of licenses and collection of annual fees is usually plain sailing in this purpose. There is, however, a phase of it that is of great importance and in the public interest, "The investigation of the sources of domestic water supply, particularly for large centres of population." Many of these watersheds are still Crown lands, and the Crown, as the land and water lord, is in a position to introduce practical conservation. During the past two seasons a field party has been continually at work following a set order in:—

(1) Determination of timber area.

(2) Cruising to determine how much timber is merchantable and whether the timber as a whole is a factor in the regulation of stream flow.

(3) Cruising of alienated timber.

(4) Extent of run-off.

(5) Obtaining the area of alienated land and the purpose for which it is held.

(6) The investigation of other rights, whether water or mineral, and the use to which they are put.

In a new country like British Columbia the value of this work must become of greater importance as time goes on. With the co-operation of an active Provincial Board of Health there will, in due course, be available data for the various centres of population that will be a guide in securing and guarding their sources of pure domestic water. The most important work in this respect now in hand is the survey investigation of the watersheds from whence comes the domestic water supply of Greater Vancouver. The results already obtained have enabled us to make equitable decisions in respect of licenses held by the municipalities who were at variance with one another. It is obvious that Vancouver must become a large city, a great railway and shipping centre. With this in mind we are compiling all the facts. The protection of Vancouver's source of domestic water supply has been rounded out to such an extent that when the time comes to provide for larger demands there will be few difficulties in the way.

Hydrographic Investigations.—When the province assumed from the Dominion the administration of water rights in the railway belt the latter decided to continue its hydrographic work in this section. It was, however, considered that it would be advantageous to the province if it could co-operate with the Dominion along lines similar to those in operation in the United States. An agreement accordingly was arrived at, and and we now have the British Columbia Hydrographic Survey. The officers of this organization have no administrative powers in respect of water rights. Outside the railway belt their whole time is devoted to hydrography, results of their work being available to the Water Rights Branch for administrative purposes. Our district engineers are thus to a large extent relieved of this work, except in sections where irrigation is practised, and proper administration depends on a direct knowledge of stream flow. In this respect we have, to some extent, adopted the system in use in Oregon, charts being prepared to show graphically the relation of records to stream flow, from which it may be seen at a glance those licenses that have to depend upon storage, and to what extent a stream may be recorded on.

I have referred to the lines of work of the district engineers as covering these three great purposes. And while I have stated that every line of work laid down has received attention in one or other of the districts, it has been impossible at the present date to give all the lines in each district the full attention they merit. For example, take "Duty of Water," a work that will demand the whole time of one man, who must specialize, and whilst this is so, it is not the intention to relieve the district engineers of their responsibility. On the contrary, their co-operation is essential, and they will be required to keep in touch with all work within their districts and to be here and there in the event of contentions arising.

In conclusion, if the administration of water rights is to count for anything, the requirements of the different sections of the country must be anticipated. To this end we have concentrated our efforts on the Okanagan Valley. By the end of another season every stream will have been traversed, every reservoir surveyed, every watershed determined, and the timber cruised; stream gauging all the while having been carried on. In fact, a thorough water investigation will have been completed in anticipation of development that is bound to come. The problem of well drilling in its application to bench lands is also under investigation; also the problem of irrigation by pumping with a view to obtaining and marshalling all the experience of other countries that we may apply them to British Columbia.

In the general conduct of the administration of water rights, whether at headquarters or in the field, we are endeavoring to follow the principles of good business by giving prompt attention to enquirers and water users; unbiased decisions where there is dissension; and in being thorough and comprehensive in field work and other investigations that we from time to time may undertake.

THE REGINA ENGINEERING SOCIETY.

At the annual meeting of the society, held recently, Mr. L. A. Thornton, works commissioner, Regina, was elected president, and J. M. Mackay, superintendent of waterworks, Regina, was re-elected secretary for the year 1914-15.

About 30 members took part in a visit to Moose Jaw on October 17th, where the city engineer, Geo. D. Mackie, had made elaborate arrangements, including a special street car and a group of automobiles, for showing the party about the various works of engineering interest in the city. Amongst those visited were the power station, where a demonstration of the recently installed high-pressure water system was given; the sewage disposal plants; the new Dominion Government internal storage elevator, and the Robin Hood flour mills.

The society's annual dinner was held in Regina on November 5th, the guests including His Honor Lieut.-Gov. Brown, Chief Justice Haultain, Wm. M. Martin, M.P., Regina; J. F. Bole, M.L.A., Regina; Robt. Martin, mayor of Regina, and Jas. Pascoe, mayor of Moose Jaw.

The next meeting of the society is being held in the Regina College at 8 p.m. on Thursday, December 3rd, the president delivering his inaugural address.

Editorial

PURIFYING RESERVOIR WATER WITH COPPER SULPHATE.

Interesting results have been achieved at the City of Gloucester (Eng.) in dealing with the nuisance, in the city's reservoirs for the supply of potable water, caused by the excessive growth of weeds which, decaying, created an offensive odor and gave an objectionable color to the water. At one time it was necessary to reduce the excessive growth of the weeds by the use of rakes—a process which involved considerable annual expense. As a consequence of experiments conducted by Mr. Geo. Embrey, F.I.C., the analytical chemist to the Gloucester County Council, the nuisance from the weed growth has now been effectually combated. The Witcombe reservoirs of the corporation were at the time choked with "Chara Vulgaris," a plant which is propagated by means of spores contained in an archegonium and fertilized by antheridia. The bursting of the archegonium sets free myriads of minute greenish cells which, with the countless anthrozoids, give the water a distinct color and a fishy odor. It was found that the use of copper sulphate in quantities of 1 to 1,000,000 was eminently successful in destroying the lower forms of plant life without injuring the fish or rendering the water toxic to human beings. One of the methods of applying the copper sulphate is to place the crystals in a canvas bag and trail this at the stern of a moving boat. Another method is to scatter the fine crystals over the surface of the water as in sowing seed, the crystals falling rapidly to the bottom of the reservoir before dissolving. This has an advantage over the former process where the solution is much diluted before reaching the bottom.

The three reservoirs of the Gloucester corporation have a total capacity of 120,000,000 gallons and the quantity of sulphate used is 400 pounds on each yearly application, or 1 to 3,000,000, which is found to be adequate to keep down the weeds. Each reservoir so treated is allowed to stand at least 3 days, and where possible a week, after the application, at the end of which period it is fit for domestic use and no trace of sulphur can be found in the water. The treatment, it has been found, is best carried out in the month of February, when the bottom of the reservoirs is usually covered with diatoms only; in March and April, under ordinary conditions, the confervæ make their appearance and later the Chara begin to grow. But if the sulphate treatment be applied in the early stages the diatoms are destroyed and neither the confervæ nor the Chara appear. Moreover, if the operation be performed with care and under proper supervision no danger need be feared.

