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HIGHWAYS AND HIGHWAY SURVEYING

FURTHER POINTS ESSENTIAL TO A SCIENTIFIC APPLICATION OF SURVEYING PRACTICE TO HIGHWAY WORK—SUGGESTIONS PERTAINING TO LEVELLING

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[*Note—This article on levelling in connection with highway surveying follows directly the subject matter of another which appeared in February 19th issue under a similar heading. The plotting and some other features of highway surveying will be dealt with in a later article.—Editor.*]

The Work of Levelling.—The taking of levels over the surveyed area is of great importance and should be done with care and judgment. If possible, a bench mark established above tide water should be obtained to start the levels. This can frequently be done from some railroad company or government survey. If this is not possible, and the surveys start near tidewater, a gauge should be put on the beach, and mean tide or mean low water obtained. The value of this is evident. On extensive surveys all sections of the work can be checked if the levels are on the same datum line. These levels can also be used for any work, and it is always of value to have them based on tide water. However, if it is not possible to get such an elevation to start the levels, an assumed elevation can be used, taking care that it is large enough to prevent any minus elevations.

With a bench mark to start from, the first work to do is to run a set of benches over a part of the surveyed line. This is one difference between highway surveying and railroad surveys. On highways the line of the survey is known, while on railroads it is not. Thus benches can be run ahead of the transit party. With a set of benches run, they can be checked as the line levels are taken, thus the levels are checked as they are taken. It is customary to run the levels as the benches are established, afterwards checking the benches. By this method, if errors are discovered, either a long line of levels must be run over or else two elevations from a bench mark must be used, one in each direction from the error, which is a great inconvenience and may lead to other mistakes.

If the benches are run first and then checked the levels can be kept right, it seldom being necessary to run over more than 1,000 ft. By all means, no matter how they are run, have the levels and bench marks checked. This is the only proper method and will save much confusion later, as well as time and money.

Levels should check within a few hundredths between benches and within a tenth for a mile. If they do not, they should be re-run until they do. Bench marks should be established about every 500 ft., making about 10 per mile. In very level country they can be farther apart, but even then not more than 1,000 ft. It is very little trouble to make benches, and to have them close together means the saving of much work on locations and construction. They should always be established near cross roads and bridges. If the bridge is high there should be one at the road level and one near the stream, so that work can be done from one set up on any part of the structure. If the bridge is a long one, a bench should be on each side, and these should be checked within one hundredth of a foot.

Bench marks can be made on the knots of trees. These are most permanent and can be used for some years. Door steps and curb stones in towns and villages can likewise be used. When trees or stones are not convenient, heavy spikes can be driven into telephone or telegraph poles along the road. Any heavy spike will do if it is driven securely, leaving only enough of the head projecting to the bear level rod. A railroad spike gives the best bench mark of this kind.

Many poles have to be removed to allow of road improvements, so it is often necessary to transfer bench marks from one pole to another. Other expeditious ways of making bench marks will suggest themselves. If the work is extensive enough and the cost will warrant it, permanent stone or concrete monuments can be set for some of the bench marks. These should have a copper tack or plate set in them, and if of concrete the elevation should be cast in the concrete.

If possible, all bench marks should have their elevations marked on them. A description of each should be entered in the note book with its location described in reference to the transit line. A list of bench marks, their elevations and description should be entered in the back of each level note book for quick reference.

In taking levels, each station should be taken on the transit line and at each break in the ground. When the transit line is not the same as the centre line of the road the centre must also be taken. These two elevations are most important. In addition to them the elevation on the sides of the roads should be taken. If the ground dips or rises much beyond the sides of the roads, enough elevations should be taken to show the character of the ground to about the limit of the right-of-way of the road. From such notes it is possible to plot cross-sections of the road.

It is evident that with the large number of levels to be taken and with checking the bench marks, the work of levelling on highway surveys goes much slower than the work of running the transit line. Thus every help possible should be rendered the leveller and his rodman. Plus stations marked on poles, fences, stakes, culverts and bridges will all aid in making measurements. If the road does not vary much in elevation from one side to the other and if the ground on the sides is about the same, it is evident that quicker progress can be made by only taking side levels every 200 instead of 100 ft. Other opportunities of saving time will present themselves to the leveller. The successful levelman is he who is so watchful that he does not waste time by taking useless notes and at the same time makes his notes so complete that a profile can be made of the transit line, of the centre line and of each side of the wagon road; and any cross-section that will show decided cutting and filling in widening the road.

work, both in recording the notes and in plotting them. This is to place all the rod readings in one column and the elevations in another, and on the opposite page show by notations the places where these levels were taken. This is shown by a sample page, Fig. 1.

The second method is similar to keeping cross-section notes. The rod reading for the transit line and its corresponding elevation is recorded, as usual, in the columns on the left-hand page and the rest of the readings on the right-hand page, as shown in Fig. 2. It is possible to set down the elevation directly instead of the rod readings, by doing some extra work in the field. Thus, above the break shown on the page, the top figures are rod readings and the bottom figures distances out from the transit line. The letter "C" denotes the centre

1 Sta.	B.S	H. of I.	F.S	Rod.	Elev.	2
B.M.					62.314	On Root of Spruce Tree 50' left of Sta. 0
	5.142	67.456				
0				6.2	61.3	Transit Line
0				6.2	61.3	2' right C. Road
0				6.4	61.1	8' right Side Road
0				4.1	63.4	12' " Bank
0				6.5	61.0	8' left side Road
1				5.8	61.7	Transit Line
1				5.7	61.8	3' right C. Road
1				5.5	62.0	9' right Side Road
1				5.3	62.2	11' right Bank.
1				5.4	62.1	7' left
1+50				4.8	62.7	Transit Line
1+50				4.8	62.7	C. Road 3' right
2				3.2	64.3	Transit Line
2				3.1	64.4	4' Right C. Road
2				3.0	64.5	10' right Side Road
2				2.9	64.6	6' left side Road
3				1.2	66.3	Transit Line
3				1.2	66.3	5' right C. Road
T.P.			0.912		66.544	on rock near Sta. 3
	10.865	77.409				
4				9.8	68.6	Transit Line
4				9.7	68.7	6' right C. Road
4				9.6	68.8	12' " side Road
4				9.5	68.9	4' left " "

Fig. 1.—Ordinary Level Book, With Notes.

At cross roads levels should be run down the centre of the roads for such distances as to show the grade of these roads and how they may be affected by changes to be made. This may mean 100 ft. or more. On private roads and entrances to farm houses, levels should be taken for at least 100 ft. or to the houses. At culverts and bridges, in addition to levels taken in the road, the elevation of the banks of the stream, the surface and bottom of the water should be ascertained, and any other elevations that may affect the building of a new bridge or culvert.

The Levellers' Note Book.—The keeping of level notes is not a difficult problem, but unfortunately the manufacturers of note books have not kept abreast of the times, there being no special book for highway surveys. The one in common use is well adapted to railroads, but is poorly suited to highways as it causes much extra

of the wagon road. The figures written vertically are the elevations of the points alongside of them.

Below the break in the page (Fig. 2) the top figures are the elevations and the bottom figures, distances out. In this the rod reading is not recorded except for the reading on the transit line. Thus, at Station O (zero) the rod reading is 6.2 on the transit line, the instrument height being 67.5; the elevation as recorded is 61.3. Now, keeping the rod 6.2 on a piece of paper, as the mean rod for that cross-section, the reading at the centre of the road, being 6.2, gives an elevation of 61.3, which is set down on the right-hand page as 2 ft. on the right and at centre. The reading at the edge of the road, 8 ft. out, is 6.4, being 2 tenths lower than the transit, making an elevation of 61.1, which is so recorded. At 12 ft. out the rod reads on top of the side of the cut 4.1, making a difference of 2.1 with the mean rod, thus adding 2.1 to the elevation on the transit line, making 63.4. The same is done on the left, and at each station the operation is repeated. The notes are thus made complete in the field and a large number of levels can be taken and recorded on a section. Although some time is saved in the long

circles with the rod reading tell the distance out to the right or left of the transit line. With this method the notations necessary in Fig. 1 are eliminated by the columns and the elevations except for the turning points, bench marks, and instrument heights, can be marked

Sta.	B.S.	H. of I.	F.S.	Rod	Elev.	Left	Right
B.M.					62.314	On Root of Spruce Tree	50' left of Sta. 0
	5.142	67.456					
0				6.2	61.3	6.5/8.0 61.0	c 6.2/2.0 61.3; 6.4/8.0 61.1; 4.1/12.0 63.4
1				5.8	61.7	5.4/7.0 62.1	c 5.7/3.0 61.8; 5.5/9.0 62.0; 5.3/11.0 62.2
1+50				4.8	62.7		c 4.8/3.0 62.7
2				3.2	64.3		c 3.1/4.0 64.4; 3.0/10.0 64.5
3				1.2	66.3		c 1.2/5.0 66.3
T.P.			0.912		66.544	On Rock	

Sta.	B.S.	H. of I.	F.S.	Rod	Elev.	Left	Right
B.M.					62.314	On Root of Spruce Tree	50' left of Sta. 0
	5.142	67.456					
0				6.2	61.3	61.0/8.0	c 61.3/2.0; 61.1/8.0; 63.4/12.0
1				5.8	61.7	62.1/7.0	c 61.8/3.0; 62.0/9.0; 62.2/11.0
1+50				4.8	62.7		c 62.7/3.0
2				3.2	64.3	64.6/6.0	c 64.4/4.0; 64.5/10.0
3				1.2	66.3		c 66.3/5.0
T.P.			0.912		66.544		

Fig. 2.—Two Different Methods of Keeping Level Notes.

run, yet in cold weather it is difficult to do this in the field, and the chance of errors being made is considerable.

Fig. 3 shows a method of keeping level notes that is less work than that shown in Fig. 1, is very accurate, and can be used by a leveller of limited experience. A

up in the office. The writer is a firm believer in keeping the elevations mentioned marked up in the field, and checking them each night by addition and subtraction.

It is evident that plotting the notes shown in Fig. 3 any line or profile can be plotted with little trouble. The

Sta.	B.S.	H of I.	FS	Elev. Benches etc.	Transit Line Rod	Transit Line Elev	Left Rod	Left Elev.	Left Rod	Left Elev	Centre Ro. Rod	Centre Ro. Elev	Right Rod	Right Elev.	Right Rod	Right Elev.
B.M.				62.314	(Spruce Tree 50' L. Sta. 0)											
	5.142	67.456														
0					6.2	61.3			6.5 (8)	61.0	6.2 (2)	61.3	6.4 (8)	61.1	4.1 (12)	63.4
1					5.8	61.7			5.4 (7)	62.1	5.7 (3)	61.8	5.5 (9)	62.0	5.3 (11)	62.2
1+50					4.8	62.7					4.8 (3)	62.7				
2					3.2	64.3			2.9 (6)	64.4	3.1 (4)	64.4	3.0 (10)	64.5		
3					1.2	66.3					1.2 (5)	66.3				
T.P.			0.912	66.544	(on Rock)											
	10.865	77.409														
4					9.8	68.6			9.5 (4)	68.9	9.7 (6)	68.7	9.6 (12)	68.8		

Fig. 3.—Showing Note Book With Level Notes.

cross-section book for plotting contours can be used and ruled up in any manner desired. For standard use the writer uses the ruling shown in Fig. 3. The columns for rod readings are made narrower than for elevations for two reasons, as so much space is not needed, and the recorder can find them more easily. The figures in

elevations of the transit line, the centre line of the road, the sides, etc, are all in single columns, except where the transit line coincides with the centre of the road only the elevation of the transit line is shown.

Each night, or on stormy days, all elevations should be marked up and the notes plotted.

COMMERCIAL RED LEAD FOR PAINTING STRUCTURAL STEEL.

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RED lead is one of the best-known and most widely used pigments at the present time for painting steel for structural and railway purposes, but very few of the consumers seem to realize the great difference in quality of the red leads sold by the manufacturers and jobbers, nor the effect of the ingredients upon the quality and durability of the paint in service.

Red lead as sold on the market is mainly a mixture of two oxides of lead, true red lead and litharge. It is made by roasting, or oxidizing, pure metallic lead in reverberatory furnaces in two stages. In the first stage the lead is melted down on the flat hearth of the reverberatory while a strong current of air is passing across its surface. Litharge, or the monoxide of lead, is formed under these conditions as a skin or crust upon the surface of the molten metal and is pushed to the back of the furnace, continually exposing fresh metallic lead to the oxidizing action of the air. Finally, all the lead becomes changed into brown-colored scales of litharge, which on grinding produce the reddish-yellow litharge of commerce. The second stage in the process consists in the further oxidation of the ground litharge in the same or a similar reverberatory furnace to true red lead. The temperature and other conditions have to be carefully controlled or, otherwise, the bright red color will be spoiled and the quality of the pigment impaired. If the oxidation is not carried far enough considerable litharge will still remain and the color will be pale. If carried too far the red lead becomes more dense and crystalline, and hence is more difficult to mix with oil into a paint and is liable to run or streak. If the temperature becomes too high, the red lead is decomposed to litharge again and a partial fusion of the material will result. The final product should contain no grains of metallic lead nor fused particles, but after grinding very fine should be of a brilliant red color and with only a small quantity of litharge.

The chemical composition of true red lead is considered to be a compound of two parts of lead monoxide and one part of lead dioxide, but the commercial product always contains litharge in varying proportions as the analyses given in Table I. will show.

Red lead containing a large percentage of litharge when mixed with oil sets into a cement in a comparatively short time. This makes it difficult to work and uneven in application. A pure red lead, on the other hand, is more inactive to oil and brushes out more smoothly. This allows the painter to cover more surface with the same quantity of paint with less exertion and in a shorter time, so that the increased cost of a high-grade red lead is more than repaid by the economy in application, as well as in the increased beauty and durability of the paint; not to mention the better protection of the steel work obtained. Fineness of grinding is, of course, an essential characteristic, as otherwise even a high-grade red lead would run and alligator.

In view of the wide variation in the purity and quality of the commercial article now on the market it would, therefore, seem advisable where large contracts are concerned and where durability and uniformity of the painting is necessary, to buy it under specifications and to rigidly inspect and test all shipments received. The following might be suggested as a specification for this purpose:—

Specification for Dry Red Lead.—The dry pigment must be of the best quality, free from all adulterants, and shall contain not less than 85 per cent. by weight of true red lead (Pb_3O_4), the balance to be practically pure lead monoxide (PbO). It must contain less than 0.1 per cent. of metallic lead, and is to be of such fineness that not more than 0.75 per cent. remains after washing with water through a No. 19 silk bolting-cloth sieve. It must be of good, bright color, and be equal to the standard sample in freedom from vitrified particles and in other respects.

Samples of one ounce of the dry red lead must be submitted to the.............Company's Chemist for analysis for each new order for the materials. No material shall be shipped until the above sample has been approved by the Chemist. Shipments must be uniformly in accordance with the specification. Further samples may be taken at any time after delivery, and if the material is found not to be in accordance with the specifications, all the materials represented by such samples shall be rejected.

Standard samples of dry red lead will be furnished on application to the.............Company's Chemist.

Wherever possible it should be arranged to have the shipments of red lead sampled before shipment, so that all trouble, delay and possible disputes may be avoided by reason of the shipment being rejected after delivery had been made. The buyer, or his representative, could then get an unbiased average sample of the different barrels of material, seal them with his own private stamp, taking note at the same time of the numbers and marks of the barrels. If the analysis proved satisfactory the latter could then be checked up and identified upon delivery. In this way no further delay nor trouble should result and both buyer and seller would be equally satisfied.

Table I.—Analyses of Dry Red Leads.

Serial No.	True red lead.*	Litharge.*	Oxide of iron.*	Barytes.*	Whiting.	Zinc Oxide.	Other mineral matter.	Organic coloring matter (dye).	Total lead.*	Residue on No. 19 silk bolting cloth.*	Color.
1	63.57	32.03	.36	None	None	None	None	....	....	Good	Good
2	56.00	43.39	None	....	....	....	"	None	91.04	8.17	Pale
3	94.85	5.05	"	....	....	....	"	"	90.58	1.55	Excellent
4	71.43	27.89	"	....	....	....	"	"	90.63	2.05	Good
5	77.37	21.71	"	....	....	....	"	"	90.29	3.03	Good
6	52.48	46.30	"	....	....	....	"	"	90.56	3.4	Good
7	55.35	42.94	"	....	....	....	"	"	90.01	4.4	Good
8	38.71	30.66	....	27.40	....	....	....	Present	....	....	....
9	60.45	38.61	None	....	....	....	None	None	90.63	....	Paler
10	71.88	26.91	"	....	....	....	"	"	90.15	3.8	Good
11	87.16	12.72	"	....	....	....	"	.12	90.84	2.6	Good
12	66.81	32.45	"	....	....	....	"	None	90.70	1.3	Orange
13	88.45	11.39	"	....	....	....	"	"	90.77	.81	Pale

* Percentage.

SOME FEATURES IN THE DESIGN OF SEWER SYSTEMS.

THE design of a sanitary sewer system for a town having a combined system serving approximately 2/3 of its area and 9/10 of its population and the subsequent construction of parts of the system and of some storm sewers is the subject of a paper read recently before the Association of Civil Engineers of Cornell University and appearing in the February number of The Cornell Civil Engineer. Mr. C. F. Fisher, of the Fairport (N.Y.) Sewerage System, is the author.

In the particular case which Mr. Fisher selected the existing sewers had been built without regard to any particular outfall, and the problem was that of combining them into a system which should serve the entire community and deliver the sewage at some outfall convenient for the treatment of the sewage.

Before proceeding to the actual design of a sewer system, the factors of future growth of the town, the character and quantity of its sewage, the conditions of its present sewers and the local topography must be considered. In estimating future growth not only the corporate area should be included, but the areas which are liable to be developed during the period it is assumed to care for. The railway facilities will usually indicate in what direction new industrial works may be expected to grow up, but the development of residential districts does not admit of such accurate forecasts. In the smaller cities and towns the main highways which are susceptible to improvement as state roads are the more likely avenues of development.

The character of the sewage will govern somewhat in the selection of the minimum grades to be used. Where manufacturing wastes of a fibrous or a gritty character occur it will be necessary to provide for a higher velocity of flow, preferably not less than three feet per second, than where domestic sewage only is expected. This requirement becomes more important where the discharge is periodic in sewers maintaining only a small normal flow. A dilute sewage admits of a lighter grade than a heavy one, and more especially so if its diluteness is due to the infiltration of ground water in old sewers, since that fact insures a steadier flow. In a separate system the problem of street grit can be eliminated by the use of tight manhole covers, or, if perforated covers are necessary to provide ventilation, by the use of dustpans in manholes.

In estimating the amount of sewage per capita per day to be expected recourse will be had to the records of water consumption for the community in question. These records, if pumping records, or records made at the intake of the water system, will show a consumption which will be in excess of the flow of sewage by the amount of leakage in the waterworks lines. However, other facts concerning the water supply may be large factors in the expected sewage flow. At Fairport, N.Y., the water consumption from pump records for the winter months, when sprinkling, etc., was zero, was 65 gallons per capita per day. This water is obtained from shallow wells in shale and is highly mineralized. In consequence, the use of cisterns to catch roof water is universal. No records were available showing what the actual per capita consumption of this roof water was, and in the absence of any definite data, an allowance of twenty gallons per capita per day was made, as being sufficient to cover general domestic uses. The cisterns in which this water is collected drain into the sewers, which will form a part of the sanitary sewer system, and, during heavy rains, all the overflow from the cisterns will pass through the sanitary sewers. The amount of this overflow is difficult of estimation. A computation of the amount to be expected by means of roof area and rainfall data, assuming that only 10 per cent. of the cisterns would overflow at once, gave an amount of water manifestly too large to provide for in sanitary sewers. It was not possible in this case to observe the increase in flow due to rains because a great many surface laterals were connected to the sewers and contributed to their flow. It was advisable to make some allowance for this water because of the limited extent of the storm water system and the probability that it would not be extended to cover the town for some time. The total amount of sewage proper to be expected was determined as 80 gallons per capita per day and the maximum flow on the maximum day as 170 gallons. An allowance of 100 gallons was made for cistern overflow in addition to the sewage flow. This amount seems liberal, and the sewers were not designed to carry this amount flowing half full but practically three-quarters full. In case future experience should show this amount to be too small an allowance for cistern overflow, the remedy will lie in connecting the overflow to the storm sewers, whose construction should be assured before the main trunk sanitary sewers carry the flow from the full estimated population for which they were designed.

The condition of the existing sewers is sometimes hard to determine, especially where no maps have been filed or manholes built along the line. The grade of many of them is an indeterminate thing as they have frequently laid over an uneven bottom. The fact that they are discharging sewage is presumptive evidence that they are in fair condition. However, when it is designed to lay pavements over them, it is necessary to dig up the sewer at several critical points before assuming its efficiency, and manholes should then be built along the line.

The proper layout of the system to take advantage of the local topography, can only be finally determined by making actual estimates of cost of the best of the apparent locations. The inclusion of the old sewers complicates the problem as they were frequently built in short sections at a time, following the growth of population, and do not take advantage of the steepest grades available. Theoretically, the most economical type of layout is that in which the main trunk sewers follow the steepest grades, since the smaller laterals seldom carry their full capacity, even on light grades.

Before proceeding to the layout of any comprehensive sewer system it will be economical to make a good topographic map of the area to be sewered and any probable extensions to that area. Such a map should include all probable sites for disposal plants and all areas contributing surface drainage. A scale of 100 feet to the inch shows detail enough for fairly smooth country where the slopes do not exceed 10 per cent., but in rough topography and in locations which a preliminary examination shows to be likely routes for intercepting sewers a scale of 50 feet to the inch is preferable. A contour interval of 2.5 has been found satisfactory in smooth country, and ten feet is close enough for long, steep slopes. It is advisable to write in the actual elevation at street intersections and abrupt changes of slope. The amount of detail it is advisable to show on these maps depends somewhat on the probable time of construction. If the investigation is only preliminary in character and actual construction is liable to be long deferred it is useless to take a large amount of detail, which may change materially before actual construction. But where it is expected to build shortly, it is a matter of economy to locate the houses and all structures, even if they do not actively govern the location of the sewer. From these large scale maps a map of a smaller scale, 200 or 300 feet to the inch, can be prepared as an index map, or for filing purposes. It is helpful also, where the topography is complex, to have a small scale map to bring out the general features of the country more prominently than is possible with several separate maps. In transferring topography to the small scale map it is essential to transfer the street lines and main drainage lines and divides with a fair degree of accuracy. The absolute correctness of intermediate points is not so essential since final locations and estimates will be made from the large scale maps. These maps will be of great value in future municipal work if they are filed in the city offices so as to be available.

The method of preparation of these maps will depend largely on the tastes and previous experience of the engineer in charge of surveys. It is possible to make fairly good maps by the method of transit topography and a draftsman to plot the transitman's notes, but the cheapest and most accurate method is by plane table surveys. By this method there is so much less detail left to the draftsman's imagination. It is necessary to use the transit and level to secure adequate control for plane table surveys, and distances, such as length of streets, should be chained unless accurate maps showing such lengths are available. In open country a transit survey to locate control points not less than 1,000 feet apart should be made and level bench marks established every 1,000 feet in distance and at least every 20 feet in elevation. With the control points plotted on plane table sheets about 20″ by 30″ and a party consisting of topographer, recorder and rodman, maps can be made which will be superior in their general accuracy to maps made by the transit method, and will be almost as cheap.

In these maps all existing sewers should be located and their exact elevations determined, even if it is necessary to dig them up to do so. Attention needs to be given to the grades of water and gas mains parallel to the new sewers, since they may interfere with the house laterals.

Before proceeding to lay out a system on these maps it is necessary to consider whether a storm sewer must be built in the near future in streets now served by existing combined sewers, if no storm sewer is to be built the old sewer will be used if possible as a part of the new system. If a storm sewer needs to be built, the question arises whether the existing sewer is of sufficient capacity to serve as a storm sewer for the area. The fact that it has so served is not evidence that it will continue to do so under new conditions incident to prospective street improvements, etc. In this case, in order to obtain the best design, it becomes necessary to practically lay out a storm sewer system for the town. It will usually be found that the old sewers are too small to be used for storm sewers. In a case in mind in only one instance was the old sewer of sufficient capacity to provide proper drainage. Here the old sewer was used for a storm sewer and a new sanitary sewer built. Questions of the efficiency of the existing sewers as sanitary sewers also affect the design. It is possible that they are entirely too large to be self-cleansing when the drainage of the street no longer enters to periodically flush them. This fact, combined with the infiltration of ground water, may be serious enough to warrant the construction of a new sanitary sewer. Unless the street is to be immediately improved, or the use of the old sewer makes a considerable detour in the direct route of the new construction necessary, however, it will be best to use the old sewer for a sanitary sewer if its grade permits. In case it develops into an active nuisance a new sewer to take its place can always be laid later.

A further point deserving of more consideration than it usually receives, especially in small communities, is the securing of proper ventilation of the sewers. The common method in large cities is by the use of ventilating ducts through the houses to the roof. In small communities it will be found, however, that a large proportion of the houses have house-traps, which prevent the circulation of air through the sewers and ventilating ducts. In such cases it is necessary to secure the passage of an ordinance prohibiting house-traps or ventilate the sewer through perforated manhole heads. It is usually easy to secure the passage of the ordinance, but where the town does not have a plumbing inspector it is a difficult matter to enforce it. The enforcement of such an ordinance is, however, so essential to prevent nuisances from foul-smelling manholes that every effort should be made to secure competent inspection of the installation of house fixtures.

For sewers of small sizes the use of vitrified clay or tile pipe is universal. Vitrified pipe, however, is so subject to breakage, due to the unyielding character of the material and the imperfect bedding of the pipe usually secured, that more attention should be given to the prevention of breakage than is commonly done. It is a common practice to place a concrete or timber foundation under sewers where the bottom is soft. The restriction of this foundation to soft bottom indicates an intention to provide against settlement rather than against breakage. In this connection it is interesting to note a discussion of the strength of sewer pipe by Dean A. Marston and A. O. Anderson, of Iowa State College, in which they conclude from their observations that (1) it is impossible to prevent cracking of the larger sizes (over 15″) of pipe by precaution as to bedding and laying the pipe or refilling the ditch; (2) that pipe cracks more readily on hard, unyielding bottom than on soft bottom; (3) that it is necessary to require the contractor to carefully shape the bottom of the ditch to conform to the surface of the under half of the pipe; (4) and to carefully bed the pipe in sand or granular material; (5) that sewer pipe cracks from such slight distortions as compared with the yielding of the most solidly packed earth filling that it is not possible to prevent cracking by side-tamping at the mid-height; and (6) that when the above precautions do not prevent failure it is necessary to bed the pipe in concrete up to its mid-height or else use stronger pipe. These conclusions are not verbatim as given in the Record, nor do they comprise all of their conclusions, but they state the gist of their conclusions as to prevention of failure by care in laying pipe.

Their statement that pipe cracks more readily on hard bottom than on soft is illuminating when regard is had to the practice of placing concrete foundations on soft foundations only. Their conclusion (3) as here enumerated is practically impossible in hard and stony soils, and is almost never done in any soil. In any soil such a requirement entails an amount and quality of inspection rarely given to pipe sewer construction. Conclusion (4) seems more possible of attainment, but would require that the trench be excavated larger and deeper than the outside of the pipe and the granular material placed and tamped around and under the pipe. Their conclusion that "sewer pipe cracks from such slight distortions as compared with the yielding of the most solidly packed earth filling that it is not possible to prevent cracking by tamping the ditch filling on each side of the pipe at mid-height," indicates the equal impossibility of preventing cracking by excavating the bottom of the ditch to a cylinder true to the line and grade of the outside of the pipe. An attempt to secure this condition will result in leaving narrow cavities under the pipe too small to be tamped full of earth, and "slight distortions" of the pipe will be very apt to occur.

It appears that the statement "that when failure occurs in spite of the careful observance of the other precautions, the only effective remedy is to bed the pipe in concrete or use stronger pipe" indicates the advisability of laying all large pipe in concrete or else using double strength pipe. In the absence of experimental data as to which of these alternations is the stronger construction, the concrete is to be preferred, since it lends itself to the making of tighter joints, particularly where cement joints are used or in wet trenches. All sewer pipe up to, and including 12" diameter, commonly conforms to the accepted specifications for double strength pipe.

Concrete for this purpose need not be expensive. During November and December of 1913, 47 cu. yds. of a 1-5 hand-mixed gravel concrete was laid under about equal lengths of 15" and 20" pipe for an actual cost, including excavation for same, of $4.00 per cu. yd. Here the gravel cost $1.07 per yd. and cement $1.50 per barrel, delivered. Labor was 20 cents per hour. Very little foreman's time was included in the cost, since the work required practically no additional supervision. This cost does not include the removal of the excess material from the street, since in this case the earth was sold for the cost of removal. This figure would need to be increased in deep trenches where the cost of excavation was high or where the concrete could not be shovelled directly in place.

This sewer formed part of a storm sewer, the main outfall of which was 27" in diameter. On the outfall the cut was so shallow that it was feared a tile sewer would be broken under the weight of heavy rollers which it was expected to operate over the street preparatory to laying a pavement. Part of the sewer passing under railway tracks also required a stronger construction than tile. A concrete sewer 27" inside diam., 6" walls, with six ⅜" square bars placed longitudinally and spaced equidistant in the walls, was used as giving a stronger section. The structure was built of 1:4 gravel concrete and the interior was painted with grout. Some criticisms of this section were made by bidders as being too small to build economically of concrete. The cost as tabulated below indicate that the concrete sewer was built considerably cheaper than a single strength tile sewer laid on concrete could have been. The entire section of the sewer was run at one pouring, leaving no joints except at the end of each day's run.

Cost of 27" Concrete Sewer.

Item.	*Labor*	Amount.	Unit Cost.
Laborers, Exc. and backfill,	677½ hours @ 20c.	$ 135.50	0.472 per cu. yd.
Laborers, concreting.	510 " @ 20c.	102.00	1.46 " " "
Foreman. exc. and backfill,	58½ " @ 40c.	23.40	0.081 " " "
Foreman, concreting,	40 " @ 40c.	19.40	0.28 " " "
	Total	$280.30	$ 0.72 per ft.
	Materials.		
Gravel,	70 cu. yd. @ $1.07	74.90	
Cement,	105 bbls. @ 1.50	157.50	
Forms,		64.85	
Miscellaneous supplies,		13.00	
	Total	$310.25	$ 0.82 per ft.
	Total Labor and Material		1.52 per ft.

Results of hydrographic surveys conducted throughout the summer under the auspices of the naval service department, lead to the conclusion that first-class harbor facilities are to be found in James Bay in the vicinity of the mouth of the Nottaway River. Good shelter, ample room and a sufficient depth of water have been found and very little silt is in evidence to necessitate dredging. Soundings indicate plenty of water right out into the bay.

THE FUNCTIONS OF THE ENGINEERING SOCIETY.*

By L. K. Sherman,

President, Illinois Society of Engineers and Surveyors.

THE constitution of almost all engineering societies state that "the objects of the organization are the exchange of technical knowledge and experience and the advancement of the engineering profession." The benefits derived from the presentation of papers and the exchange of professional experience are of themselves ample reason for membership in the society, and incidentally they are large factors toward the professional advancement of engineering.

In my opinion, however, the time is now ripe when the engineering societies should enlarge their field of endeavor from the purely technical and literary functions to engage directly in efforts promoting the material status of the engineering profession and the individual members thereof.

I am not advocating this effort to promote the material status of engineers because of any alarming conditions. Engineering has advanced from a trade to a profession. Figures gathered by engineering societies, records of the graduates of technical schools and pay rolls of corporations show that the average annual income of the civil engineer to-day compares moderately well with similar statistics of the lawyer and doctor.

The field of the engineer has broadened, especially in lines of sanitation, highway construction and reclamation of lands. His position before the public is better recognized. Engineers are being placed as town managers, on public commissions, as investigators for financial corporations, and as constructors, instead of letting the work by contract.

It is, however, not our place merely to accept what the conditions of the times offer; it is our duty to take advantage of and to push those conditions which result in our rightful material welfare. This can be accomplished only through organization. This is the day of organization—individual effort fails. In business, consolidations alone survive. If engineers are to progress and to retain their rightful sphere they must do so through organization. The legal and medical professions are strongly organized to guard and advance their interests in legislation and in public relations. The architects of this State have an able organization, which legislated a certain kind of structural work out of our hands into theirs. Almost all lines of business have their lobbies. However much we may disagree with the methods of the building trades union we have to admire the efficiency of such organization. Some factors that have contributed toward the delinquency of engineers furthering their material welfare are their modesty, the fact that they are migratory animals, their false sense of dignity and too much conservatism. One of the unavoidable handicaps of the civil engineer arises from the very nature of his work. His work ends when the particular structure which he may be engaged on is completed. He then must seek other and often remote fields where new construction is to be started. These intervals between jobs are often of frequent occurrence. Thus the engineer is a migratory animal. I do not mean to underrate the desirability of maintaining the dignity of engineering as a profession, but dignity should not interfere

*Presidential address to the annual meeting of the society.

with business progress with us any more than it does with law or medicine.

I once heard of a secretary of an engineering society who was so conservative that he did not believe in any co-operation with the societies and in fact scarcely believed in a meeting of his own society.

The Illinois Society of Engineers and Surveyors has been one of the few engineering associations to enter the field of promoting material professional welfare. This society originated a movement to demand justice for a member engaged on a government bureau at Washington. Our action and his vindication were highly commended by the technical press, but the conservative constitutions of many engineering societies preclude this sort of work. During the past year a proposition was submitted at Springfield to place the State Geological Survey under the Board of the State University. This matter was brought to our attention and after consideration by the trustees and officers of this society it was decided that the proposed change would be detrimental to the efficiency of the Geological Survey, and communications were sent to a number of legislators at Springfield to that effect. The change was not made and the Survey maintains its separate existence.

After the passage of the law creating a State Public Utilities Commission, this society presented a petition to the Governor urging the appointment of an engineer upon said commission. Our membership is now honored with a member of the State Public Utilities Commission. In a number of instances the society has had special committees working in the interests of legislation affecting surveys and matters pertaining to land drainage and special assessment work.

The technical press of the country during the past year contains more communications than in any previous period on: "The Status of the Engineer"; "Compensation of Engineers"; "Engineers' License Laws"; "Code of Professional Ethics"; and "The Consolidation of the Engineer's Work in Large Engineering Corporations," etc. An association of consulting engineers in New York has been actually formed to handle these matters. The formation in Chicago of a Technical League, a union of engineers, associated with the American Federation of Labor, is a recent and most radical development. All of this is an indication that the engineering society is not entirely meeting the problems of material professional welfare.

Among the plans, projects and suggestions presented for advancing the status of engineers are: The licensing of engineers and surveyors; civil service laws; legal compensation for city engineers, etc.; trade unions; code of professional ethics; standardization of fees; and employment bureaus operated by the societies.

I cannot attempt here to consider the various arguments for and against these plans. What I am advocating here is that it is the proper duty and function of the engineering society to consider such plans, and to have an organization which possesses the necessary executive machinery to act upon those measures which are of benefit, and to circumvent those which are detrimental to the engineer and his allied works.

I recommend that the trustees and officers of this society be authorized to act as an executive committee in the name of the society in all matters of legislation and public relationship, and to receive, consider and act upon, or report upon, any complaint or suggestion presented by any member of the society. I also advocate the appointment of a committee on legislation whose duties it is to follow and to report to the executive committee any proposed state or municipal legislation which might be of interest.