NEW STEEL PLANT IN OPERATION.

Along with the encouraging reports of increased activity among steel companies has come the announcement from the Armstrong, Whitworth of Canada, Limited, that its new mill at Longueuil, Que., is practically completed and will commence business in all its branches before the month is ended. Although controlled by English capital, this company is essentially a Canadian manufacturing concern, employing Canadian workmen, and manufacturing grades of steel which, up to the present, have been scarce commodities in this country. A high-grade crucible steel for the manufacture of drills, taps, cutters, dies and other tools belonging to machine shop practice, will mark the initial activities of the new plant. Drop forgings will be started early next year, and it is the intention of the company to extend its present plant by the construction next season of a projectile shop.

Sir Percy Girouard is president of the company and the other directors are the Right Hon. Sir George Herbert Murray, P.C., C.B.; Saxon William Armstrong Noble, George Green Foster, K.C., and Matthew Joseph Butler, C.M.G.

PLANS TO REBUILD BELGIAN BRIDGES.

An important conference was held in Toronto last week by representatives of the Canadian Pacific, Grand Trunk and Canadian Northern railways, and of the Allan, Canadian Pacific and Canadian Northern steamship lines. The project under consideration was the rehabilitation of the numerous railroad bridges in Belgium and France, that have been destroyed in military operations. It was felt that the reconstruction of these bridges meant to Canada the employment of great numbers of men and the outlay of millions of dollars. Communications from the seat of war pointed out the enormous task which European engineers had before them in replacing railroad bridges in the shortest possible period of time, and bridge builders are of the opinion that field fabrication will largely give way to the transportation of entire sections of steel bridges from other parts of the country to the desired location. Discussion centered upon the steel bridges in possession of the railroads and not in use, since their removal to make way for heavier structures. It was stated that these released bridges, if laid down in Europe, could be of great service, as they might be immediately installed to replace those destroyed.

Those who took part in the conference were: J. L. Perron, solicitor for the C.P.R. and Montreal Tramways Company; Wm. Lyall, of the P. Lyall Construction Company; Timothy Foley, E. T. Foley and O. W. Swenson, of Foley, Welch and Stewart; W. F. Tye, civil engineer of Montreal; Patrick Dubec and Jno. Jenkins, Montreal railroad men; C. W. Allan, of the Allan Line, and Hugh Sutherland, of the C.N.R.

PROGRESS ON THE HUDSON BAY RAILWAY.

From Le Pas to Thicket Portage, a distance of 185 miles, the new line has been practically completed. It will be remembered that a year ago this portion of the line, known as Section 1, was graded for a distance of 130 miles and had received steel for 60 miles. Section 2, extending from Thicket Portage to Split Lake, a distance of 68 miles, has been graded and steel is now being laid. On Section 3, the remaining 165 miles between Split Lake and Port Nelson, considerable clearing and grading has been done. Officials of the Department of Railways and Canals, Ottawa, state that the work will be continued throughout the winter, and that completion of the Hudson Bay Railway may be looked for early in 1916.

SASKATCHEWAN LIGNITE.

THE sole sources of fuel in Southern Saskatchewan are the brown deposits of coal, which, in quantity, is estimated in billions of tons lying east and west of the Souris River. It is of marked woody structure, but its character throughout practically all the deposits is a true lignite of cretaceous age. A full report will shortly be presented by Mr. S. M. Darling, who is in charge of the government's lignite experiment station at Estevan. It will be looked forward to with interest, as this source of fuel and power premises bright prospects for the industrial future.

This lignite, as it is found in Saskatchewan, requires drying to eliminate a 30% content of water. It is then crushed to about 1 inch in size, the larger sized lumps of dried fuel being then suitable for burning on automatic stokers, while the smaller sized lumps pass on to the carbonizing oven for treatment before being briquetted.

Mr. Darling states that at Superior, Wisconsin, he recently dried a carload of lignite, briquetted it and burned the briquettes in a boiler test under the boilers at the Parliament Buildings, Regina. The amount of water evaporated per pound of fuel as fired was 6.36 pounds. Temperature of feed water 57° F. Last January in a test at the city power plant, using a good Alberta coal, under like conditions, the amount of evaporation was 6.5 pounds per pound of fuel as fired. "With equipment designed specially to handle this lignite," states Mr. Darling, "we can make briquettes that will be fully equal to the western coals is evaporative efficiency."

The lignite dust is very explosive. The drying plant must be equipped with explosive safeguards, and a plant equipped for the purpose can remove practically all of the moisture.

No byproducts are, of course, obtained where the lignite is simply dried.

The most profitable way to utilize the lignite is to carbonize it; that is, to distil off all volatile matter.

On carbonization, the products, in round numbers are:

1. Gas, per ton of lignite...... 10,000 cubic feet
2. Oil or tar per ton .... 15 gallons
3. Ammoniacal liquor .... 35 gallons
4. Carbon residue .... 1,200 pounds

The gas has a heating value of 400 British thermal units per cubic foot and makes a good "town gas," for use in stoves and ranges. It is not a good illuminating gas; it is serviceable principally for fuel and power.

There is more gas in one ton of lignite than is required to carbonize the next ton. This surplus gas has a very direct bearing upon the matter of cheap power. Six thousand cubic feet of gas are required to carry on carbonizing, leaving a surplus of 4,000 cubic feet per ton to be used for power.

The market for domestic fuel, states Mr. Darling, is very large and it is not unreasonable to expect that the demand for carbonized lignite, for gas producers and domestic fuel in the shape of briquettes, will be sufficiently large to yield from the surplus gas all of the power required within a wide range of the lignite fields. The power derived from this surplus gas costs less than Niagara water power, $8 per horse-power year. If necessary, the amount can be augmented by using carbonized lignite in gas producers.

The oils and tars extracted from the lignite can be put to many uses—fuel oil, creosoting oil, leather preservative, water proofing, tar paper, roofing pitch, etc. The pitch makes an excellent binder for briquettes and will go far towards reducing the cost of this item. Almost all our coal tar dyes and other coal tar products have heretofore come from Europe, principally Germany. Several million gallons of creosoting oils for preserving timber have been imported annually. That supply is now cut off and the value of these materials on this continent greatly enhanced.

From the ammonia compounds is derived a substantial quantity of valuable fertilizer.

Lump carbonized lignite is the ideal gas producer fuel. The amount of gas is equal to that from anthracite pound for pound, but the gas is richer, has less tar and less clinker and burns more freely.

The 100 horse-power producer gas plant in the Leader Building, Regina, has used six carloads of this carbonized lignite, and on anything approaching a full load they got a horse-power on each pound of fuel. There are two dozen gas producer plants in this territory that will use this carbonized lignite when it can be supplied in sufficient quantities. It means a reduction of 30 per cent. in their fuel bills.

As a domestic fuel the carbonized lignite briquettes are fully equal to anthracite, ton for ton. They have a heating value of 12,000 British thermal units per pound as against anthracite's 13,000 British thermal units. But there is no clinker from the lignite briquettes, no loss in burning, and they can be used nicely in kitchen ranges, which is impracticable with hard coal.

This drying, carbonizing and briquetting of the lignite results in substantial economies from the standpoint of the mine owner. There is not the large waste in screenings as at present; every pound mined is used for some purpose. The product is put into such a condition that it can be stored indefinitely and shipped any distance without deterioration. This is not possible with the raw lignite, which can be mined only as it is used. The lignite mines are therefore idle a large part of the year. This ability to operate at a steady rate throughout the year, storing the products during the summer for shipment in winter, will effect a decided reduction in the cost of production.

To sum up:—

1. For domestic fuel for heating and cooking there are dried or carbonized lignite briquettes.

2. For steam raising purposes there are dried lignite for automatic stokers, dried lignite briquettes for hand-fired furnaces and powdered fuel.

3. For electrical power there is the carbonized lignite for use in gas producers at local points in different parts of the country; and, when the time comes, if it is not already here the surplus gas from the carbonizing process will be adequate to generate current at Niagara rates for distribution over a wide area from a central station at the mine.

4. Finally there is the utilization of the byproducts, which is bound in time to be a large industry in itself.

RAPID LINE WORK.

A construction gang of 9 men belonging to the engineering staff of the Hydro-Electric Power Commission of Ontario, is in possession of an excellent record for speedy construction. Between October 26th and November 10th it erected 450 steel transmission towers, and strung 8 miles of wire.

THE STRENGTH AND DESIGN OF WASHERS IN REFERENCE TO THE BEARING ON WOOD.

At the present time very few washers are designed with any idea of obtaining economy of design. An amount of metal is cast in a certain shape and trusted to hold the load to which it is to be subjected. But owing to lack of definite knowledge on the subject it is customary to add considerable unnecessary metal to a washer simply to insure safety. In the casting of washers, however, the cost varies directly with the weight and the question of an economical design should be a vital one. The common washer is essentially an uneconomical one in design and it seems possible that a design with less metal and sufficient strength could be obtained. It was with this in view that a careful study was undertaken by L. R. Rodenhiser, whose results appeared in a recent issue of The Cornell Civil Engineer.

The objects of his investigation were two-fold: (1) To determine the safe bearing value and ultimate strengths of different woods under different washers. (2) To determine the economic size of washers and their weights in order to make the first aim as high as possible and yet keep the weight of washers down to a minimum.

Four kinds of wood were selected and tested by the end test with the following results: Douglas fir, 9,000 lbs. per sq. in.; oak, 9,000; whitewood, 4,500; and white pine, 3,600 lbs.

The conditions of the test were as nearly like actual conditions as possible. A hole was bored in the wood the size of the hole in the washer and the two holes placed concentric. The loads except in two cases were applied by a nut. In those two cases an edge was used to apply the loads. The depression of the washer into the wood was very accurately measured.

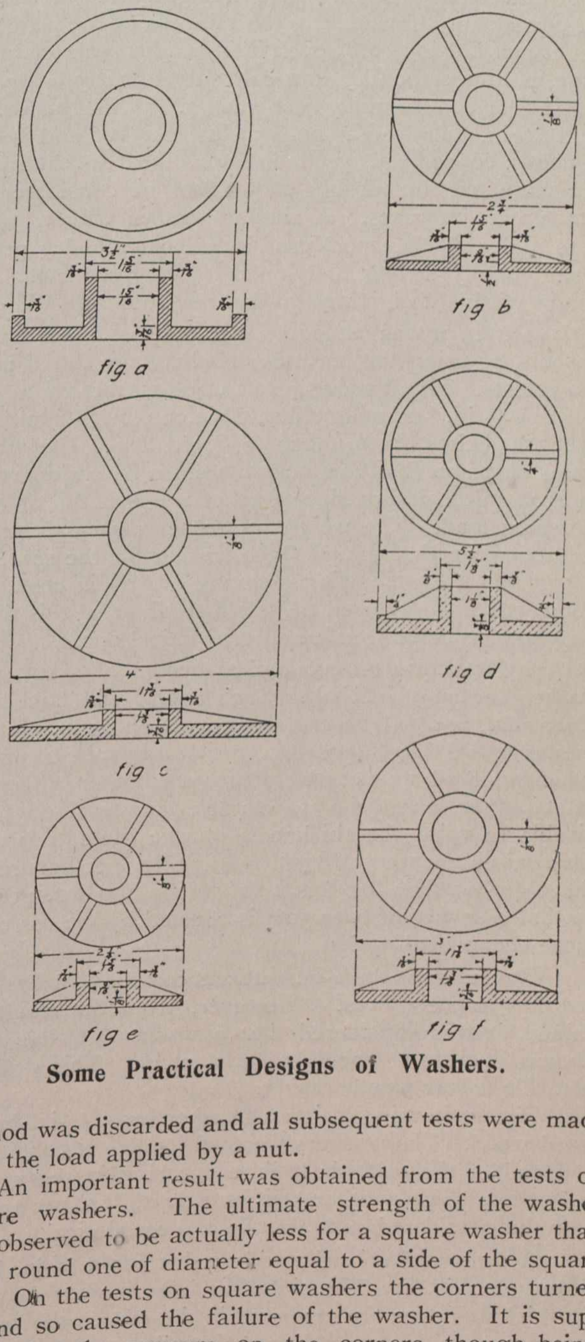
The timbers used in the testing were four feet long and were all 4 in. x 6 in. except the Douglas fir, which was 6 in. x 6 in. The wood was not selected but was taken at random from the stock of a local lumber-yard. From the results, however, the wood appears to have been well seasoned.

Professor Johnson's rule for determining the elastic limit was used. That is: the apparent elastic limit is the point on the stress of any material at which the rate of deformation is 50% greater than at its origin. In other words, it is the point of tangency of a line whose slope is 50% greater than that of the tangent through the origin. The washers that were designed for economic ones were designed for a bearing of 500 lbs. on soft wood and 900 lbs. on hard wood, these being just half the values found for the elastic limits by experiment. In the application of results it should be remembered that in commercial casting the bearing surface of the washers may be irregular and so cause uneven stresses in the wood. Also the quality of the metal used in commercial foundries is poor and variable.