The local or state engineering society is the logical organization to initiate such measures as are conducive to the material betterment of engineers. The efforts initiated by the local society should in turn be supported by the action of the interstate or national engineering societies.

The ability to accomplish practical results will to a large extent depend upon the numerical strength of the society. The voice of the society should be the representative voice of all engineers in the state. I believe that if the state society would acquire the reputation for action in measures affecting the status of the engineering profession and especially of its individual members there would be an immediate and large addition to its membership list.

POWER DEVELOPMENT AT GREAT FALLS, MAN.

Mr. Gano Dunn, president of the J. G. White Engineering Corporation of New York, was in Ottawa recently conferring with the Dominion Water Power Branch regarding the development of water power at Great Falls, on the Winnipeg River, in the province of Manitoba. This company has been retained by the Winnipeg River Power Company to design and construct a 100,000 horse-power plant at Great Falls. It is desired to have construction work commenced as soon as possible after the spring break-up, and an initial installation of 40,000 horse-power completed for use within three years.

The engineers of the Dominion Water Power Branch have recently completed an elaborate investigation of the Winnipeg River powers, and general conclusions have been arrived at with respect to the best method of concentrating the several natural falls of the river in order that there may be no portion of it left unused. As the Great Falls development must form a component part of the comprehensive scheme of concentrations arrived at by the Water Power Branch engineers, the J. G. White Company have made a thorough study of the Government investigations, and have decided to recommend to their clients, the Winnipeg River Power Company, that the Great Falls development should conform to, and be a component part of the Government proposals. Engineers of both the Water Power Branch and the company are in conference at Winnipeg and Ottawa in connection with the whole project with a view to having the necessary plans, specifications, etc., required by the Dominion regulations, submitted to the Department of the Interior for approval at the earliest possible date, in order that construction work may be commenced early.

The hearty approval by the J. G. White Corporation of the conclusions arrived at by the engineers of the Dominion Water Power Branch is a well-deserved tribute to the good work done by them in connection with important power possibilities of the Winnipeg River. This work has attracted a great deal of favorable attention, and the complete report of the investigations which will be published in the coming summer is awaited with great interest by all those interested in power development in Canada.

It is stated that the Western Railway of Buenos Ayres will eliminate all existing grade crossings and will electrify its suburban zone for a distance of about 25 miles from the terminal.

METHOD OF WELDING JOINTS IN CONTINUOUS STEEL GAS AND WATER MAINS AND OIL PIPE LINES.

THE material most commonly used for jointing water and gas mains is lead. For cast iron pipes, except where turned and bored joints are used, lead still holds the field undisputed excepting by a few patented lead compounds. Since the introduction of steel pipes with bell and spigot joints, lead has also been used for jointing steel pipes.

Since the perfection of oxy-acetylene welding, several attempts have been made to weld steel pipes together into continuous mains. Probably the most successful experiments of this sort have been those conducted by Stewarts and Lloyds, Limited, of England. This firm has patented a method of welding steel pipe joints that seems to have passed the experimental stage and to have become a commercial success.

Their joint consists of a spigot with a slight taper, which is drawn tightly into a faucet with a corresponding taper (see Fig. 5), the welding being effected by fusing soft Swedish charcoal iron wire with the metal of the spigot and faucet by the oxy-acetylene process. The close fit of the tapered surfaces of the spigot and faucet relieves the actual weld of any bending stresses which may come on the pipes.

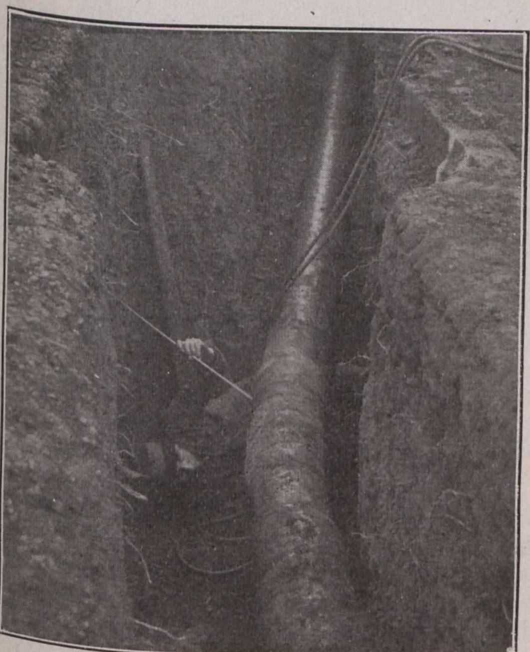

Fig. 1.—Welder working underneath the joint.

Fig. 3.—Welder at work in position where it has been impossible to turn pipe so as to keep welding portion at the top. A recess was made to allow the welder sufficient space to work all around the joint.

The end of the faucet is slightly bellmouthed, and this bellmouth serves the threefold purpose of facilitating the entry of the spigot into the faucet, of affording a long contact surface for the weld, and of enabling the joint to be safely and easily made from either above or below the pipe without endangering the person of the welder.

The welding outfit consists of a supply of compressed oxygen, usually confined in steel cylinders holding 100 cubic feet, and an acetylene generator and gas holder, fitted with a purifier. To the oxygen cylinders are attached a reducing valve and two pressure recorders, one for recording the pressure in the cylinder, the other for recording the pressure at the outlet of the reducing valve. The carbide for making the acetylene is supplied in air-tight drums containing 100 lbs.

The acetylene generator, gas-holder and purifier and the oxygen cylinders are mounted on a small trolley which can be wheeled from joint to joint along the trench as the welding progresses.

In districts where few cross-pieces are encountered in the trenches it is usually most convenient, in dealing with pipes up to 6 in. and 8 in. internal diameter, to weld the joints above ground over a couple of trestles or timber triangles (see Fig. 4), one about 18 in. and the other

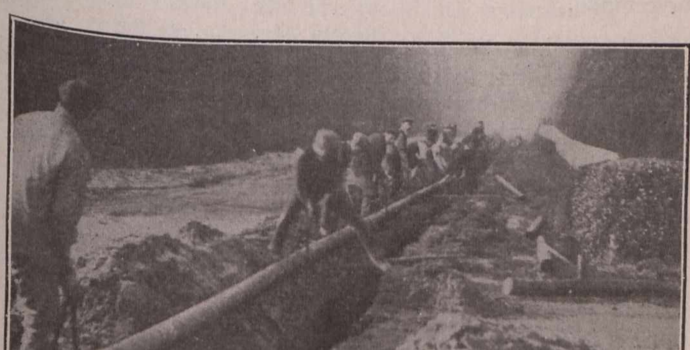

Fig. 2.—Stretch of pipe being lowered into trench after pipe has been welded above ground.

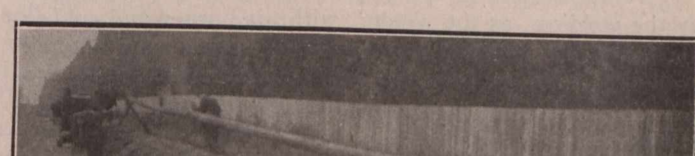

Fig. 4.—Six-inch pipe welded on trestles, then settling by its own weight into trench.

about 36 in. high, shifting the trestles forward a pipe length at a time, as each weld is completed, and allowing the finished part of the pipe line to settle down into the trench by its own weight, the pipes and joints being strong enough to make this method practicable.

Where the pipes must be threaded into position among numerous cross pipes, electric conduits, etc., the above method is impracticable. Under such circumstances some or all of the joints must be made in the trenches, without turning the pipes round, and to do this a recess about 6 feet long and 12 inches to 15 inches deep, under and in line with the pipe, must be provided at each joint for the welder, as shown in Fig. 3.

Where the trenches are straight and free from bracings it is practicable to weld up 6 to 12 pipes, depending on the diameter and conditions, either above ground (see Fig. 2) or in the trenches, without having a recess at every joint for the welder, the pipes being turned round as the welding of the joints proceeds. Two or more stretches having been welded up in this manner, these stretches can be welded together in the trenches, recesses for the welder being necessary, of course, at such welds, as shown in Fig. 1.

Joints occasionally occur in awkward positions, amid a labyrinth of other pipes. Welded joints in such positions may offer considerable difficulties, but the same applies to lead joints, the main difference being that to make a lead joint it is not always necessary to see it, but it is necessary to have sufficient space for the free use of the caulking tools and hammer. With welded joints, on the other hand, such clearance is often unnecessary, provided the welder can see the joint all round the pipe.

After welding, the joints can be tested with water or compressed air (see Fig. 6) before being put into service. In short lengths of main, or mains of small diameter, this can be done by means of a hand-operated pump, but where this would be too slow, a power-driven compressor can be employed.

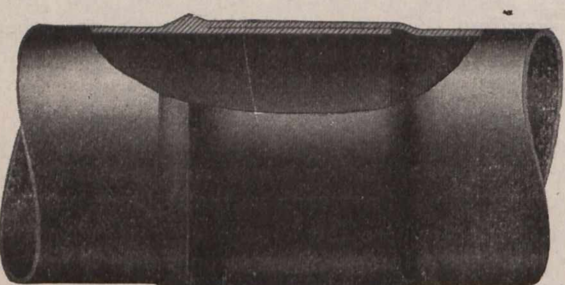

Fig. 5.—Welded socket and spigot joint.

When a main is being laid, the work is not delayed by the welding, as the welder, with his burner and rubber tubes, his gas outfit, a few bottles of oxygen and a small quantity of iron wire, will weld up at the rate of 150 feet of 4-inch main per hour, the pipe being in 20-foot lengths.

The cost of the joint under favorable conditions is said to be about the same as that of lead joints.

One of the objections commonly raised against welding long lengths of pipe into a continuous piece is that expansion and contraction due to variations in temperature may damage the joints.

In this connection interesting experiments were conducted by the patentees. A long straight pipe, held longitudinally and transversely against deformation, will be stressed to the extent of 2,240 lbs. per square inch of pipe section for every 10° F. variation in temperature. Tests of the patented joints showed a tensile strength of over 20 gross tons per square inch of pipe section. Under actual tests, variations of 80° F. did not affect the joints.

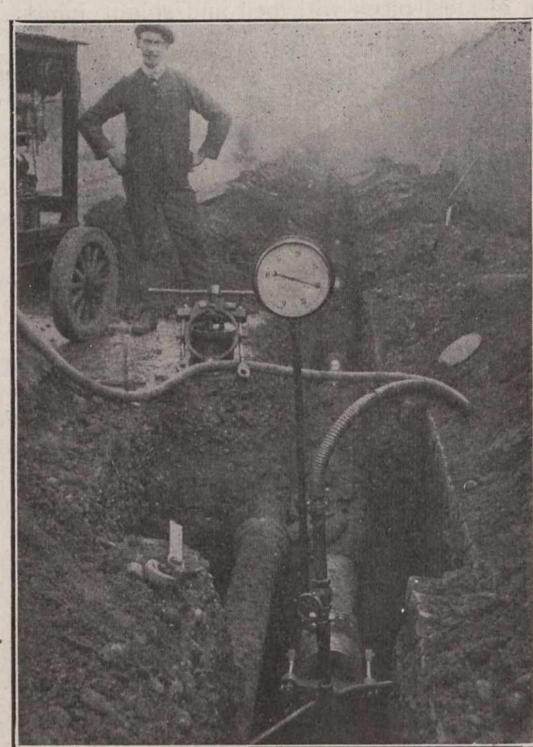

Fig. 6.—Testing main with compressed air to thirty pounds per square inch. Part of trench has been filled in, leaving only joints exposed.

A continuous stretch of these welded pipes, 4 inches internal diameter and 350 feet long, was embedded in a trench between two heavy concrete blocks and subjected to an air pressure of 100 lbs. per square inch, both ends being sealed. Throughout its entire length the temperature of this pipe was varied from day to day over a range of 80° F. for a month, the pipe ends meantime being kept rigid by the concrete abutments. At the end of the month the joints were as tight and sound as when first made.

Regarding the permanence of the joint under vibration, two 20-foot lengths, welded together and set horizontally, were vibrated by means of an eccentric with a 6-inch lift, revolving 300 to 400 times per hour, day and night, for a period of three weeks. After this severe treatment the joint was tested and was found sound and tight at 100 lbs. pressure.

When welding round the joint and coming back to the starting point, a small portion of the first weld is remelted to secure continuity in the weld. If this is not done a leak may develop at that point.

Steel pipes are coated outside and inside, or outside only, as required. The usual practice is to wrap the pipes, after the outside coating has been applied, in jute cloth saturated with solution. But, to avoid discomfort to the welder, the pipes are left free of coating and cloth for a distance of about 6 inches from each end, and a sufficient quantity of special solution for applying cold and hessian cloth for wrapping the joints after welding, is supplied with each installation. The mains are thus not only welded up into one continuous length, but they are also provided with a continuous coating of anti-corrosive material, reinforced by a continuous envelope of cloth soaked in the same rust-resisting compound.

Steel pipes with this type of joint have been supplied for gas and water mains, and also for oil pipe lines, laid under water. In the latter case the pipes were paid out like a cable from a barge as the joints were made, and in a certain instance were welded on the bank and drawn in one length across a river a mile wide.

They have also been used for pump delivery mains in vertical pit shafts, the welding being done in the shaft, and in some cases on the pit head; the main, in the latter cases, being let down, a pipe at a time, as each joint was completed. The tensile stress on the joint, due to the weight of a vertical line of pipes 1,000 feet long, is equivalent to about 1½ gross tons per square inch of pipe section. As the joints have been found by tests to bear fifteen times this stress, the patentees state that this method of jointing may safely be adopted even for very deep shafts.

THE RELATION OF RAINFALL TO RUN-OFF IN AMERICAN RIVERS.

In a paper, published recently in the School of Mines Quarterly of Columbia University, Mr. W. F. White, Jr., assembles the available data on the rainfall and run-off in the various drainage basins of the United States, in an endeavor to determine what definite relations there exists between them. The following extract from his paper brings out also the factors that influence these relations, with their nature and relative importance:

The subject is one to which little study has been devoted, and the scarcity of written information is surprising considering the importance of the questions involved, in the development of both water power and water supply. The subject, furthermore, has a vital bearing upon the floods, which are of frequent and disastrous occurrence in some sections of the country. In the Am. Soc. C.E. Transactions are several papers with lengthy discussions which afford much valuable information on the actions of several individual streams and of the proportion of run-off from their catchment basins. The United States Geological Survey has taken up the study of rain and run-off, and in one of its bulletins G. W. Rafter sums up what is known of their relations. In addition, several water supply papers on various areas have given figures for the per cent. of rainfall appearing in stream flow, but have not gone more deeply into the causes of the variations for different times and streams.

Sir John Murray has published an article (Scottish Geographical Magazine, Vol. 3) on the amount of rainfall and run-off of the large rivers of the globe, and from them has assumed the ratio of run-off to rainfall for the world. He estimates that ratio is as 1 to 4.499, or about 22.2 per cent. of the precipitation. An interesting paper, "Ecoulement fluvial et Denudation," by H. Baulig, bearing more on the problems of denudation by streams, and on the chemical side, has recently appeared; with this, the list of papers on the relations of rainfall and run-off in the United States practically ends.

For the calculation of the ratios in this paper, the measurements have been taken for the years 1906 to 1910 inclusive. In this 5-year period a very good average of weather conditions is obtained, especially in regard to the precipitation. Of the five, two were of rather greater rainfall than is the ordinary experience, viz., 1907 and 1909; two were of less than average rainfall, namely, 1908 and 1910; and one, 1906, was of nearly average amount. These statements can be made, however, only in a general way, and the mistake must not arise of assuming that any one section of the country had precipitation of more than average amount, because the country as a whole had a year of heavy rainfall. Thus, though the year 1907 had generally a much heavier rainfall than 1908, yet locally, as in the southeastern states, the latter year records the heavier precipitation. This goes to show that the rainfall is a very uncertain quantity, and makes difficult the task of determining the amount at one point of comparison with that of some other region.

The amount of rainfall even in one place shows surprising variation from year to year. In general, the maximum annual total is from two to four times the minimum. Thus, at Orono, Me., a record for 42 years gives a minimum annual precipitation of 28.5 in. in 1895, and a maximum of 58.7 in. in 1888, or a ratio of 1 to 2.1. At Boston a record for 74 years shows extremes of 27.2 in. and 67.7 in., or a ratio of 1 to 2.5, slightly greater than at Orono. The mean annual rainfall for the whole United States amounts to 29.4 in., but, due to the extreme variability for different places and times, gives no clue to the rainfall of any particular area.

The distribution of the rainfall through the year also varies greatly in different sections of the country. The precipitation may be fairly uniform throughout the year, as in the New England states, where the mean of a period of years showed that 12.2 in. of rain fell in spring, 11.4 in. fell in summer, 11.7 in. fell in autumn, and 11.7 in. fell in winter. On the other hand, the precipitation may be nearly all crowded into one period, as is commonly the case along the Pacific Coast, where, in the Sacramento Valley, 83 per cent. of the annual precipitation falls in the period from November to April.

When rain falls on the surface of the earth it may do one of four things: It may be evaporated directly by the sun; it may flow directly into streams or lakes; it may sink into the ground; or it may be taken up by vegetation or combine with minerals of the earth's crust. The part that is evaporated by the sun is lost, and no further consideration of it need be made. The quantity of water which finds its way directly to streams varies greatly with the time of year and the nature of the country. It is much higher in winter, when the ground is frozen, than in summer, when the rain has a chance to sink into the ground. This part constitutes what is known as surface flow.

That part which sinks into the ground is by far the greatest and most important, though it, too, varies with the nature of the soil. In a sandy, porous soil the amount will be very high, while in an impervious, clay soil it will be comparatively slight. This underground water serves as a source of supply in times of drought. It may reach the surface in springs, wells, or by seepage. This last is of the greatest importance, and, when it is considerable, serves to keep the flow of the streams uniform throughout the year. When it comes to the surface it is again exposed to evaporation and is partly removed in that way. With the exception of a negligible amount which sinks into the earth and is not recovered, this water finally is returned either as stream flow or evaporation.

Of the part that is consumed by vegetation, some is lost, but a considerable proportion is returned to the atmosphere by evaporation from leaves and other surfaces. Thus a very large part, which has been estimated at over 99%, is ultimately delivered back in the form of stream flow and evaporation. It is with stream discharge, or the run-off from a catchment basin, that we have specially to deal. The amount of this depends primarily on the precipitation, for without this there could be no run-off; yet there are many other factors which influence the flow, and create very complex relations.

The flow of streams has been divided into the following periods: Storage, growing, and replenishing. The storage period for the eastern United States begins about December, though it may vary from year to year and in different localities, and concludes about May. During much of this time, evaporation is slight and the demands of vegetation are small, so that a large percentage of the rainfall reaches the streams. The growing period includes approximately the months from June to August, during which time both absorption by plant life and evaporation are at a maximum. As a result, the amount of rainfall that finds its way to the streams is small, and the streams have their minimum flow unless a very rainy season upsets the customary conditions. During this period, the drain on the underground water supply is severe and the level of the ground water falls. During the replenishing period, which lasts from September to November, the flow assumes more normal conditions, and the run-off is higher than during the growing period. The ground water regains its former height, and by the beginning of the next storage period everything is in favorable condition for a large stream flow.

The method used in calculating the precipitation of each basin was to select such stations of the United States Weather Bureau as were within it, and from them to pick out a number from the different sections of the basin, which would show the average conditions. From the records of these, it was possible to arrive at an approximation of the mean annual rainfall for the basin in question. The number of stations selected necessarily varied widely with different basins. In a small basin, with comparatively uniform conditions throughout, a few stations sufficed, while in a long basin, with widely varying conditions, such as that of the Columbia River, a greater number of records was required to determine the mean precipitation.

The stream measurements are those secured by the government at its gauging stations on the different rivers. The volume of the discharge is computed by securing a profile of the stream bed at the gauging point, and then placing on some permanent object a gauge which will read the height of the water. Daily readings are taken to ascertain the cross-section of the stream, while the speed of the current is determined with a current meter. After a number of discharges have been computed, a rating curve can be drawn which will give the discharge directly from the gauge height. Where the gauge is at a dam or weir, somewhat different methods are used, the flow being calculated by formula. Unfortunately, these gauging stations are rarely at the mouths of streams, and as the run-off for the entire drainage basin of the stream is not given, care must be taken to specify above what point the data apply.

Steam discharge is commonly given either as foot-seconds of flow, which is the number of cubic feet passing a given point in a second; or as the average total inches in depth of water flowing from the entire drainage surface during a stated length of time. This latter method has been followed in this paper, in order that the results may be directly comparable with the precipitation records.

Rainfall measurements are always given in inches of depth during a stated time, usually a year. Accordingly, the precipitation of an entire drainage basin is expressed in inches over its area.

The sources of error in precipitation records are several. In the first place, a rain gauge can cover only a few square inches of ground, and to obtain accurate results a large number of gauges in the same district would be necessary, which is usually impracticable. The elevation of the gauge above the ground also has an important bearing on the accuracy of the measurements. The gauges should be kept as near the ground as possible, whence records of rainfall taken on the tops of buildings are of little value.

The fact that many streams have their headwaters in the mountains adds to the difficulty of securing reliable records, as there are few stations in the mountainous regions, and these are generally confined to the valleys.

The accuracy of stream measurements depends upon the type of gauge used. If at a weir or dam, reliable measurements can be obtained, generally within an error of five per cent. At other gauging stations the results are not always so accurate, and the error may range up to 20 per cent. in exceptional cases. The main cause of this trouble is the constant shifting of the bottom, which renders the cross-section used in the computations inaccurate unless frequently corrected.

The data in the tables accompanying Mr. White's article were compiled in this manner: Following the name of the river comes that of the gauging station above which the data are computed. In the third column is stated the area of each river basin in square miles, and in the fourth the percentage which each basin constitutes of the whole drainage district. This is done for the purpose of giving due weight to the larger streams. The fifth column records the average annual rainfall of each basin, in inches, during the five years 1906 to 1910 inclusive, except in a few cases in which the average is based on only three or four of these years. The sixth column gives the annual run-off of each basin, averaged on the same five years; the figures represent inches in depth over the area of the basin above the gauging point. The ratio in the seventh column is obtained by dividing the average run-off by the average rainfall for the five years, not by averaging the ratios of the five years. The product in the last column is computed by multiplying the percentage area of each basin by its average ratio; hence the sum of this column represents the mean run-off ratio of the district.

It was found convenient to follow the divisions of the country made by the Geological Survey, and the streams have accordingly been grouped into the following districts: North Atlantic; South Atlantic and East Gulf of Mexico; Ohio River; St. Lawrence River; Upper Mississippi River; Hudson's Bay; Missouri River; Lower Mississippi River; Western Gulf of Mexico; Colorado River; Great Basin; Pacific Coast in California; North Pacific Coast.

From a study of the tables and a consideration of the basins of the individual rivers, some conclusions can be derived as to the various factors determining the run-off of a stream. The influences operating on the discharge of a river basin are too intimately associated and involved to allow an exact statement as to their respective importance, but certain general relations can be shown, and the relative importance of the factors judged approximately.

Run-off is, of course, primarily dependent on precipitation, but to say that the run-off varies directly as the rainfall is a broad statement which statistics fail to support. This is true, not only for different drainage basins, but even in the same basin. Thus in the Penobscot River, above Millinocket, Me., in 1906, with a rainfall of 41.9 in., there was a run-off of 18 in., or 43 per cent., while during the next year, with a rainfall of 42.1 in., the run-off was 26.9 in., or a ratio of 64 per cent. Cases so extreme as this, however, are of unusual occurrence and are due to outside influences. Ordinarily it can safely be said that the per cent. of run-off in any particular stream will increase with an increase in rainfall. This is well illustrated by the Columbia River, which shows the following variation:

Year.	Rainfall.	Run-off ratio.
1906	21.5	45.6%
1908	24.2	49.0
1909	24.1	50.2
1907	26.1	52.1

Even though varying with the rainfall, the run-off is not directly proportional to it, but shows much greater variation than the rainfall ever does. The maximum annual rainfall rarely exceeds four times the minimum, while the maximum run-off may exceed the minimum by several times that amount. If the rainfall and run-off should be plotted for a period of years on an equal scale, the curve of the rainfall would be found to be much the more irregular, with far sharper changes. An example of this is given by the Oconee River, above Dublin, Ga.:

Year.	Rainfall.	Run-off.	Ratio.
1906	50.1	19.6	.391
1907	45.9	14.7	.319
1908	54.3	25.2	.464
1909	49.1	18.2	.369
1910	43.3	12.4	.288

Of even greater importance than the total amount of the rainfall is its distribution throughout the year. A stream which has its precipitation concentrated in a few months will yield a higher percentage of run-off than a similar one with its precipitation distributed evenly throughout the year. The causes for this are apparent. In the former case, evaporation has a smaller opportunity to act on the water, since in a rainy season evaporation is at its poorest efficiency. Also, as the ground can hold only a certain amount of water, when it becomes saturated the remaining water can flow off as a surface discharge.

An example of this principle can be found in the Merrimac of Massachusetts and the Kaweah of California. With nearly equal annual rainfall of about 32 in., the Kaweah has 33 per cent. higher run-off, the ratios being respectively 0.514 and 0.714. This is due to the concentration of 83 per cent. of its total rainfall into the months from November to April, while in the Merrimac basin the precipitation is distributed very nearly equally throughout the year, with 26 per cent. falling in spring, 24 per cent. in summer, 25 per cent. in autumn, and 25 per cent. in winter. This distribution of the rainfall is of the greatest importance, and special emphasis should be placed on it in calculating water supplies.

One reason for the increase in the ratio of run-off with higher rainfall is found in the evaporation, which remains nearly constant from year to year, irrespective of the amount of precipitation. The explanation of this is that conditions favorable for high evaporation, i.e., heavy rainfall and high temperature, rarely occur together. Due to this the evaporation of a wet year is about equal in amount to that of a dry, hot year. This uniformity of evaporation, so noticeable as between years, is not found as between seasons of a single year, when, on the contrary, great differences occur. In the basin of the Sudbury River of Massachusetts, evaporation during the summer is six times as great as during the winter, owing chiefly to the higher temperature and greater amount of sunshine during the former, and to the occurrence of ice during the latter season.

The evaporation of different streams varies widely, being dependent upon a number of separate factors. The most important of these is the temperature. Evaporation is directly proportional to the temperature, and will therefore be higher in warmer regions, other things being equal. It is even sufficient, in very hot regions, as some parts of the Great Basin, completely to exhaust the streams, leaving no flow in the river bed. The velocity of the wind also has an important influence on evaporation. Other factors of major importance are the roughness of the surface, the amount of sunshine, and the area forested.

Numerous attempts have been made to construct formulas by which to compute the run-off of streams from the precipitation records. Several of these are in use, but they are inaccurate and require important modifications for each stream. A formula for one stream may give fair results for a neighboring one of similar character, but to apply it to a stream in a different section of the country would be futile. The only reliable way to ascertain the run-off from rainfall data is to construct a curve for the particular stream from the records of former years, and use it as a standard.

The influence of topography on run-off is hard to gauge, as it is closely associated with other factors. It is probable, though, that this is one of the less important agents in determining stream flow. Roughly, it may be stated that in a steep basin the run-off will be large but very irregular, while in a flat basin the run-off will be less, but more uniform.

Two streams which flow over the same geological formation will be found to have a close resemblance in flow. The character of the soil and underlying rock is chiefly important by its ability to hold the rain in the form of ground water. Igneous and other massive rocks, such as the pre-Cambrics of the upper Hudson valley, give little opportunity for the rain to penetrate them, and therefore yield a relatively high run-off. At the other extreme, very porous rocks, as some sandstones and highly jointed limestones, yield little or no surface flow, but conduct the water at a deeper level, returning it to the surface at a lower point, possibly in some other drainage basin. These rocks afford a more regular flow to the streams, but the opportunities for loss are greater, and the ultimate total run-off is somewhat less than where denser rocks occur. Likewise a sandy surface soil yields a more uniform but smaller flow than where the soil is clay.

An interesting example of the influence of geological formation on the run-off is found in the basin of the Mohawk River, where those tributaries flowing from the granitic area to the north of the stream have a greater run-off than those coming from the Devonian shales to the south. It must not be forgotten, however, that the area to the north is much more heavily forested, and its greater flow is undoubtedly partly due to this influence.

The proportion of a drainage basin that consists of lakes and marshes has a modifying influence on stream flow, through the ability of these to store excessive rainfall and to distribute its flow over a longer period of time. On the other hand, due to increased evaporation over a water surface, lake area decreases the total run-off of a basin to an appreciable extent. An example of high evaporation is seen in the Oswego River basin, of which 10.6 per cent. consists of lakes and marshes, where the evaporation amounts to 28 in. annually. The equalizing effect of lakes on stream run-off is also well illustrated in the basin of the Androscoggin River, which has 69 square miles of lake surface.

Lakes and marshes are not the only means of storage, for over most of the country large quantities are stored in the form or ice and snow, occurring as loose drifts in the lowland, which will melt and will find their way to the streams at the first thaw, or as deep solid drifts on the mountain ranges, or more rarely in the form of permanent glaciers. Snow of the first type serves only to swell the already high streams of early spring, without having any beneficial character. If of the latter types, the melting period is much later and more protracted, which is of great service in maintaining flow during the summer months when all other agencies are working toward the reduction of the discharge. It is a general rule that streams which have their sources in the mountains maintain a more constant summer flow than those rising in the lowlands. Nowhere is this better illustrated than in the streams of the Pacific Coast, where the mountains of the Coast Range are close at hand, and contain the headwaters of most of the streams.

That the vegetation of a drainage basin is of great importance in determining the amount of run-off is generally accepted, but whether the forests increase annual rainfall, as commonly believed, has not been proved. Indeed, it is now considered very doubtful whether any difference in rainfall can be traced to the influence of vegetation. The real value of vegetation, and particularly of forest growth, is in restricting the evaporation of the rain that does fall. Plants somewhat counterbalance their effectiveness in this direction by the water which they consume themselves, but the balance is well in their favor; and if, of two similar watersheds, one is heavily forested and the other is not, the run-off from the forested basin will exceed that from the other.

The effectiveness of the vegetation depends largely upon its character. The best type is old coniferous forests which allow little wind and less sunshine to penetrate their depths. Where extensive areas of such forests occur the run-off is sure to be high. Deciduous growth is not so influential, yet is still of value, and even cultivated fields are of some, though limited importance. The means by which the increased run-off is produced are several. First is the restriction of evaporation, due to the inability of the wind to circulate freely among the trees, to the maintenance of lower temperature and higher humidity during the summer months, and to the protection which the foliage gives from the sunshine. Aside from the lessening of evaporation, forests provide conditions favorable for the accumulation of snow drifts and their preservation until after the time of the spring floods. The ground-water circulation is also increased by forests. Examples of high run-off from heavily forested regions are common, but the Machias, Mohawk and Umpqua Rivers are excellent illustrations.

In spite of the prominence of forests in governing the run-off from an area, other factors may combine to overcome its influence; as a result, some basins show low or irregular run-off notwithstanding their being heavily forested. This is well shown by the streams of western Oregon and Washington, which, although well protected by forests, are subject to floods, due to heavy and concentrated rainfall.

The recent disasters in Ohio and Indiana have brought the general subject of floods prominently before the public mind, and the study of their causes and occurrence is of special interest. It has been noticed of late years that floods have been increasing in frequency and a study of the records of almost any stream subject to floods will prove this. On the Allegheny River, during the period from 1874 to 1890, floods occurred in only three years, while during an equal period, from 1891 to 1907, there were ten years when floods occurred. Likewise, on the Savannah River, from 1876 to 1890, there were three years with floods; while during the years 1892 to 1906, there were five years with floods. These rivers indicate fairly well the change in conditions throughout the eastern states.

The explanation of this increase must lie in a change of one of the influences governing run-off. Records show that rainfall and temperature have not changed; the topography and geology of a river basin are permanent, for this discussion; artificial agencies tend to check rather than encourage floods; hence the prime cause must be a change in vegetation, chiefly deforestation. The records sustain this supposition by proving that it is those very basins that have been most denuded of their forests which record the greatest increase in the number of floods. Thus, on both the Allegheny and the Savannah river basins large lumbering industries have been at work during recent years, and the increase in the number of floods can be traced directly to this cause.

In conclusion is should be emphasized that the solution of the problems herein discussed is not final, because reliable records over long periods of time are not available, and little attention has yet been paid to this important subject.

In a report made by State Engineer Bensel, it is announced that New York State will have invested in its barge canal, when complete, $86,000,000, an increase of nearly $10,000,000 over the original estimate in 1913. He recommends also that the United States federal government be asked to deepen United States waters at Oswego, Albany and Whitehall; and favors also the conversion of all old canal lands into boulevards and parks.

L. R. Grabill, superintendent of suburban good roads, Washington, D.C., considers that the prime factors which should determine the selection of a type of road surface, when selection is not limited by any necessity for giving undue preference to any factor, are; first, the volume and nature of the probable traffic over the pavement; secondly, conditions incident to the location of the pavement; including the character of the adjacent land and improvements, the character of the foundation, the kind of adjoining pavements, the ruling gradients, the climatic conditions and especially the availability and cost of different materials at the work; thirdly, the characteristic of the surface which will adequately meet physically, hygenically and aesthetically the conditions expressed in the two factors first named; and last, the quotient obtained by dividing the total estimated traffic to be carried per unit of width into the cost per unit of area of the pavement during its probable life; including first cost and interest on the same, special surface treatment for dust suppression or other purposes, and any necessary repair until replacement; but not including the cost of cleaning.

WATER POWERS OF MANITOBA.

THAT Manitoba is richly endowed with numerous water-powers has been generally known, but previous to the investigations of the Water Power Branch of the Department of the Interior of Canada, their extent and magnitude have only been approximated. Recognizing the great value of such powers, and with a view to the power requirements of both the present and future, a complete study has been made of certain power rivers, and is being made of all other power rivers throughout the province. In such studies it is the aim of the Department to form a comprehensive scheme contemplating the maximum development of the total head available upon a river.

A general summary of the water-power resources of the province forms a part of a report prepared recently by the Department for the Public Utilities Commission of Manitoba. The information given here is extracted from the report. *The Canadian Engineer* for February 12th, 1914, published another portion dealing with the power possibilities of the Winnipeg River as a part of the same investigations.

The preparation of the material in the report, with the exception of that relating to the Winnipeg River, was commenced by Mr. D. L. McLean, Chief Engineer of the Manitoba Hydrographic and Power Surveys. Owing to his resignation in October last, most of the work devolved upon the assistant engineer, Mr. S. S. Scovil, whose enthusiastic co-operation made possible the speedy completion of the whole, in order that it might be in the hands of the Public Utilities Commission by December 15th, 1913.

The great power possibilities of Manitoba are due to the geological and topographical features of the province. The central portion of Manitoba acts as a collecting basin for the waters from an immense drainage area. This vast area extends from the Rocky Mountains practically as far eastward as Lake Superior; it also comprises a great portion of the Northern States and reaches into the northerly lands of Western Canada.

As these waters reach the central portion of the province, a depression occurs between the prairie steeps and the Laurentian plateau, through which an extensive fall is available for power development. Lake Winnipeg forms the reservoir into which is collected practically all the runoff from the above drainage area. From this lake to Hudson Bay the flow is concentrated in the Nelson river, on which a drop of approximately 700 feet occurs.

It is thus apparent that the major portion of the powers throughout the basin are concentrated within the lower portion of the drainage area, or more particularly in Manitoba.