Discussion of Results.—Tests were made to determine the advantage of spools on washers with the result that spools were found to increase the strength of the washer from 50 to 100% according to the size of the spool, without a proportionate increase in the weight of the washer. A test was made for a spool of greater height than that indicated in the above specification but no appreciable increase in strength was shown for the added metal.

An interesting set of tests was made with round-edged washers. It was expected that the round edge or the contact face of the washer would reduce the amount of the cutting and consequently the amount of the depression. On the first test the washer turned up on the edges so no satisfactory results were obtained. Further tests were made on stiffer washers but the results did not indicate any decrease in depression of the washer due to the rounded edge. In these tests the outside edge was rounded and no advantage was observed. It is thought possible that rounding the lower edge of the inside of the bolt hole may work to advantage by relieving the pressure from the fibers which were cut by the bit. However, no tests were made to determine this.

In the first tests the load was applied on a line but in each case the ultimate strength of the washer was so much less than when applying the loads by a nut that the



Some Practical Designs of Washers.

method was discarded and all subsequent tests were made with the load applied by a nut.

An important result was obtained from the tests on square washers. The ultimate strength of the washer was observed to be actually less for a square washer than for a round one of diameter equal to a side of the square one. On the tests on square washers the corners turned up and so caused the failure of the washer. It is supposed that the pressure on the corners, though being lower per unit area, has such an increased lever arm about the bolt that the bending moment in the washer is greater than it would be if the corners were cut off. In no case were square washers found to be of advantage. This information could be applied, it would seem, to the design of plates for more than one bolt, where the corners could be rounded to increase the strength of the plate.

Two similar washers were tested, one with a rim 3/16 in. high and 3/16 in. wide around the edge, and one without the rim. The tests showed an increase in strength of 45% with an increase in weight of only 25% for the addition of the rim. The bearing at the elastic limit was 92 lbs. per sq. in. and the ultimate strength 1,050 lbs. per sq. in., the break occurring radially. The design for this washer is shown in Fig. *a*. Another test was made with the rim moved in ¼ in. from the edge but no advantage was discovered in the change and if ribs were used the rim on the edge would serve as a brace for these.

A ribbed washer with a 1/16 in. plate, and a 3/8 in. spool was found to stand a load of slightly less than 1,000 lbs. per sq. in. Considering the thinness of the plate this was remarkable. However, this washer was carefully made in Sibley foundry and can not be fairly compared to a similar commercially cast washer. While this design for a ¾ in. bolt weighs only 53 lbs. per 100 and is consequently economical, yet it is impractical to cast such a thin plate and the design should not be considered for commercial purposes. A similar washer with a ¼ in. plate and a ¼ in. spool cast in a local foundry proved about equally strong and much more practical. The weight of this design was 70 lbs. per 100.

An attempt was made to design a series of economical washers by using the features of advantage found in the above tests. Fig. *b* shows a soft wood washer for a ½ in. bolt. A ½ in. bolt will hold safely 2,000 lbs., the ultimate strength being from 6,000 to 8,000 lbs. The washer broke at 7,400 lbs. and may therefore be considered as an economical design since washer and bolt fail at about the same load. The weight of these washers is 30 lbs. per 100 while that for an Ogee washer for the same bolt is 37.5 lbs., thus showing a saving of 25% in cost. The wood was not stretched to its elastic limit so this design may be considered a safe and economical one.

Fig. *c* shows an economical design of a soft wood washer for a ¾ in. bolt. Such a bolt will hold safely 4,600 lbs., and on the first design with a ⅛ in. plate the washer stood only 8,500 lbs., which might be considered sufficient if all washers were uniform but as a factor of safety of at least four is desirable, it was thought advisable to raise the thickness of the plate to 3/16 in. This raises the weight from 63 to 75 lbs. per hundred but the Ogee washer for this bolt weighs 100 lbs. per 100, so that a saving of over 30% is effected by the use of this more economical design.

The tests for the 1-in. washers did not prove as satisfactory as the others. However, from the results obtained, it was considered that a washer of the design shown in Fig. *d* would be satisfactory. This design is also for a soft wood washer.

Fig. *e* shows a design of washer for a ½-in. bolt for hard wood. The washers were all in perfect condition at the end of the test, the failure occuring in the wood at 7,800 lbs. This washer weighs only 26 lbs. per 100 and may be considered as both safe and economical.

A design of a hard wood washer for a ¾-in. bolt is shown in Fig. *f*. The plate has been increased 1/16 in. in thickness over the one used in the test as that one did not prove quite strong enough for all purposes. The design shown would hold from 15,000 to 18,000 lbs. and as the safe stress on the bolt is 4,600 lbs. this is sufficiently strong for all purposes. The washers used in the test broke radially under a load of 1,820 lbs. per sq. in. The weight of the washer shown in the design is 50 lbs. per 100, which is 22 lbs. lighter than the Ogee washer for the same bolt.

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2. For each inch of diameter of the plate there shall be 3/16 in. in height for the spool but no spool shall be less than ¼ in. in height.

3. For each inch of diameter of the plate there shall be 1/16 in. in thickness for the spool but no spool shall be less than 3/16 in. in thickness.

PUBLIC WORKS ON THE PACIFIC COAST.

Over and above the expenditure connected with the construction of the new 1,150-ft. drydock at Lang's Cove, Esquimalt, B.C., the Department of Public Works of the Dominion Government has under construction in the province improvements amounting to $4,500,000. The Ogden Point breakwater, 2,530 ft. long, is under construction by Sir John Jackson (Canada), Limited, and is to be finished in about 15 months. It will cost about $1,800,000. The government has awarded a contract to the firms of Grant, Smith & Co., and McDonnell, Limited, for the construction of the first two piers. One side of the pier, the nearest the breakwater, will be 1,000 ft. long. The other side, and the sides of the adjoining pier will be 800 feet each. The width of the piers will be 250 ft. and they will be separated by 300 ft. of water of a minimum depth of 35 ft. at low tide. The piers will be of concrete cribbing filled in with rubble. The time limit of the contract is March, 1916. The amount of quarry run and rip-rap, which has been deposited for the foundations of the breakwater, is 673,197 tons, and the pier contractors have dumped 148,241 tons of similar material for levelling off a base for the cribs. A total of 12,940 tons of granite blocks has so far been laid by the breakwater contractors, and in connection with the land excavations 54,847 tons cubic yards of earth and rock have been removed.

The core of the breakwater has been built for the entire length, 2,500 ft. The core consists of 233,611 tons of small rock. The foundations on which the granite blocks will be set have been completed to within 700 ft. of the outer end of the breakwater. In connection with this work 439,586 tons of rubble has been dumped. The foundations are 20 feet below low water, and the rubble deposited included rocks of weight from 200 pounds to 16 tons. These foundations have been levelled off on the exposed side of the breakwater for a distance of 800 ft. from the shore. The granite blocks, weighing 15 tons, have been set in position by divers to a mark 500 ft. from the shore end and to a point 5 ft. above low water. The concrete superstructure has been prepared out 300 ft., and the contractors are now finishing the first block of this, which is 26 ft. in length.