The powers are naturally separated into two divisions, viz., those occurring on the rivers draining into Lake Winnipeg, which are situated in the older or southern portion of the province; and secondly, the powers which occur in the northern portion lying in the drainage from Lake Winnipeg. Under these two divisions the estimated powers of the province are tabulated below.

It should be noted that while on many rivers, possible power concentrations have been investigated, and an estimate of the available power is given for various sites, yet, as future investigations will show, further power may be available on such rivers. Again, in the case of other rivers, no surveys to determine the extent of concentration available have as yet been made, and in these cases where a record of the flow has been obtained, an estimate is made of the power available per foot head. In many cases the power has been estimated both for the extreme minimum flow and for the lowest monthly mean flow of the highest six months of the year as obtained from the present record of discharges.

The horse-power has been calculated for a turbine efficiency of 80 per cent., while no estimate has been made as to the power available during short periods of high or peak loads, since this would be impossible without a knowledge of the circumstances for which the power might be desired. The powers on the Winnipeg river have been considered on a 75 per cent. efficiency basis for reasons set out in the treatment of that river. (See *The Canadian Engineer*, February 12th, 1914.)

The data for these tables, and also for the more detailed description of the rivers as given in the following chapters, has been secured in the field by the Manitoba Hydrographic and Power Surveys, and office compilation in Winnipeg and Ottawa.

The following tabulation of the powers in the province is not intended to fully cover the subject, as many rivers are as yet to be investigated:—

POWERS OF SOUTHERN AND CENTRAL PORTION OF PROVINCE.

Table No. 1.—Existing Water Power Developments.

River.	Plant.	Power developed. H.P.
Winnipeg	City of Winnipeg*	20,800
Winnipeg	Winnipeg Elec. Ry. Co. ..	26,500
Little Saskatchewan.	Brandon Elec. Light Co..	500
Little Saskatchewan.	Minnedosa Power Co. ..	500
Shell	Assessippi	50
	Total	48,350

*The city of Winnipeg's plant can ultimately supply, with a regulated river, 76,800 24 hr. power.

Table No. 2.—Possible Water Power Developments.

Winnipeg River.

Site.	Head.	24 hr. power at 75% efficiency. 12,000 sec. ft.	20,000 sec. ft.
Slave Falls	26	26,600	44,400
1st site Seven Sisters ...	39	11,600	34,800
2nd site Seven Sisters ...	37	12,600	37,900
McArthur	18	18,400	30,700
Du Bonnet	56	57,300	95,500
Pine	37	37,900	63,100
Total		164,400	306,400

Table No. 3.

Horse-Power on 80% Efficiency 24 hr.

River.	Site.	Min. flow.	Total	Reg. flow.	Total	Period of 6 highest mos. of yr.	Total.
Whitemouth	No. 1	46	....	..	....	180	....
	No. 2	46	92	..	....	180	360
Brokenhead	X	0	....	..	....	8	....
Roseau	X	0	....	..	....	3.6	....
Red	St. Andrews	..	....	..	....	3,270	3,270
Pembina	X	..	....	..	....	...	....
Souris	X	0.5	....	..	....	4.5	....
Shell	X	..	....	..	....	18	....
Assiniboine	Currie's Landing	653	....	..	....	1,685	1,685
X	Headingly	36	....	..	....	108	....
X	Millwood	14	....	..	....	64	....
Little Sask.	No. 1	180	....	840	....	....	....
	No. 2	203	....	945	....	....	....
	No. 3	212	....	987	....	....	....
	No. 4	90	685	420	3,192	....	....
Valley	No. 1	34	....	102	....	172	....
	No. 2	34	....	102	....	172	....
	No. 3	101	....	303	....	504	....
	No. 4	94	263	282	789	468	1,316

Table No. 3.

Horse-Power on 80 % Efficiency 24 hr.

Mossy	No. 1	272	....	..	....	....	....
	No. 2	272	544	..	....	....	....
Waterhen	Meadow Fort	6,800	....	..	....	....	....
Fairford and Dauphin	No. 1	3,630	....	..	....	....	....
	No. 2	2,950	....	..	....	....	....
	No. 3	12,706	....	..	....	....	....
	No. 4	7,260	26,546	..	....	....	....
Swan River	X	4.5	....	..	....	14.5	....
Red Deer	X	13.7	....	..	....	....	....
Manigotagan	No. 1	90	....	449	....	....	....
	No. 2	22	....	109	....	....	....
	No. 3	33	....	163	....	....	....
	No. 4	82	....	408	....	....	....
	No. 5	33	....	163	....	....	....
	No. 6	49	....	245	....	....	....
	No. 7	92	....	462	....	....	....
	No. 8	76	....	381	....	....	....
	No. 9	57	....	286	....	....	....
	No. 10	74	608	368	3,034	....	....
Saskatchewan	Demi Charge	6,808	....	..	....	46,289	....
	Red Rock	6,808	....	..	....	46,289	....
	Grand Rapids	36,305	49,921	...	.....	246,877	339,455

The estimated power as shown refers only to horse-power per ft. head as investigations as to possible concentrations are as yet to be made.

POWERS OF NORTHERN PORTION OF PROVINCE.

Table No. 4.—Nelson River.

Site.	Horse-Power Based on 80% Efficiency. (Est. Min. Flow, 50,000 sec. ft.)
Whisky Jack Portage	181,150
Ebb and Flow Rapids	77,150
White Mud Rapids	135,860
Bladder Rapids	90,575
Chain of Rock Rapids	158,510
Devils Rapids	113,220
Grand Rapids	122,530
Birthday Rapids	163,375
First Gull Rapids	77,150
Second Gull Rapids	95,105
Third Gull Rapids	90,575
Fourth Gull Rapids	135,860
First Kettle Rapids	77,150
Second Kettle Rapids	97,370
Third Kettle Rapids	181,150
Upper Long Spruce Rapids	181,150
Upper Long Spruce Rapids	235,495
Upper Limestone Rapids	149,450
Lower Limestone Rapids	185,680
	2,548,505

During 1912, a thorough study of the advisability of paying close attention to the air consumption of the machine drills in a mine, especially where power is purchased, as shown by the experience of the Central Mining-Rand Mines group on the Transvaal (Journ. So. African Inst. of Eng., November, 1913), was made; and the new methods of handling the machines was adopted. The air consumption for all purposes underground was reduced to units of 3¼-in.-piston drill shifts. The average number of such units was between 75,000 and 80,000 per month over the year. The air was purchased in so-called air units, representing energy to the extent of 0.641 kilowatt-hours. The consumption of these units was about 11,500,000 per month and the average consumption per machine shift was reduced from 163 to 138. This represents a clean saving of $0.25 per machine shift, over $225,000 in a year's time. This would seem worth while.

CONSERVATION OF COAL IN CANADA.

The Commission of Conservation has now in press a report on the conservation of coal, according to the address of Hon. Clifford Sifton, at the last annual meeting of the Commission. This report catalogues briefly the methods followed in operating the principal coal mines of Canada. Emphasis is laid on the advantages of the leasehold system of granting coal areas which is in vogue in Nova Scotia, and the adoption of a similar system is recommended in other provinces, more especially in Alberta, with a view to stopping the wasteful methods of mining coal which obtain in certain districts.

Attention is also directed to the advantage of briquetting coal, in order to prevent the waste of slack; and the advantages of the by-product coke, even over the type generally in use, are set forth.

The fact that the practice of briquetting coal has not yet been followed on any considerable scale in Canada is an illustration of the difficulty of securing the introduction of well-proved, economic methods which have been in use in older countries for many years. It is hoped that a beneficial change in this respect will come about in a short time.

In addition to visiting the different mining plants for the purpose of getting information upon which the report respecting the conservation of coal is based, W. J. Dick, B.Sc., Mining Engineer of the Commission, in acting as guide in connection with the visits of the International Geological Congress to the coal mines of western Canada, had the benefit of gaining the opinions of foreign scientists in regard to the conduct of the coal mining industry.

NEW PULP MILL ON THE ST. LAWRENCE.

On the south side of the Gulf of St. Lawrence, about sixty miles back from the end of land, the St. Lawrence Pulp and Lumber Corporation is erecting a plant which, when finished, will represent an investment of close to a million dollars. There is an irregular group of buildings, mostly one-story, and measuring something like 900 by 200 ft. in plan, forming a complete pulp mill for making high-grade bleached sulphite pulp, together with a digester building covering digesters reaching 160 ft. above the ground. All of this is now being built by the Aberthaw Construction Company, of Boston, and is to be finished by next September. The buildings have concrete exterior, the interior structure being largely of structural steel, with yellow pine roofs.

There is to be an independent steam turbo-generator plant, giving power for both the pulp mill and a saw mill, which is being erected separately. A private railroad is to supply the mill with logs from the extensive timber and pulp-wood limits of the company, aggregating some 500 square miles. The Dominion Government has undertaken to develop a harbor for safe wharfage for ships up to 6,000 tons burden.

Canadians may praise the condition of English roads, but the following facts show the Englishmen see plenty of room for improvement. Proceeds of the petrol tax are enabling seven counties to spend $4,000,000 this winter, on road making, with the object of creating a smooth, waterproof, dustless surface. The road board, which Mr. Lloyd George created, has already made grants of $22,500,000 from the imperial taxation for strengthening the main roads to meet the requirements of modern traffic.

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OTTAWA'S TEST FOR INTELLIGENCE.

A plebiscite on a question of civic concern cannot be said to achieve its purpose unless the voter has a clear conception of its fundamentals in order that he may poll his vote in accordance with his convictions created thereby. To be able to vote intelligently is the chief desire of every enfranchised citizen. A city council should assist the ratepayer to a clear understanding of the projects it may have under consideration, especially when it contemplates acting according to the vote of the citizens. Perhaps a more illustrative instance could not readily be found of a city council taking for granted that the man on the street can weigh and judge, with competence, questions which tax the agile and discriminating capabilities of the experienced engineer, than that which has appeared in connection with the Ottawa water supply situation. The city's serious position has brought forth reports from engineering experts on five separate proposals. They have appeared at intervals during the past 3½ years. Each in turn was subjected to a round of discussion and criticism which left the layman in such a quandary that the water supply situation has continued substantially unchanged.

On March 9th, the citizens will vote upon the acceptance of any one of the five schemes or the rejection of them all. The reports upon them are being presented in their entirety through the medium of the daily press. They occupy 4½ closely printed newspaper pages. The ratepayer is supposed to select the scheme best adapted to the needs, and likewise the finances, of the city. He is obviously expected to appreciate the significance of each, to differentiate between considerations of purification, precipitation, run-off, pipe line construction, pumping installations, future population, annual operating costs, fixed charges, etc. Then he is supposed to place himself on record as being in favor of one and against the others, influenced only by his own intelligent comparison.

Rather than subject each ratepayer to an ordeal which he is quite incapable of satisfactorily accomplishing, how much better it would have been for the City Council of Ottawa to have engaged a consulting engineer to condense and standardize the voluminous reports so that the citizens could then make an intelligent comparison and understand the meaning of their vote. This, however, is what the City Council considered and decided not to do.

THE KINEMATOGRAPH IN SCIENTIFIC RESEARCH.

Professor Anderson, of the University of Toronto, has favored us with an interesting description of the newly installed kinematograph which will add materially to the facilities at the University for exhaustive scientific research. The article on page 415 of this issue will doubtless be found very instructive by our readers, many of whom can realize at once the important bearing such an apparatus will have in many of the studies which enter into university training.

The very great importance of visualization in teaching is so universally recognized that projecting lanterns form a most important part of the equipment of every scientific institution in the country, and every lecturer who wishes to make his subject clear and attractive feels bound to provide plenty of pictorial illustration. However, it must be admitted that while the stationary picture forms an invaluable adjunct to a description of an object, be that what it may, that picture fails to convey any adequate idea of a process, of an event, of machinery in motion, of people in action, in short of life in general. The photograph exhibits all life and motion as instantly arrested—a sort of cold-storage representation, if one may use the expression.

With the kinematograph, however, all is different, and we see representations of events taking place, of processes being carried on, of machinery in motion and of people moving about as in actual life. Perhaps it is not too much to say that the kinematograph is as great an advance on the stationary lantern slide or photograph as the latter was on the laborious written descriptions that preceded the discovery of photography.

There is not a branch of scientific work in which this facile method of illustration may not be used with the greatest advantage. In elementary education where the child learns most readily through observation, we may use moving pictures to teach history and geography, to illustrate manual training and handicrafts of all sorts. In more advanced work, engineering in all its branches offers a fruitful field for this method. In the laboratory we may take records of tests of all sorts and study every phase of the reaction at leisure afterwards; industrial plants may be photographed and exhibited in action in the class room; field operations of all kinds may be similarly shown. In the domain of medicine there is also abundant scope for the moving picture, whether we are dealing with objects of large size or minute organisms that are only visible through the microscope. In military operations or naval manoeuvres there is likewise an ample field of usefulness for this method. The naturalist will welcome the kinematograph as an unrivalled method of studying and illustrating the habits and motions of animals and the growth of plants. Many other possibilities will no doubt occur to the reader, but enough has been indicated to show the universality of the motion picture in educational work and it is not too much to predict that we shall soon see every technical school and university equipped with a paraphernalia for this work as the University of Toronto has been equipped.

ELECTRICITY IN BLASTING OPERATIONS.

Electric ignition in the blasting of charges in mining, tunnelling and similar operations, has greatly assisted in the prevention of accident and disease by permitting the withdrawal of operators from the sphere of danger. Not only from the explosion itself but from the dangerous gases which follow perfect or imperfect detonation, does it afford more and better opportunities for safety, thereby becoming a factor of great importance. When blasting gelatine has been properly detonated the products are chiefly CO_2, H_2O and N_2. If it is merely burnt the products of combustion are CO_2, CO, N_2 and NO. In either case the carbon dioxide causes asphyxiation; carbon monoxide is a strong poison, and the nitrogen compounds, if inhaled, cause intense irritation of the air passages, bronchitis and pneumonia.

In a properly organized system of electric ignition, blasting accidents are reduced to a minimum, and the underground worker is requested to withdraw to a place of safety before a single shot is fired.

The introduction of the ignition of blasting charges by electricity is a subject that appeals to engineers, it being associated with the history of electrical engineering itself. After the discovery of the primary cell by Volta, the thermal effect obtained by interposing in the circuit of a Voltaic battery a short piece of wire of high resistance was noticed by Professor Hare about 1822. This discovery was immediately used as a means whereby blasting charges could be exploded.

The discovery by Dr. Oerstedt in the year 1820 that a magnetic needle tended to place itself at right angles to a current of electricity, and the subsequent development of this discovery by Faraday led to the introduction of magneto exploders. According to records obtainable from about the year 1840 onwards the progress of the art alternates between improvements in the apparatus for producing the necessary current, and the means of starting the explosion.

While British and American engineers developed apparatus which depended upon the heating effect of current for its operation, European engineers, chiefly in Austria, sought efficiency in systems of ignition by sparks, from which were evolved the two distinct methods known as high and low tension systems. In the former, the terminal wires are bridged by combustible as well as electro-conductive composition of fairly high electrical resistance. In the low tension exploder-fuse the terminal wires are metallically connected and surrounded by highly combustible mixture.

LETTER TO THE EDITOR.

Micrometer Method of Surveying Water Routes.

Sir,—The article by R. B. Sinclair under the above heading in your issue of February 12th, will bear some elucidation. In the past the micrometer has not been used very extensively and to many surveyors of to-day is practically unknown; consequently, a brief description of the instrument and the principles of operation may not be out of place.

For the micrometer measurement of distance a gradienter attachment on the vertical arc of a transit might be used in conjunction with an ordinary or target levelling rod, but the stadia method is preferable. It is, however, the double-image micrometer that is now under consideration.

There are two types of instruments in use, the Rochon, used by the Dominion Geological Survey, and the Canadian modification of the Luguel, introduced by Jas. Foster, of Toronto, some years ago.

The first consists of a long telescope fitted with thick double refracting prisms. The angular measurement is small and is read on a graduated scale from a pointer sliding longitudinally in a slit in the telescope by a rack and pinion motion. Too much light is absorbed by the prisms in this type of micrometer, and there is a consequent dimness of the images which is the reverse of what is required in a good instrument. The other type of instrument has a split objective, one cut diametrically in halves and each half fixed to a metal frame holding each semi-objective. Motion is communicated by a shaft screw of which one-half is left hand and the other, right. Each part turns in a corresponding nut fixed to the frame thereby moving the objectives in opposite directions.

Targets and Base.—Without expanding on the operation of the instrument as explained by Mr. Sinclair, there are a few important points which he does not touch in his description. When the vernier reads zero objects appear identically the same as if viewed through an ordinary inverting telescope. Two targets attached to a rod will appear as four targets as soon as the split objectives are moved vertically by the screw. This motion is continued until the two central images coincide, when the angle is read in terms of revolutions of the micrometer screw.

The product of the target base and the micrometer reading is a constant. Thus, after checking a few readings at different distances, a table can be compiled to suit individual requirements. Targets may be attached with screw eyes to any pole cut in the bush—a dry tamarack serves the purpose well—and the longer the target base the better. When the pole is held vertically the lower target should not be closer than 5 or 6 feet from the ground, hence, a pole with base longer than 15 links or 10 feet will be found very inconvenient to handle from a canoe.

The style of target is important. Bevelled rectangular frames fitted with ground glass have been used, but glass is fragile at best. Translucent celluloid answers the purpose better. The frame should be at least 15 x 8 inches. Japanned galvanized iron is better than wood, because the latter will not stand rain. The object in using a translucent target is to allow the sun's rays towards evening to penetrate the marginal frame, otherwise the targets cannot be seen when pointing the telescope towards the sun. The writer has had satisfaction using an enamelled metal disc with one half white and the other half one-third red and two-thirds black. With these targets a long horizontal line can be obtained by slightly rotating the telescope, thus securing perfect superimposition. The object in using the red is to find the targets more readily when snow is on the ground, and particularly at long range.

Results.—A comprehensive paper on the "Micrometer Measurement of Distances," by Wm. Ogilvie, D.L.S., appeared in the 1887 Proceedings of the Association of Provincial Land Surveyors of Ontario (O.L.S. since 1893). Mr. Ogilvie points out that the errors would probably be in the inverse ratio of the lengths of base used, were it not for the fact that atmospheric moisture, density and temperature are varying quantities which constitute the greatest barrier to reasonably uniform results with any form of micrometer.

With a 15-link base and fair atmospheric conditions, distances of 40 chains can be determined within five or six links of error. The error, however, may be ten times that amount on a bad day even though we use our utmost care. Refraction affects the lower disc more than the upper under certain atmospheric conditions. Other hindrances, sometimes impossible to remedy, are improper light and shade and bad background.

By taking shots not exceeding twenty chains equally good results can be obtained for shore line traverses where chaining would be tedious and inconvenient. In very rough country better and quicker results are obtainable if the micrometer is used in preference to the chain.

For exploratory work such as river and lake traverses, the writer has used the micrometer with satisfaction in conjunction with transit, compass and plane table for azimuth or bearing. On a river traverse, where two canoes were used and the entire camp equipment carried along, six miles of traverse per day was the average work accomplished. The river in question was the Wanapitei, a stream full of rapids after turning south, necessitating numerous portages. The courses averaged 8 per mile or 10 chains each, and the error in distance did not exceed two chains across a six-mile township. On larger streams it would be quite possible to traverse ten miles per day.

W. R. ROGERS, Topographer.

Bureau of Mines, Toronto, February 28, 1914.

THE KINEMATOGRAPH AT THE UNIVERSITY OF TORONTO.

By G. R. Anderson,
Associate Professor of Physics.

THE evening of February 6th, witnessed the first public use of the new moving picture installation at the University of Toronto. The occasion was that of a lecture by F. N. Speller, B.A.Sc., Engineer of the National Tube Company, of Pittsburg, on the manufacture of steel tubes and pipes, delivered to the Engineering Society of the University and the Central Railway and Engineering Club of Toronto. The exhibition included all phases of the work, from the mining of the ore to the testing of the finished product, and was unique from an educational point of view, and thoroughly appreciated by the large audience present.

In view of the widespread interest evinced in this method of illustration, a general description of the various parts of the installation may be of interest to readers of *The Canadian Engineer.*

The camera for the taking of films is illustrated in Fig. 1. It consists of a leather-covered body containing the usual film-boxes, each capable of holding 60 metres of film. The lens is an anastigmat of focal length (2 in.)

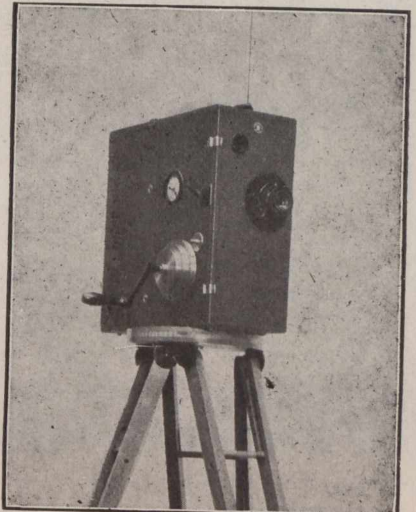

Fig. 1.

and having an aperture of 3.5, thus permitting of exceedingly rapid exposures. The finder is large, and so placed that the field may be observed throughout the exposure. The film is ordinarily driven by a crank, but provision is also made for motor driving when desirable, as will be seen by the triple-step pulley, shown in the illustration. An indicating dial on the side of the camera shows the amount of film being used.

The equipment also includes the apparatus necessary for the animated photography of microscopic objects, such as bacteria, for which purpose the parts are arranged as shown in Fig. 2. The stand is entirely of metal, and sufficiently heavy to be perfectly rigid. The camera is attached to a pair of vertical rods in such a way that by loosening the lever L it may be instantly swung to one side, leaving the microscope in position for eye observation, and as quickly returned to place. The lens of the camera is removed and connection with the microscope established by means of a small leather bellows, while an adjustable lens inserted in the side of the camera permits the observer to watch the microscopic field at the same time that the photographs are being taken. The film in the case of microscopic work is preferably driven by a motor operating against a worm gear, whence the motion is transferred by a belt to the camera. The motor is controlled by a foot-switch, so that the operator has both hands free to take care of the adjustments of the microscope and lamp. The light for the illumination of the microscopic field is furnished by a small arc lamp, the light from which passes through

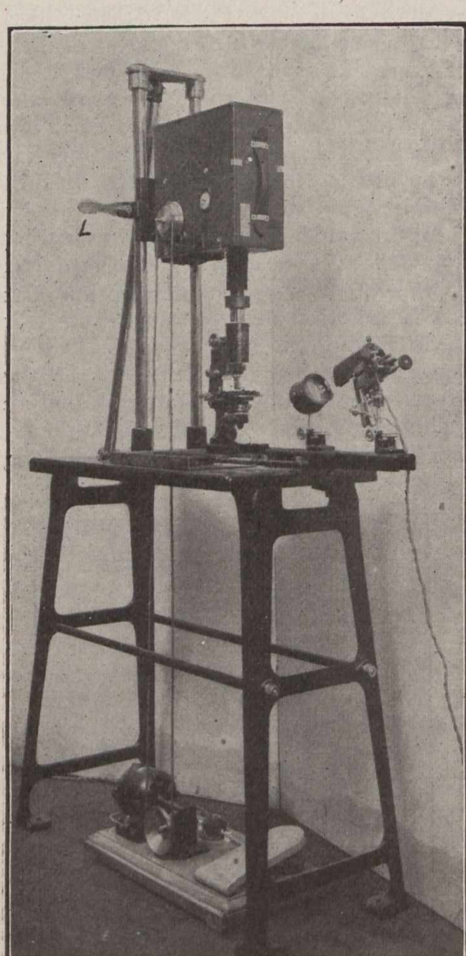

Fig. 2.

a condenser and a liquid cell to absorb the heat and, if necessary, the violet and ultra-violet rays. All these accessories move on a planed optical bed and are readily adjustable to suit requirements.

The microscope is a Zeiss of the large barrel type, specially designed for photo-micrography. It has a photo-micrographic stage, adjustable by rack and pinion in two directions, its position being indicated by verniers reading to 1/10 mm., and furnished with an achromatic substage condenser, which can be instantly swung out if not required. The optical equipment consists of 4 apochromatic objectives and 6 compensating oculars, giving magnifications ranging from 31 to 2,250. Provision is also made for using polarized light if required.

The projector (Fig. 3) for exhibiting the finished films is of particularly substantial construction to insure steadiness and rigidity. The stand is of metal, and has a tilting top with a range of about 17°, permitting of both elevation and depression. The lamp-house is constructed of sheet iron lined with asbestos, ventilated by means of a rising roof provided with a wire guard and closed at the rear by an asbestos curtain. The lamp is of the right angle type, provided with adjustments for tilting, raising and side-swinging the arc. The condenser is open-mouthed, of hard water white glass, and can be instantly lifted out of its bearings. The film fire-guard, G, is a distinctive feature of this projector. It is of two-ply steel, enclosing an interlining of asbestos, and extends from the upper magazine wall above the film exit to the base, so that there is no possibility of the film coming into contact with the lamp. The magazines are large and of very solid construction, consisting of spun steel without joints and lined with asbestos; the doors are securely locked, so that it is not possible for them to become unfastened accidentally. The film emerges from the upper magazine through a film-way of metal, closed by a clasp, and which is so narrow that in the event of the film taking fire the flame cannot pass up through this throat and set fire to the reel; the same construction is, of course, followed at the lower magazine. The winding of the film on to the lower spool is effected by a metal driving-rod geared to the main shaft. This is much more reliable in its action than the usual belt drive. Fig. 4 shows the left side of the machine with the cover of the Geneva movement removed. The special features of this

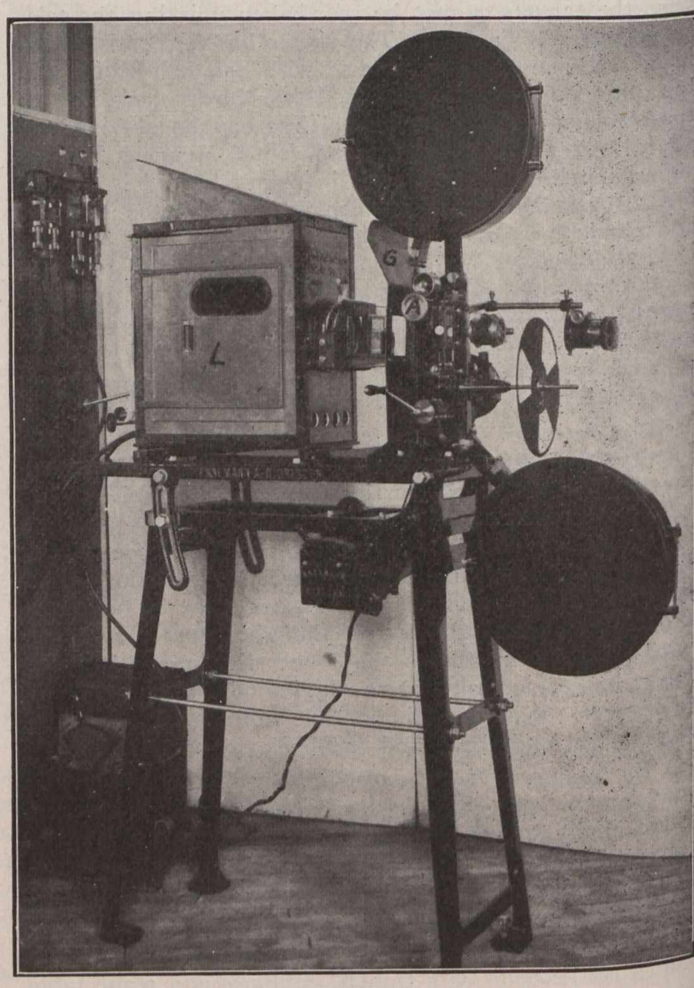

Fig. 3.

vital part of the mechanism are the extra large Maltese Cross and the roller bearing for it to operate on (ordinarily this roller is merely a pin); this eliminates friction, noise and wear of the parts; further, the whole movement is enclosed in an oil bath.

The machine is driven by a motor bolted to the framework and provided with a speed regulator, so that absolute steadiness of the film is secured over a wide range of speeds. The lamp-house slides on two planed rails, so that it can instantly be pushed over to the end for the purpose of showing ordinary slides. These are inserted in a double carrier attached to the frame on which the condenser rests, and one slide may always be left in place while the film is being shown. There are two projection lenses of large aperture and flat field, one for the projection of the film and the other for the slides, the focal length of the former being 5 inches and of the latter 15 inches, so that the images from film and slide are of equal size. The adjustment of the mask to fit the film is accomplished by a rack and pinion movement operated by a large milled head, shown at A, Fig. 3. This permits

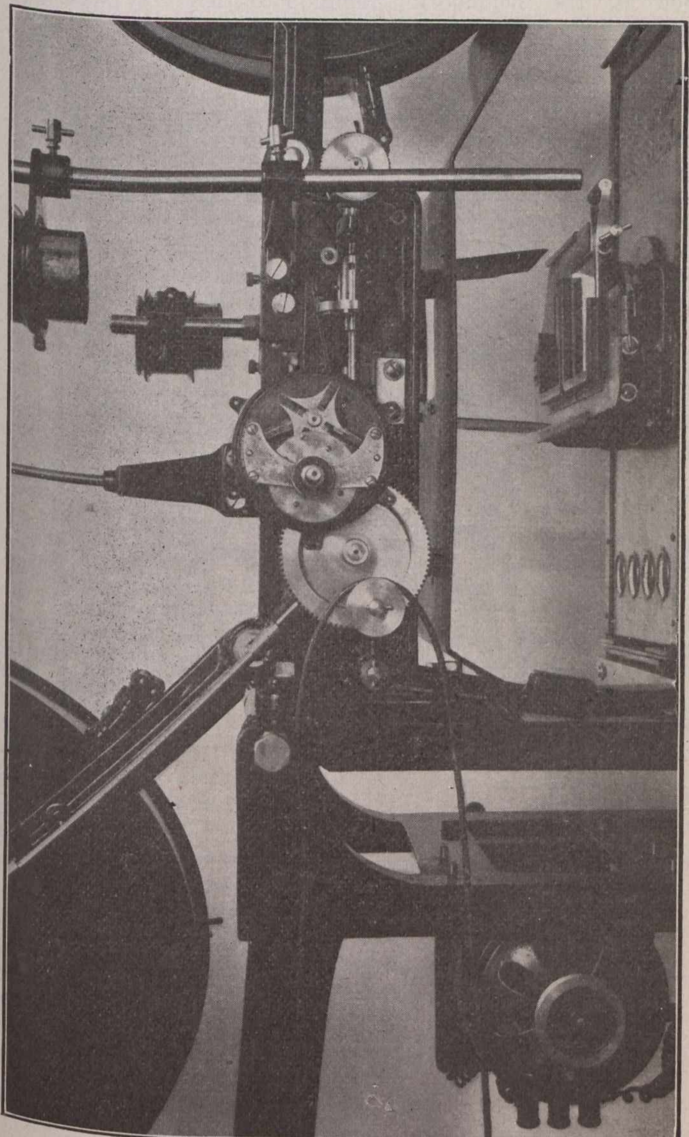

Fig. 4.

of the film being correctly placed without interfering with the position of the projecting lens or the mask, an exceedingly convenient arrangement in practice. The workmanship throughout the entire installation is of excellent quality, the gears are carefully cut, and the machine runs lightly and steadily with a minimum of noise.

A recent publication at Sydney, N.S., announces that the output at the several collieries of the Dominion Coal Company for the month of January was 347,000 tons. This is about 38,000 tons less than the output for January, 1913. The company's officials anticipate an increased output for this month, however, and it is believed the total will run over 400,000.

REPORT ON OTTAWA RIVER AS SOURCE OF SUPPLY FOR CITY OF OTTAWA.

On March 9th the City of Ottawa will take a plebiscite vote to ascertain the will of the citizens in the choice of water supply. The difficulties which the city has experienced in coming to a decision in this matter has been frequently commented upon in this journal. A new report has been submitted to the city council covering the latest scheme to be included in the vote next Monday. Mr. Arch. Currie, City Engineer, was requested by resolution of council a month ago to prepare a report on a proposal to derive the supply from the Ottawa River from a point not higher up than Britannia Bay on Lake Deschenes by an all-land pipe line route on the Ontario side of the river, to the present pumping station, the system to include a low-service reservoir and a rapid sand filtration plant.

The other four schemes are: The Thirty-One Mile and Pemichangaw Lakes, as reported upon by Sir Alexander R. Binnie and Dr. A. C. Houston; McGregor Lake, as reported on by Mr. Allen Hazen and others; mechanical filtration of the Ottawa River water, as reported upon by Mr. Allen Hazen; Lake Deschenes, without filtration, as reported upon by Arch. Currie, City Engineer.

Mr. Currie was instructed to report upon the feasibility of a plan to take the Ottawa River water from a point above the present intake and purify it by means of a modern rapid sand purification plant; to estimate the capital cost of providing such a purified supply, based on an average daily use of 25,000,000 Imperial gallons per day; to estimate the annual operating costs and fixed charges for pumping and purifying a supply of 25,000,000 gallons per day; and to estimate also the additional annual operating costs and fixed charges which would be incurred over and above present conditions.

The report states that in the vicinity of Ottawa the Ottawa River has a minimum flow known to be many times greater than the requirements of the city for a public water supply. The quantity available for this purpose may therefore be considered as unlimited.

The water of the river is colored yellow or brown by organic matter. It is a soft water having a slight odor and taste. The turbidity varies from month to month but for most of the year is not serious. It is also somewhat polluted, especially below the Chaudiere Rapids and Lemieux Island. Above these points the pollution is and always will be much less, and as far as natural rivers are concerned it is one of unusual purity for public water supply.

Mr. Currie refers then to a special study which he has made of the available data on the purification of waters similar to that of the Ottawa.

During his regime as city engineer of Westmount, the Montreal Water and Power Company installed a purification plant which has been in successful operation for the past few years. This plant supplies a colorless, purified water of excellent quality and at the rate of 25,000,000 gallons per day to the customers of the company, among whom are the citizens of Westmount. The water purified by this plant is, during a considerable part of each year, almost identical in character and quality with that of the Ottawa River at Ottawa, and is, in fact, almost entirely Ottawa River water.

The plant upon which Mr. Currie has estimated is of similar character and has operating conditions very like the plant at Montreal.

There are other purification processes which could be used for the water of the Ottawa River, but none of them are, for various reasons, so well suited to the local conditions as the type mentioned. In order to avoid the large amount of pollution in Nepean Bay and the necessity of delivering purified water under this portion of the Ottawa River if the purification plant be placed on Lemieux Island, the report recommends that the intake be placed at some point above the Little Chaudiere Rapids, with the purification plant on the mainland, and estimates were made accordingly.

General Description of Proposed Works.—The intake pipes, two in number, extend out into the river between the Little Chaudiere Rapids and Remic's Rapids. This point of intake reaches a part of the river where the conditions are favorable for minimum pollution. The water passing through the natural sedimentation basin of Lake Deschenes is partly purified by nature during this process and the point of intake has been selected with the object of taking full advantage of this fact. When the Georgian Bay Canal will have been built the purification due to this natural sedimentation basin will be even better owing to the larger area of lake created by the building of the canal works.

On the shore near the end of the intake pipe is situated the pumping station. This should contain electrically driven, low-lift turbine pumps of sufficient capacity to supply the purification plant at its maximum rate of working with provision for some spare machinery in case of breakdown. The low-lift pumps at present in use at Lemieux Island may perhaps be found suitable for part of the equipment after some modifications, in which case the estimated capital costs could be reduced accordingly. The electric current for the regular operation of these pumps could best be derived from hydro-electric units installed in the main pumping station.