Grant, Smith and McDonnell are concentrating all their work on pier No. 2. The western side of the pier is to have a length, as stated, of 1,000 ft. and rubble for the foundation of this face has been dumped to give a depth of 34 ft. below low water. The last foot of the foundations is of very fine gravel in order to form a good bed on which the cribs will rest. On the western face of the pier, which is to be 800 ft. in length, rubble has been dumped for three-quarters of the distance. A portion of the foundations on the eastern face is now ready for the cribs. These cribs, each weighing 3,500 tons, are being built on a floating drydock of 8,000 tons capacity, which is now moored off the newly acquired quarry at Royal Bay. Earlier in the year the drydock was chartered from a Seattle corporation and during the past few months a large force of men have been engaged in equipping it with machinery and appliances to facilitate rapid progress in the construction of the cribs. Two cribs are to be put together simultaneously, the total weight when completed to be 7,000 tons.

Plans call for cribs of reinforced concrete 100 x 35 ft. in plan, with walls 39 ft. high and floors 2 ft. in thickness. In each there will be two longitudinal walls, 11 ft. 8 in. apart c. to c., and transverse bulkheads 10 ft. apart and 10 in. thick. Sea cocks will be provided in the floors for the purpose of admitting water to sink the cribs after they have been put afloat.

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At William Head quarantine station, where the passengers of inbound overseas vessels are examined, much needed alterations are being carried out.

For the Militia Department nearly $300,000 will be expended on the new drill hall, occupying a site on Bay and Field Sts., and McBride Ave. This building is now well on towards completion. The post office extension is also advancing rapidly, and will complete an imposing block in the heart of the city.

At Little Saanich mountain, near the city, an astronomical observatory is soon to be built to house a 73-in. reflecting telescope, the largest of its kind in the world.

The Provincial Government is completing the extensions to the legislative buildings, which will, when completed, represent a total investment of nearly $3,000,000 in Parliament Square. Some of the extensions have already been occupied by the various departments. The provincial goal, five miles out of Victoria, has just been finished, and the Normal School for Vancouver Island, situated at Mount Tolmie, overlooking the city, will be finished at the end of this year. Very large works are contemplated by the government on the old Songhees Indian reserve, which lies in the heart of the city. The Canadian Pacific Railway has constructed its terminals there, except the depot, while the Canadian Northern Pacific Railway also plans to erect for its island line, a depot connected with the Canadian Pacific Railway structure, the two joined to the city by the new bridge and a road through the reserve. To protect the area from erosion the two governments are co-operating on building a revetment wall costing $150,000.

MAINTENANCE OF EARTH ROADS.*

By George W. Cooley,
State Highway Engineer of Minnesota.

IN the consideration of this subject, it is presumed that the fundamental principles of road construction have been followed, *i.e.*, that an ample drainage system has been provided, and that the sub-grade or foundation has been built up without the use of perishable material. Unless the road has been so primarily constructed, weak spots will develop when the drainage is imperfect or where sods or vegetable matter has been used in its construction, and the cost of proper maintenance will become excessive.

In the construction of a new earth road made in an open level or rolling country, the use of an elevating grader is quite common and under suitable conditions its use is justified by economy in construction work, but its value as a road builder is lessened if the too frequent result is obtained of casting the sods into the road bed, and depending on the regular traffic to thoroughly consolidate the mass so built up. This can be avoided by the use of a tractor in hauling the grader, which thoroughly pulverizes and packs the material cast in by the grader.

We may safely take if for granted, then, that in any road bed carelessly constructed with a large percentage of vegetable matter, the future bills for repairs and maintenance will be governed largely by the quantity of unsuitable construction material used, and in case of a lax system of construction, a more elaborate system of maintenance must be adopted.

I quote the following from Mr. L. W. Page, director of the office of public roads:

Overtopping all other road problems in its importance is that of maintenance. The destructive agencies of traffic and the elements are unceasing in their activities, and it is idle to talk of permanent roads any more than to speak of a house, a fence or railroad ties as permanent. The public roads to-day, by reason of the exceptionally obstructive traffic conditions, are more costly in construction and this cost is continually increasing with the advance in the prices of labor and material. It is criminally wasteful, therefore, to invest large sums of public money in building the highways demanded by traffic, unless the investment is conserved by adequate maintenance.

We conclude, therefore, that continuous maintenance being such an important factor in the general scheme, especial effort must be made to install a satisfactory and economical system as soon as a road is opened to travel. In some of our western States, the plan has been suggested of requiring contractors on surfaced roads to provide for maintenance as soon as any section is completed, and continue the same for at least thirty days after the work is accepted, thus giving time for the engineering department to provide for the organization of a maintenance crew without overlapping or interfering with the work of construction; and in Minnesota the plan has been adopted in the construction of earth roads to require the continual use of a drag or planer on grade building. This latter plan has been found very efficient and renders future work on the surface less expensive, besides tending to produce a more compact road bed. The tool found most satisfactory in this work is that known as the "Minnesota Road Planer," which consists of the two blades of an ordinary road drag, fixed between a pair of runners about 14 feet long, the blades set at an angle of about sixty

*Read at Fourth American Road Congress, Atlanta, Georgia, November 9-14, 1914.

design of plates for more than one bolt, where the corners could be rounded to increase the strength of the plate.

Two similar washers were tested, one with a rim 3/16 in. high and 3/16 in. wide around the edge, and one without the rim. The tests showed an increase in strength of 45% with an increase in weight of only 25% for the addition of the rim. The bearing at the elastic limit was 92 lbs. per sq. in. and the ultimate strength 1,050 lbs. per sq. in., the break occurring radially. The design for this washer is shown in Fig. *a*. Another test was made with the rim moved in ¼ in. from the edge but no advantage was discovered in the change and if ribs were used the rim on the edge would serve as a brace for these.

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In the inner harbor, adjacent to the new Johnson Street bridge, the Dominion Government has under construction a wharf, which is to be completed by the erection of a new agency building for the offices of the Department of Marine and Fisheries, on a similar design to that of the building at St. John, N.B. Work on the building has been delayed by the indefiniteness of progress in the construction of the bridge.

At William Head quarantine station, where the passengers of inbound overseas vessels are examined, much needed alterations are being carried out.

For the Militia Department nearly $300,000 will be expended on the new drill hall, occupying a site on Bay and Field Sts., and McBride Ave. This building is now well on towards completion. The post office extension is also advancing rapidly, and will complete an imposing block in the heart of the city.

At Little Saanich mountain, near the city, an astronomical observatory is soon to be built to house a 73-in. reflecting telescope, the largest of its kind in the world.

The Provincial Government is completing the extensions to the legislative buildings, which will, when completed, represent a total investment of nearly $3,000,000 in Parliament Square. Some of the extensions have already been occupied by the various departments. The provincial goal, five miles out of Victoria, has just been finished, and the Normal School for Vancouver Island, situated at Mount Tolmie, overlooking the city, will be finished at the end of this year. Very large works are contemplated by the government on the old Songhees Indian reserve, which lies in the heart of the city. The Canadian Pacific Railway has constructed its terminals there, except the depot, while the Canadian Northern Pacific Railway also plans to erect for its island line, a depot connected with the Canadian Pacific Railway structure, the two joined to the city by the new bridge and a road through the reserve. To protect the area from erosion the two governments are co-operating on building a revetment wall costing $150,000.

MAINTENANCE OF EARTH ROADS.*

By George W. Cooley,
State Highway Engineer of Minnesota.

IN the consideration of this subject, it is presumed that the fundamental principles of road construction have been followed, *i.e.*, that an ample drainage system has been provided, and that the sub-grade or foundation has been built up without the use of perishable material. Unless the road has been so primarily constructed, weak spots will develop when the drainage is imperfect or where sods or vegetable matter has been used in its construction, and the cost of proper maintenance will become excessive.

In the construction of a new earth road made in an open level or rolling country, the use of an elevating grader is quite common and under suitable conditions its use is justified by economy in construction work, but its value as a road builder is lessened if the too frequent result is obtained of casting the sods into the road bed, and depending on the regular traffic to thoroughly consolidate the mass so built up. This can be avoided by the use of a tractor in hauling the grader, which thoroughly pulverizes and packs the material cast in by the grader.

We may safely take if for granted, then, that in any road bed carelessly constructed with a large percentage of vegetable matter, the future bills for repairs and maintenance will be governed largely by the quantity of unsuitable construction material used, and in case of a lax system of construction, a more elaborate system of maintenance must be adopted.

I quote the following from Mr. L. W. Page, director of the office of public roads:

Overtopping all other road problems in its importance is that of maintenance. The destructive agencies of traffic and the elements are unceasing in their activities, and it is idle to talk of permanent roads any more than to speak of a house, a fence or railroad ties as permanent. The public roads to-day, by reason of the exceptionally obstructive traffic conditions, are more costly in construction and this cost is continually increasing with the advance in the prices of labor and material. It is criminally wasteful, therefore, to invest large sums of public money in building the highways demanded by traffic, unless the investment is conserved by adequate maintenance.

We conclude, therefore, that continuous maintenance being such an important factor in the general scheme, especial effort must be made to install a satisfactory and economical system as soon as a road is opened to travel. In some of our western States, the plan has been suggested of requiring contractors on surfaced roads to provide for maintenance as soon as any section is completed, and continue the same for at least thirty days after the work is accepted, thus giving time for the engineering department to provide for the organization of a maintenance crew without overlapping or interfering with the work of construction; and in Minnesota the plan has been adopted in the construction of earth roads to require the continual use of a drag or planer on grade building. This latter plan has been found very efficient and renders future work on the surface less expensive, besides tending to produce a more compact road bed. The tool found most satisfactory in this work is that known as the "Minnesota Road Planer," which consists of the two blades of an ordinary road drag, fixed between a pair of runners about 14 feet long, the blades set at an angle of about sixty

*Read at Fourth American Road Congress, Atlanta, Georgia, November 9-14, 1914.

degrees to the runner and made rigid or adjustable as may be deemed best. The planer is hauled on a line parallel with the axis of the road and its operation is similar to that of the ordinary drag, with the additional advantage of making a smoother surface. The old style drag without runners has a tendency, especially on new work, to increase the "waves" or undulations frequently occurring on road construction, while the planer eliminates these faults, and as a general maintenance tool has proven the most satisfactory.

An important feature of maintenance is prevention of the growth of sod and weeds along the travelled track. When sod is allowed to form along the highway, it has a tendency to catch the dust and wash from the road surface, and soon becomes a high, tough shoulder, preventing drainage. The use of a spring tooth harrow along the roadside two or three times a year will prevent this growth.

The State of Minnesota has given special attention to the matter of maintenance and in the present road laws has made adequate provision for the care of all roads. Township and county roads constitute approximately 90 per cent. of the road mileage of the State, and of these roads, about 90 per cent. are earth roads. To care for the town and county roads, a one mill tax is levied on all property in the town, the proceeds of which constitute the town dragging fund. This fund is expended under the direction of an overseer, appointed by the town board, for the purchase of drags, and in dragging all roads of the town, excepting State roads. This appears to be the most satisfactory method of caring for the earth roads under control of the local authorities, but there should be a provision in such cases for general supervision of the work by the county highway engineer.

For the care of State roads in Minnesota, 20 per cent. of the State road funds, with a due proportion of county funds, are set aside and may not be used for any other purpose than maintenance of State roads. As the State roads include all types of construction, different systems of maintenance have been required in the different localities. In general, three systems have been established: The patrol system on macadam and well built gravel roads, and the maintenance section system, and road drag system on other roads, all being under the direct supervision of the district highway engineer.

Under the patrol system, one man is assigned a section of from 5 to 7 miles of road and works with hand tools. It has been found necessary to supplement this work with the occasional use of a team and in that manner it has proven satisfactory on macadam and gravel roads.

Under the maintenance section system, one man is given charge of a section of from 20 to 30 miles of road and is employed continuously with his team on the care of his section. He is given authority to employ additional help, both teams and men, and usually has two teams and four or five men at work. Contracts are also entered into by the section foreman with residents along the road, for the dragging of same after each rain, or when ordered to do so by him. The section crew takes care of all minor items of construction, such as placing culverts, etc., and we have found that the work when properly done, is really of a constructive nature. This system is without doubt the most effective, and is being adopted generally throughout the State.

The dragging system requires the employment of a superintendent of maintenance, who for convenience should be one of the engineer's assistants, whose duty is to contract or make arrangements for the dragging of all roads under his charge, and to see that the work is done at proper times. This system is suitable for slightly undulating prairie country, where most of the roads are of earth, and to get best results, the superintendent should have at his disposal light graders to re-shape the road bed at least at the beginning of each season.

On earth or gravel roads, no maintenance system is complete which does not contemplate the use of planers or similar devices, and a combination of work as outlined under the section system is recommended.

SUMMARY OF TUNNELING PRACTICE.

THE following has been adopted by the American Railway Engineering Association in accordance with the findings of its Committee on Roadway with respect to methods of tunnel construction.