When the Georgian Bay Canal will have been built it will be necessary to remove the pumping station from its first location to one above the elevation of the new water surface. This is not a serious matter and involves no special difficulty or great cost. The proposed location for the pumping station under these conditions is indicated on the plan. Under these future conditions the power required at this station will be reduced appreciably.

The transmission lines from the main pumping station to the headworks pumping station may well be carried on cedar poles treated to prevent decay. They should consist of 3-phase circuits in duplicate at a suitable voltage.

The estimates are based upon the use of steel pipes from the headworks pumping station to the purification plant and reservoir, and thence to the main pumping station. The quantity of water required under maximum conditions is such that an effective cross-sectional area of about 19 sq. ft. is desirable in the pipe line in order to provide for this quantity with some capacity for future growth. The smallest single pipe which should be used for this purpose is one of 60 in. in diam. My estimates are based upon using two pipes each 42 in. in diam., having an area equivalent to that of the 60-in. pipe, but giving a greater flexibility in operation and a good insurance against breakdown. The two 42-in. pipes will cost somewhat more than a single 60-in. pipe, but the extra expenditure is justified by the advantages gained. Cross-connections at intervals are provided for from one 42-in. pipe to the other, thus insuring flexibility in operation. In case of trouble occurring in either pipe line, or in case inspection or repairs be required, it will be necessary to shut down only a comparatively short length of

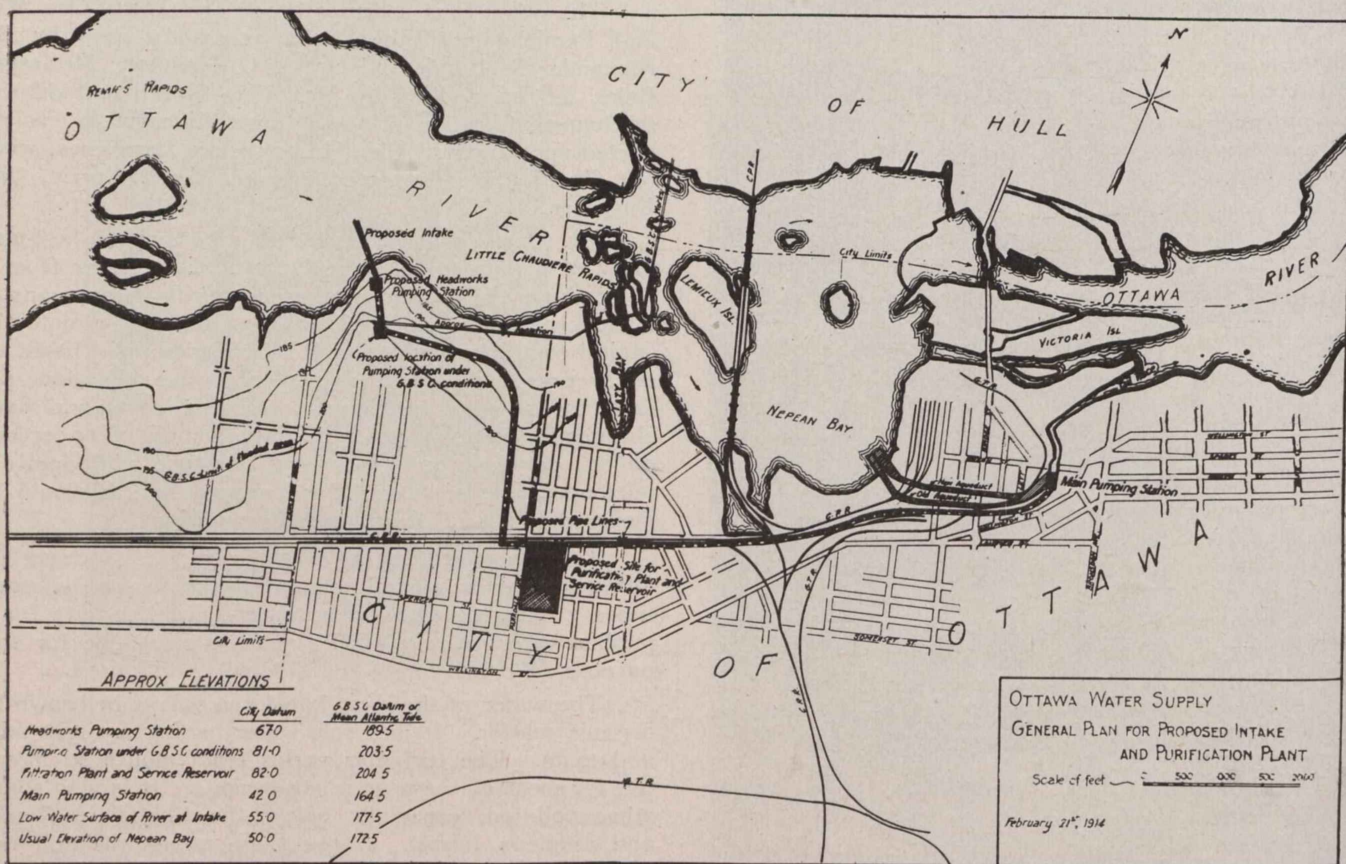

Fig. 1.

one pipe at a time, a proceeding which will effect the gross capacity of the pipes by only a small percentage.

Purification Plant and Reservoir.—The purification plant should consist of comparatively large sedimentation and coagulation basins designed with baffle walls to cause the water to flow slowly enough through the basins so that a large part of the impurities will be deposited in them. From the coagulation basins the water should flow by gravity to the filter beds and down through the sand in these to the clear water reservoir beneath. The coagulation basins, filter plant and clear water reservoir should all be covered on account of our climatic conditions and to prevent local pollution. Such additional machinery and appliances as are necessary in and about the purification plant require very little space and are simple in character. Two or three men per shift operate such a plant without difficulty.

The average daily output of water, 25,000,000 gallons, is much less than the nominal capacity of the plant estimated upon. The proposed plant can filter satisfactorily over 35,000,000 gallons per day and many of the parts have been so proportioned that the capacity of the plant may be considerably increased at a comparatively small expense either for capital cost or yearly operating charges.

The clear water reservoir has been designed to hold 10,000,000 gallons of filtered water, which is ample to provide for very heavy fire requirements in addition to the maximum draft under ordinary conditions of use.

Main Pumping Station.—Certain work is necessary at the main pumping station on Queen Street in order to develop the best efficiency. While it is possible to use all of the present pumping equipment for some time to come, the report advises discarding some of the present pumps and substituting for them modern machines of a different type and of sufficient capacity to serve all needs with ample spare units. If this be done, the present building is sufficiently large for the installation of several new pumping units. A certain amount of work is necessary in the headrace and some remodelling of the wheelpit and tailrace is essential. Certain new drains and a proper spillway should also be constructed. The draft tube arrangements must also be modernized. Where the pure water comes into the pumping station provision should be made for a standpipe and a header or for a common suction well so that all the pumps may obtain a sufficient supply of water, which they do not get at present. On the delivery side of the pumps a common discharge header should also be installed so that any part of the distribution system of the city may receive water from any of the pumps.

Two hydro-electric units should be installed of sufficient capacity to generate current to be transmitted to the headworks pumping station and to the purification plant for the operation of the pumps at these places. There is sufficient hydraulic power available at this pumping station site for this use with a good allowance for future extensions beyond the daily average use of 25,000,000 gallons.

In the time allotted for the preparation of the report it was impossible to determine the best course to adopt in connection with the main pumping station. The above discussion is only indicative of one general programme which would be highly advantageous compared to the present state of the old plant.

The distribution system is not dealt with in the report as it has already been covered in a previous one.

Estimated Capital Costs.

1.—Intakes, cribs, two suction pipes each 54 in. x 850 ft. complete ....$	67,000
2.—Headworks pumping station, pumps and equipment, electrical apparatus and transmission lines from main pumping station..	54,000
3.—Costs of moving station and equipment to suit new elevation of Georgian Bay Canal, with new connection	25,000
4.—Two 54-in. pipe lines, as far as future pump house site with reducing and cross-connections, complete, 650 ft. each, in one trench and suitable for future suction conditions	43,000
5.—Two 42-in. pipe lines from pump house to purification plant, and thence to main pumping station, 11,300 ft. of double line in one trench, making 22,600 ft. of pipe, with valves, cross-connections and so forth, complete	356,000
6.—Real estate and right-of-way, headworks pumping station sites, reservoir and filter plant site at 10c. per sq. ft. and $10,000 for right-of-way, say	45,000
7.—Purification plant, nominal capacity 37,000,000 gallons per day, and based on average daily use of 25,000,000 gallons per day with large coagulating basins and 10,000,000-gallon clear water reservoir, complete	705,000
8.—Remodelling present pumping station, replacing units 1, 2, 3 and 4 with four 10-million-gallon turbine pump units connected to new power turbines, changes in headrace, tailrace, wheelpit and draft tubes, new suction arrangements with tank, new delivery header, two hydro-electric generating units	159,000
	$1,454,000
Add for engineering, contingencies and miscellaneous costs, say ....$	246,000
Total.........................$	1,700,000

Annual Operating Costs and Fixed Charges.—The annual operating costs and fixed charges of the system outlined include everything down to the beginning of the distribution system. The annual costs have been estimated on the same conservative basis as the capital costs. The number of men allowed for is sufficient for any contingency and will probably be less in actual practice.

The treatment necessary for the Ottawa River water requires the use of sulphate of alumina and carbonate of calcium with a final treatment with a minute quantity of sodium hypochlorite if found necessary. The amount varies from month to month, depending on the changing character of the water, but the figures given in the table below are more than sufficient to treat any condition of the Ottawa River. For protracted periods it will be unnecessary to use a final treatment. A liberal amount has been added for the item of maintenance and repairs, while oil, waste, fuel, packing, small tools and other supplies have also been provided for in the same generous degree. The charge for power should be very small. The costs of power generated in the pumping station will only be the fixed charges on the machinery equipment itself, as the labor, supplies, repairs and so forth of the electrical equipment are included with the figures for the pumps. To provide for interest and sinking on the total capital invested, a figure of 6½ per cent. has been assumed, which should be more than ample.

Estimated Annual Operating Costs and Fixed Charges.

Wages and Salaries—	
Intake pumping station (3 operators and 3 assistant operators)	$ 5,500
Reservoir and filter plant (1 chief chemist and superintendent, 1 assistant superintendent, 3 operators, 3 assistant operators, 1 spare man)	10,000
Main pumping plant remodelled (3 assistant engineers, 3 operators, 3 assistant operators, 3 winter men, 1 spare man)	11,500
General (1 patrolman inspector, emergency help and proportion of time of waterworks engineer, say)	3,000
	$ 30,000
Supplies—	
Oil, waste, fuel, packing, small tools, and chemicals for headworks, station, purification plant and main pumping station	43,000
Repairs and Maintenance—	
Intake, pipe lines, filters and reservoirs, main pumping station, aqueduct, transmission lines, headworks pumping station and miscellaneous	16,000
Power—	
Main power service is included in operation and fixed charges	
Fixed Charges—	
Interest and sinking fund, say, 6½ per cent. on whole amount of $1,700,000	110,500
Total	$199,500

The report concludes with the following summary: For the City of Ottawa the intake would best be placed between Remic's rapids and the Little Chaudiere Rapids. The general plan considered to be best suited consists of an overland steel pressure pipe line from the intake to a purification plant situated at the intersection of Scott Street and Parkdale Avenue. From the purification plant the pure water will collect in a service reservoir at the same site, whence it will flow in a steel gravity pipe line to the present main pumping station remodelled. The requisite power will be obtained from the present aqueduct. The system outlined above can be constructed and put in operation within two years.

The estimated capital cost of the above plant based on the average daily use of 25,000,000 gallons is $1,700,000.

The annual operating costs and fixed charges on the same basis will not exceed $200,000.

The additional annual operating costs and fixed charges which would be incurred over and above present conditions would not exceed $145,000.

After 9 years of labor the last barrier was broken on January 10th in the Catskill Aqueduct tube, the longest water tunnel in the world. It extends 111 miles, from the Ashokan dam at Esopus, N.Y., to Brooklyn; and when in operation, will supply New York with 500,000,000 gallons of water daily. The tube for the most part is 500 feet beneath the ground, and in spots dips to more than 700. It varies in diameter from 11 to 17 feet.

ONTARIO GOOD ROADS ASSOCIATION.

The twelfth annual meeting of the association was held in Toronto on February 24, 25 and 26th. Several hundred delegates, were in attendance from all parts of the province. The papers and discussions were, in the main, upon subjects bearing upon administration and financing, although a few dealt with engineering aspects of road work. Among the latter were "City and Town Streets," by A. B. Macallum, City Engineer, Hamilton; "Bridge Construction," by L. E. Allen, Belleville, Engineer, Hastings County, and others. C. A. Macgrath, Ottawa, chairman, Ontario Highway Commission, gave an address during one of the sessions on the work of the Commission.

MODERN CONCRETE CONSTRUCTION.

Some very interesting concrete work has just been completed by the American Cyanamid Company of Niagara Falls, Ont. The construction was started last October of a Silo Building, 90 feet high, having 184 corners to its 16 columns. The columns are connected by 16 very large triangular lintels, which are heavily reinforced. They support nine 18 x 18 feet bins, 50 feet high, each have a suspended concrete hopper.

These bins carry a weight of ten thousand tons of cyanamid. The entire building, from foundation to roof, was built with the Blayney system of steel forms, manufactured by the Standardized Steel Form Company, Niagara Falls, Ont. With a slight change, the column forms were used as wall forms right to the roof.

1914 WORK IN MEDICINE HAT.

The following work is contemplated for the coming season in Medicine Hat, Alta.:—

Surface and stearm sewers	$ 60,000
Extending and improving waterworks	175,000
Parks and other municipal purposes	14,000
Extending and improving electric plant, light system and power system	150,000
Extending gas system and drilling gas wells	50,000
Grading and gravelling streets and purchase of road construction plant and machinery	50,000

A paper was presented by G. E. Lygo before the Junior Institution of Engineers in England, showing that plants in which all kinds of wood waste, from sawdust to pieces 6 inches in diameter, as well as cotton seeds, cocoanut shells, coffee husks and many other kinds of refuse, can be used for the manufacture of producer gas are now being manufactured in England. In designing a plant for this purpose many changes must be made from the coal producer. The surface area required is determined by the nature of the fuel used and its size, but will average 2.5 times that required with coal. The depth of the fuel bed will depend upon the size and density of the fuel. A deep bed is necessary where the pieces are large; whereas a shallow bed is preferable with small fuel like sawdust. A vaporizer is not required. The gas must be cooled and washed immediately upon leaving the generator or else the heavy tar in suspension is deposited and will choke the piping. The calorific value of wood when air-dried is approximately 6,000 British thermal units per pound. The amount consumed in generating a horsepower-hour depends upon the moisture, which varies from 10 to 20 per cent. in air-dried wood to 30 or 50 per cent. in fresh wood. Fuel containing an excess of moisture must be dried until it is reduced at least to 60 per cent.

MONTREAL WATER SUPPLY CONDUIT

REPORT OF THE BOARD OF EXAMINERS OUTLINING DEVELOPMENT OF CITY'S WATER SUPPLY AQUEDUCT, CONDITION OF THE CONCRETE CONDUIT, GENERAL CONCLUSIONS AND RECOMMENDATIONS.

THE following is from the report to the Board of Commissioners of the City of Montreal covering the result of the investigation of Messrs. J. A. Jamieson, R. S. Lea, and G. R. Heckle, Board of Engineers, as to the cause of the accident to the city waterworks conduit*; the measures necessary to provide, as far as possible, against any further damage; and the condition of the entire conduit as shown by inspection of its interior, and the exterior condition of the aqueduct bank adjacent to and overlying it:—

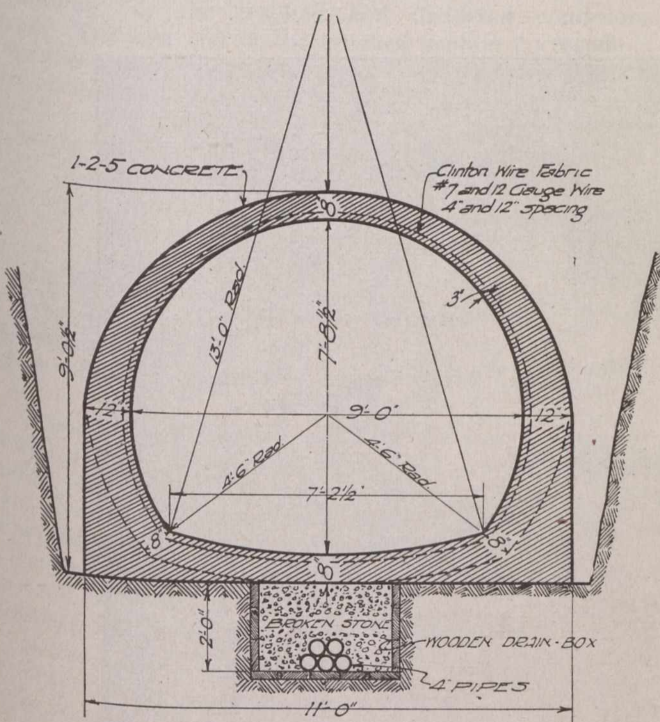

Fig. 1.—Cross-Section of the Conduit.

Description of the Water Supply System.—As the question of the conduit is intimately associated with the enlargement of the aqueduct, a brief history of the more important events in connection with the city's water supply is necessary to give a more complete understanding of the subject.

The City of Montreal has, for many years, obtained its water supply from the St. Lawrence River through an open canal, or aqueduct, as it is locally known, extending from a point some distance above the Lachine Rapids, and running in a northeasterly direction nearly parallel to, but a considerable distance from, the river to the pumping station located at the junction of Centre Street and Atwater Avenue.