Tunnel Construction.—Railway tunnels, as ordinarily constructed, are more economically built by driving the heading entirely through, first, but such method usually requires a greater length of time for completion of the tunnel.

For material requiring support, the top heading should usually be driven.

It is economical and expedient to use an electric shovel or an air-shovel, for the removal of the bench where the section of the tunnel permits the safe operation of the same; and where the material does not require support there are advantages in low cost and quick removal of the bench in driving the heading at the sub-grade line.

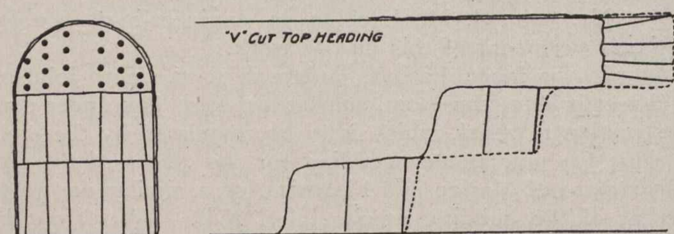
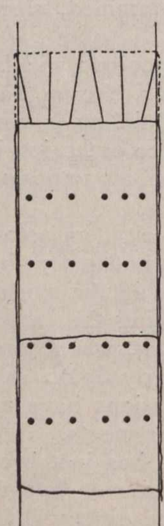


Fig. 1.—Construction in Hard Rock With Few Seams.



Where the time limit is of value, the heading and bench should be excavated at the same time, the heading being kept about 50 ft. in advance of the bench. Where the material of the roof is not self-supporting and timbering is to be resorted to, the bench should not be removed until the wall-plates are laid and the arch ribs (or centering) safely put up.

Opposing grades should preferably not meet between the portals of a tunnel, so as to put a summit in the tunnel, and where practicable the alinement and ascending grades in the tunnel should be in the same direction as the prevailing winds.

Figs. 1, 2 and 3 are representative of American practice in single-track tunnel construction, where the time limit is of value. Fig. 1 relates to tunnel construction in hard rock with few seams.

Heading in material of this kind is usually driven by a "V" cut, using from 16 to 22 holes about 8 ft. deep. The holes near the middle of the heading are drilled so as to nearly meet at the end. These holes are the first row shot, then the second row and outside holes last. The arrangement of these holes will vary slightly according to the way the material breaks.

Bench in hard material of this kind is usually taken out in two lifts of almost equal weight. Sub-bench is drilled from 20 to 40 ft. in advance of the bench. From 4 to 8 holes in a row, with about 6 to 8 ft. face, are used in both sub-bench and bench. One or two rows of holes may be used. Centre holes are shot first, round and side holes last.

In Fig. 2 the method of construction in moderately hard rock with seam, is illustrated. Heading in material of this kind is usually driven by a "hammer cut," using

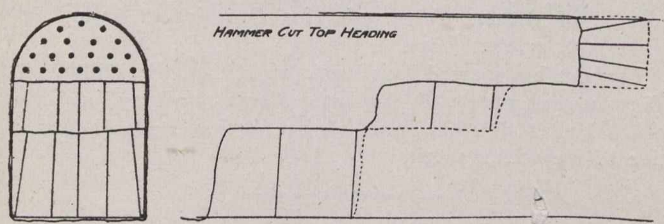
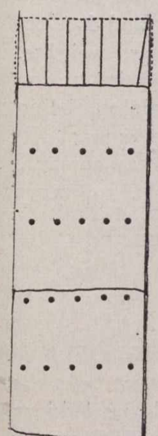


Fig. 2.—Construction in Moderately Hard Rock With Seams.



from 14 to 20 holes 6 to 10 ft. deep. The bottom row of holes is inclined at about an angle of 30 degrees. The bottom row is shot first and each row shown in succession. These holes should be arranged to suit the seams in the material.

Bench in material of this kind is usually taken out in two lifts, but the sub-bench is not as deep as the bench. Sub-bench is best drilled from 20 to 40 ft. in advance of the bench. From 4 to 6 holes in a row may be used with 6 to 10 ft. face. The bench is sometimes taken out in one lift. Centre holes are shot first, round and side holes later.

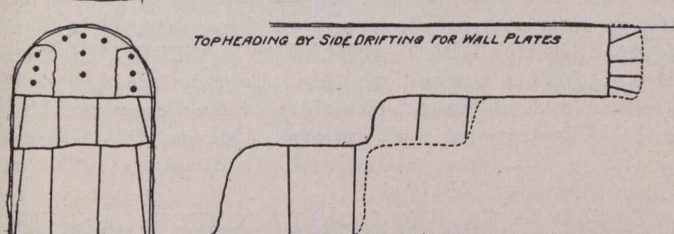
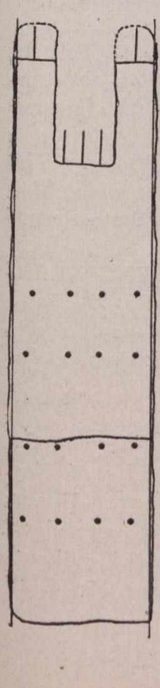


Fig. 3.—Construction in Soft Rock or Hard Clay.



The method of tunnel construction in soft rock or hard clay is shown in Fig. 3.

This method is only used when material is so soft that heading cannot be driven for full length of timber used for wall plate. Drifts about 4 ft. wide and 6 ft. high are driven for each wall plate, and then core is taken out as timber rings are put in. Three or four holes may be used from 3 to 5 ft. deep in each drift. The amount of shooting necessary depends entirely upon the softness of the material. It can often be picked. The core may be soft enough to pick, or may be shot with from 4 to 8 holes, either drilled from face as shown or from sides of drifts.

Bench in this class of material is shot in one or two lifts. Very few holes are necessary.

Coast to Coast

Vancouver, B.C.—The new $300,000 immigration building is now under construction. Messrs. Snider Brothers and Brethour are the contractors.

South Vancouver, B.C.—A number of water mains will necessarily be lowered in the near future, owing to grading operations now being carried on by the city and adjoining municipalities.

Peterborough, Ont.—The new line of the Grand Trunk Railway between Belleville and Lindsay has progressed so rapidly that steel now extends over half way between Belleville and Peterborough. It is probable that this portion of the line will be completed before the end of the year.

Ottawa, Ont.—On the Hudson Bay Railway steel has now been laid on 180 miles of the total 420 miles to Port Nelson. Grading has been completed on 325 miles. Construction work this season has been handicapped by bad weather, but it is expected that the close of next year will see the steel laid completely to tide water.

Cobalt, Ont.—The new high-grade vein on the Savage property is estimated to average between 7,000 and 8,000 ounces to the ton over an average width of 4 inches. It was located at the 140-ft. level, and has been proven for a depth of 55 ft. This vein was encountered in the cross-cut driving through virgin territory from the 140-ft. level.

Chatham, Ont.—Civic improvements this year have been extensive. The programme in the matter of sidewalks was completed last week. Three reinforced concrete pavements and a bitulithic pavement have been laid in addition to numerous other pavement improvements. The sewerage programme will have been completed by the end of the week.

Montreal, Que.—To the Home Guard has recently been added a company of 250 men from the Canadian Pacific Railway Co., arms and equipment being supplied by the company. Half of the number is being enrolled from the Angus shops and the other half from the Windsor and Place Viger stations. It is intended that miniature rifle ranges will be established at Angus and Windsor station.

Toronto, Ont.—Good progress has been made by the city on the large trunk sewers in Ward 7. The work has been handicapped on both the Woodville Avenue and Humberside Avenue conduits by the intrusion of water, but steam pumps have been constantly in commission, and the work has proceeded without interruption. Both are rapidly nearing completion.

Regina, Sask.—The new Regina jail, a 3-story building of brick and reinforced concrete, has been completed. It is six miles from the city. Power is supplied by two semi-Deisel engines with direct-connected generators. This power is used for lighting, ventilating, water supply, laundry, while a motor is also used for operating the septic tanks at the sewage disposal works.

Fort George, B.C.—The Pacific Great Eastern Railway has now a force of nearly 7,000 men along its route between Squamish and this city, and it is expected that the entire route will be graded before the close of the year. Track will extend to Lillooet by the end of January, and it is hoped, to Clinton, by June. The entire line should be completed from tide water to Fort George by the close of next season.

Vancouver, B.C.—Traffic to the coast by way of the Kettle Valley Railway will likely be accommodated next summer. The Kootenay Central Railway is also well on the way to completion, the swing bridge over the Columbia River, near Lake Windermere, having recently been put into position. Construction on this line has been carried on northwards from the Crow's Nest line and southwards from Golden, and the two sections will meet at the Columbia River bridge.

Toronto, Ont.—Owing to the present unsettled conditions, it is a question whether the next session of the Provincial Legislature will draft an extensive programme of construction in the matter of highway improvements in Ontario. During the past season much work has been done by the Public Roads and Highways Commission by way of investigation, compilation of statistics, traffic census, etc., and, under normal conditions, legislation should shortly be introduced, providing the necessary machinery for carrying the policy into effect.

Viking, Alta.—Natural gas has been struck near Viking, Alta., on the Grand Trunk Pacific Railway. The well has been bored for the city of Edmonton, and the gas will be piped to Alberta's capital, eighty-two miles distant. The well is 2,340 feet in depth, and is making 9,350,000 cubic feet per day. This well is only exceeded in size of flow on the continent by the one at Bow Island. It is stated that two wells of this capacity would supply all the power, light and heat required in the city of Edmonton.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA.

On December 1st a large attendance of the membership of the Society heard Mr. J. S. Plaskett, D.Sc., of the Dominion Observatory, who delivered an illustrated address descriptive of the new telescope now under construction for the observatory at Victoria, B.C.

At its next meeting, on December 15th, the Society will be addressed by Prof. L. B. Stewart, University of Toronto, on "Experiences on Surveying and Exploring Expeditions." The address will be illustrated. Mr. A. F. Miller is secretary of the Society, whose offices are at 189 College Street, Toronto.

PERSONAL.

R. S. BUCK, chief engineer of the Dominion Bridge Co., Montreal, has been appointed maintenance-of-way engineer for the New York Railway.

JAS. SHIELDS, consulting electrical contractor, has been chosen by the Toronto Hydro-Electric System as inspector of city wiring.

J. L. HARRINGTON, consulting bridge engineer of Kansas City, addressed the Victoria branch of the Canadian Society of Civil Engineers at its recent meeting on modern bridge construction.

GEO. GAUTHIER, assistant superintendent of the Montreal Light, Heat and Power Co., was seriously burned by a short circuit at one of the plants of the Shawinigan Water and Power Co. last week.

A. F. STEWART, chairman of the Toronto branch of the Canadian Society of Civil Engineers, delivered an illustrated address to the members of the Branch at a meeting on November 26th. His subject was "Bridges Destroyed during the South African War."

D. C. COLEMAN, of Calgary, general superintendent of the Alberta division of the C.P.R., will, it is reported, succeed Mr. Grant Hall as general manager of Western lines, the latter advancing to the vice-presidency vacated by Mr. George Bury, when Mr. Bury moves up to succeed Mr. McNicoll.

OBITUARY.

The death occurred last week of Mr. John H. Housser, secretary and one of the directors of the Massey-Harris Co., Toronto. Mr. Housser was connected with the firm for 42 years.

The death occurred in Montreal last week of Mr. R. C. Hadley, of the engineering staff of the George A. Fuller Contracting Co.

It has been announced that Mr. Fred. C. Robertson, inspector of C.P.R. Telegraphs for Ontario, died on November 29th at Port Hope.

The death occurred last week of Mr. A. E. Wilkinson, traffic superintendent of the Intercolonial Railway in Nova Scotia. Mr. Wilkinson was in his 45th year, and was a native of New Brunswick.

NEW G.T.R. BRIDGE AT PRINCE GEORGE, B.C.

The vertical lift-bridge over the Fraser River at Prince George, B.C., was opened last week to permit the passage of steamers. The lift-span is 100 ft. in length, and is electrically operated, assisted by concrete counter weights. When raised, it is 150 ft. above the river. The entire bridge is one of the longest steel bridges in the Dominion, being 2,654 ft. between abutments. There are twelve spans, excluding the lift portion. The structure rests on 14 concrete piers, and provides accommodation for two 12-ft. roadways and a 19-ft. railway right-of-way.

COMING MEETINGS.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—**The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.**

AMERICAN ROAD BUILDERS ASSOCIATION.—**Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.**

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Annual Convention to be held at the King Edward Hotel in Toronto, January 26, 27, and 28, 1915. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

EIGHTH CHICAGO CEMENT SHOW.—**To be held in the Coliseum, Chicago, Ill., from February 10th to 17th, 1915. Cement Products Exhibition Co., J. P. Beck, General Manager, 208 La Salle Street, Chicago.**

AMERICAN WATERWORKS ASSOCIATION. — **The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.**

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—**Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.**

Officers of University of New Brunswick Engineering Society:—The Engineering Society at the University of New Brunswick elected their officers, recently, as follows:—Honorary president, Mr. Wallace Broad, St. Andrews; president, Prof. J. A. Stiles; first vice-president, Mr. E. McL. Balkam; second vice-president, Mr. J. P. Mooney; treasurer, Mr. J. D. Hickman; secretary, Mr. A. C. Edgecombe.