For a number of years following its construction, this aqueduct supplied water for city consumption, and also furnished hydraulic power for pumping the water into the city mains and reservoirs. As the population and water consumption increased, the hydraulic power became inadequate, and a supplementary steam pumping plant was installed. Eventually the hydraulic power available from the aqueduct represented such a small proportion of the total requirements for pumping purposes as to be almost negligible.

The question of enlarging the aqueduct to a size sufficient to supply power for pumping the total quantity of water required for city consumption had been investigated and reported upon by various engineers from time to time, and in 1907, based on a report submitted by Mr. Geo. Janin, Chief Engineer of Public Works of the City of Montreal, it was decided by the authorities to proceed with the enlargement referred to above.

The conduit which failed on December 25th, 1913, was built to protect the city water supply against surface pollution between the river and the pumping station, and also to provide continuous service while the aqueduct was being enlarged, during which period it constituted the only source of supply.

This conduit extends from the St. Lawrence River to the pumping station, and is located in a trench along the north bank of the aqueduct. The water flows through it by gravity under a head varying from six to twelve feet. It is constructed of concrete lightly reinforced with Clinton wire fabric. The plans and specifications were prepared under the direction of Mr. Janin. Fig. 1 shows the cross-sectional plan. The contract for its construction was awarded to Mr. P. McGovern, under date of October 3rd, 1907, and the work was completed about two years later.

*See *The Canadian Engineer*, January 8th, 1914, Page 151.

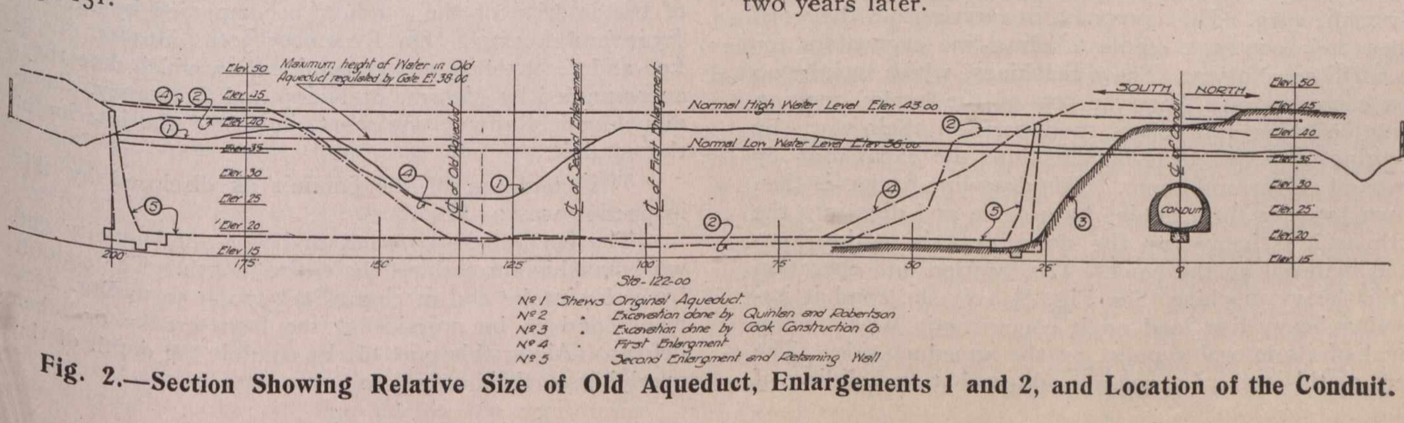

Fig. 2.—Section Showing Relative Size of Old Aqueduct, Enlargements 1 and 2, and Location of the Conduit.

On October 12th, 1909, a contract for the enlargement of the aqueduct was awarded to Messrs. Quinlan and Robertson. This is now known as Enlargement 1. The enlarged section was estimated to carry sufficient water to produce 2,500 h.p. during the winter months, with a probable 5,000 h.p. during the summer, to be used for pumping the city's water supply.

Before the work covered by the above contract was entirely completed, it was decided by the city authorities to still further enlarge the aqueduct in order to obtain sufficient power to generate electric current for lighting purposes in addition to pumping the city water. This is now known as Enlargement 2, for which the plans and specifications were also prepared under the direction of Mr. Janin. Fig. 2 shows the relative size of the old aqueduct, enlargements 1 and 2, and the location of the conduit.

To obtain the necessary cross-sectional area of aqueduct, and, at the same time, to keep as nearly as possible within the limits of the property owned by the city, the plans for Enlargement 2 required the excavation to be carried much closer to the conduit than under contract 1.

The contract for Enlargement 2 was awarded by the city to the Cook Construction Company, under date of July 17th, 1913. This company, in carrying out the work under their contract, employed drag-line excavators for the earth excavation. These machines, which weigh 120 tons each, operate from the top of the banks, moving along on skids and rollers, and perform their work by swinging 3-cu.-yd. drag-buckets into the excavation by means of cables and boom. This drag-line bucket is then drawn towards the machine by a cable and digs into the earth as it is hauled up the slope, depositing the excavated material on the bank. The location and operation of this heavy machine (See Fig. 3) over the conduit imposed a heavy live load on it concurrently with the removal of its lateral support on the aqueduct side. The effect of this was to cause a readjustment and sliding of the bank which tended to produce excessive stresses in the conduit.

During December, one of these machines was working eastwards along the north bank over the conduit, and between Sta. 119 and 129 the excavation was carried so close to the conduit that an earth slide partially exposed its side between Sta. 123 and 124, about 100 ft. east of the Asylum bridge. Inspection showed that considerable water was leaking from the conduit at this point through cracks in its side, and attempts were made to stop the leaks and support the conduit, but without success. At about 4.30 p.m. December 25th, the side of the conduit burst out for a length of about 60 feet, as shown in Fig. 3.

As this break in the conduit entirely cut off the city's water supply, emergency repairs were planned by Messrs. Janin and Lesage, and the Cook Construction Company's plant and organization were called upon to execute the work. These repairs were made and the water again let into the conduit on January 2nd. Since then the supply has not been interrupted.

Fig. 3.—Montreal Waterworks Conduit Break as it Appeared on December 27th, 1913. (Drag line excavator has been moved up from point of operation at extreme right of photo, to be used in excavating the earth around the break).

Examination of the Conduit.—On December 28th, Mr. J. A. Jamieson was retained as consulting engineer, and during the following 48 hours made an inspection of the interior of the conduit, accompanied by Messrs. Janin and Lesage. On December 30th, Messrs. R. S. Lea and G. R. Heckle were retained, on which date they, accompanied by Messrs. McKillop and Ommaney, Canadian Pacific Railway engineers, inspected the interior of the conduit.

The condition of the conduit as disclosed by this inspection was as follows:—

The concrete was found to be of good quality and workmanship throughout the entire length. The conduit from the intake end at river, Sta. 270 + 50 to Sta. 220, was found to be practically free from cracks or other defects. Along this part of the conduit the depth of the overlying earth is only 6 to 8 ft.

At about Sta. 220, there is a coffer-dam built across the aqueduct. From this point to the river the water stands in the aqueduct at the river level, while from the cofferdam eastward to the pumping station, the aqueduct has been unwatered to permit the enlargement to proceed.

Between Sta. 220 and 214, a distance of 600 ft., a serious crack was found in the crown of the arch. This crack was about ⅜-in. in width, and in places the roof on one side has sunk down about ⅜-in. further than on the other. There are also corresponding cracks in the invert, and signs of strain along the springing line on both sides. These cracks clearly indicate a distortion of the conduit from an overlying load.

An inspection of the interior disclosed the fact that along the cracked section excavated material had been dumped directly over the conduit up to about El. 58, making the overload about 25 ft. above the crown, plainly accounting for the cracked and distorted conditions found. The east end of the cracked section corresponds with the point where the conduit passes from earth into rock.

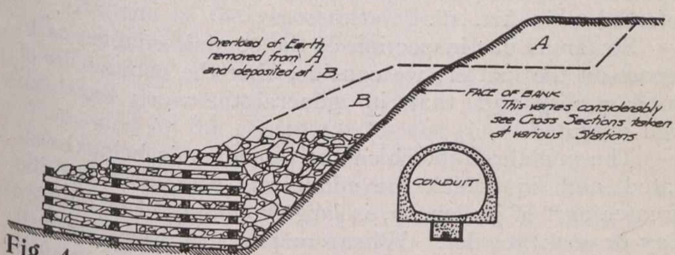

Fig. 4.—Method Adopted to Support Bank and Conduit.

A subsequent inspection along the aqueduct bank showed a very considerable leakage of water from the conduit along the cracked section between Sta. 220 and 214. For the most part, this water finds its way into the aqueduct through gravel strata, and shows no signs of transporting any of the clay material; and the conduit is located at this point approximately 40 ft. back from the aqueduct bank.

Between Sta. 214 and 133, the conduit is located partially or wholly in rock, and was found to be generally in good condition.

Between Sta. 133 and 120, there are cracks along the crown, both sides, at about the springing line of the arch, and in the bottom, but as a rule these are not open to any extent. They indicate considerable stress, however, and some distortion in the conduit. It is in this section, between Sta. 123 and 124, that the break occurred, and an inspection made after the conduit was filled with water disclosed the fact that, at several points along the bank, water was leaking from the conduit and finding its way into the aqueduct.

Between Sta. 69 and 120, there is a light crack along the crown for a considerable part of the distance, but for the most part this crack is comparatively small. An apparent leak has been found in this section near Sta. 94, but the water was running out through gravel strata and was quite clear, indicating that the leakage is probably not endangering the conduit at this point.

Between Sta. 69 and 50, the conduit is cracked along the crown and in the invert, these cracks being open for the most part about ⅛ in., and by cutting into the concrete at certain points it was found that the reinforcing wires were broken in the crown. There are also some cracks at about the springing line of the arch. Along this section it was found that the original fill over the conduit was only 5 ft., but that during the operations under the Quinlan and Robertson contract, excavated material from the aqueduct had been deposited along the bank over the conduit up to approximately El. 45, making the fill about 15 ft. higher than the top of the conduit. This fill, however, is not generally over the centre of the conduit, but south of it, thus producing an unbalanced load. A close examination would indicate that these cracks were not of recent date.

Between Sta. 50 and about 30, the conduit was in good condition, showing no evidence of anything beyond occasional fine cracks. It was impossible to proceed further east with the inspection on account of the depth of water.

An inspection was made of the existing head gates at the entrance of the aqueduct, and where the section has not been disturbed by either Contracts 1 or 2. It was found that the aqueduct had been provided with both head gates at the entrance from the river and regulating gates further down, but that in both cases the gates were in very bad repair, and entirely useless at the present time.

As there should be a means available at all times for controlling the flow of water in the aqueduct, it is urged that the Cook Construction Company proceed at once with the construction of the coffer-dam at the entrance as covered by their contract, also that the necessary gates and sluices for controlling the flow be included in the structure.

Recommendations After First Inspection.—On the night of December 30th, after completing the above inspection of the interior of the conduit, the Board of Engineers met Controller Godfrey, Messrs. Janin and Lesage, and Mr. Herlihy, of the Cook Construction Company, at the city's office near the break, and verbally made certain recommendations, as follows:

1. That rip-rap be placed against the toe of the slope along the weakened sections in the vicinity of the break as rapidly as possible.

2. That, when the water was turned into the conduit, it should not be allowed to run more than ¾ full, and kept below that depth if possible.

3. That the overload of earth be removed from the top of the conduit for a considerable distance east and west of the break.

4. That the overload on the section lying approximately between Sta. 214 and 220 be also removed as soon as possible.

5. That the excavation work on the north side of the aqueduct be suspended, and that for the present no blasting be allowed in the rock section on the north side.

These verbal recommendations were confirmed and further emphasized in a written report addressed to the Board of Commissioners under date of January 7th, in which certain other additional recommendations were made, including the construction of a rock-filled timber crib along the toe of the bank at the weakened section both east and west of the break, to support a fill in an endeavor to reproduce the original conditions of loading.

In accordance with the recommendations of the interim report, an arrangement was made by the Board with the Cook Construction Company to proceed immediately with the carrying out of the work involved. The most important measure, namely, placing rip-rap along the toe of the slope at the weakened section on both sides of the break, between Sta. 119 and 129, to be followed at once with the construction of a rock-filled crib, was proceeded with first, night and day shifts being employed. Mr. J. R. Dorrance was placed in charge of the work by the city, as resident engineer, and Mr. F. S.

Pearson, as superintendent. While the above-mentioned work was being carried out, the very difficult matter of securing the conduit at both ends of the steel pipe at the break was being done. This work required the utmost care as it was found that cavities had been eroded on both sides of the conduit and directly underneath by leakage, which, of course, made the situation a very serious one. Blocks of concrete were placed in sections underneath the conduit where the foundation was scoured out, and the leaks in the side were caulked and afterwards encased in concrete. The water draining through the conduit in both directions towards the break and at other points on both sides was carried in troughs to the aqueduct, so that no further scouring would occur.

Fig. 4 shows a cross-section through the rock-filled crib, and the conduit, and gives a general idea of this work.

When the protection work adjacent to the break was well under way, a force was started removing the excessive load from the top of the conduit between Sta. 214 and 220, a wedge-shaped section being taken off to El. 47, approximately, thus removing about half the load over the crown. It was considered advisable to do this work entirely by hand labor, on account of the danger of using machinery adjacent to this cracked section.

At this time it was thought advisable by the Board, and with the approval of Mr. John R. Freeman, to lay a pipe connecting the Lachine canal with the present pump-well; this work being at once proceeded with. This precaution was justified by the possibility of another break in the conduit which might expose the city to the danger of a conflagration. It should not interfere in any way, however, with measures being taken as soon as possible for furnishing the city with an alternative supply of pure water, and that water from the Lachine canal should not be turned into the city mains except as a last resport.

Details of Design and Construction of Conduit.—Fig. 1 shows a cross-section of the conduit used in soft soil. The dotted line below the springing line of the arch shows the form used in firm soil or rock. In both the latter cases, the reinforcement was to be omitted below a point 12 in. below the springing line. In firm soil, the earth was to be excavated to the neat line of the bottom and the side walls. In rock, any excess excavation was to be filled with lean concrete composed of 1, cement; 3, sand; 8, 3-in. broken stone.

Article 18 of the specifications covers the character and location of the reinforcement. It reads as follows:

> The reinforcing material of the conduit shall consist of expanded steel No. 6 with 6-in. mesh; or of other reinforcing metal which shall be known to have an equal degree of resistance. In the case of tenderers wishing to substitute a different material than No. 6 expanded steel with 6-in. mesh, they will have to clearly specify the nature and weight of the reinforcing material they propose to make use of. The reinforcing metal shall be set at about 3 in. from the interior surface of the conduit, and each sheet of metal shall be lapped over the adjoining one, to the width of one mesh to form a continuity of joints, but only in the crown of the conduit shall the adjoining sheets of metal be attached together with wire.

As will be noted in Fig. 1, Clinton wire cloth was substituted for the expanded metal specified.

With regard to the design of the conduit. From the information which we have obtained from the city, the maximum depth of fill over the crown would be approximately 25 ft. Engineering practice in concrete conduit design exhibits a considerable variation in the sections of concrete and the percentage of reinforcement used. While there are examples of as light, or possibly lighter, types of similar structures in existence, we consider the concrete sections employed in the Montreal conduit are lighter than are warranted by safe engineering practice. We feel, moreover, that the percentage of steel used and the position in which it is placed does not constitute an adequate reinforcement against the stresses to which the structure is subjected. The above statements are particularly pertinent having regard to the fact that this conduit represented the only water supply line to the city.

The weight per sq. ft. of the reinforcement called for in the specifications is not stated therein, and as expanded steel of this particular class is not now commonly manufactured, we have not been able to definitely compare the relative weights of the steel fabric specified with that actually used. So far as our information goes, however, it appears to us that the reinforcement does not represent an adequate equivalent for the expanded steel referred to in Art. 18.

So far as our inspection of the conduit enables us to report on the matter, we consider that the concrete is of good quality and that in general the work has been well executed.

The soil through which the aqueduct is being excavated and in which the conduit is embedded for the greater part of its length, is largely composed of boulder clay or rock powder. When comparatively dry, or well drained, it will stand in a bank with practically vertical face, but when fully saturated with water tends to flow a horizontal surface, and is easily eroded and transported by running water. This latter property has a very direct bearing on the safety of the conduit, in view of the proximity of the aqueduct excavation.

Water leaking from the conduit under pressure tends to find an outlet through the intervening bank into the adjacent aqueduct, the bottom of which is about 5 ft. lower than the invert. This water erodes and transports the soil surrounding the conduit, removing its lateral support, and the leaks are a serious source of danger, so long as the aqueduct remains unwatered.

The only practical way to stop these leaks, in the opinion of the Board, is by filling the cracks from the interior. This, however, can only be done by unwatering the conduit. Under existing conditions, however, this latter cannot be done within a reasonable time owing to the fact that there is only one 12-in. pipe through which the conduit can be drained. The suction pipes of the pumps at the pumping station do not extend sufficiently low by several feet to permit the conduit being unwatered by pumping. We would, therefore, recommend that the installation of a new suction well or gallery, at least 6 ft. lower than the existing one, should be immediately constructed, and the suction correspondingly lowered. This arrangement would permit the conduit to be quickly unwatered, and the work of interior repairs proceeded with during short periods, and would also permit the conduit being run partially full of water.

Work on the Aqueduct.—Referring to the contract of the Cook Construction Company for the widening and deepening of the aqueduct, it is found that the contractor is required to construct reinforced concrete retaining walls along both sides of the aqueduct in the earth section, and plain concrete retaining walls in the rock section.

While the contractor is, in his contract, called upon to use extreme care and diligence in his work in order not to endanger in any way the water supply conduit, and is particularly cautioned regarding the sections between Stations 10 and 14, and from 80 to 85, it is not found that there is any particular provision made by which the contractor is obliged to follow up his earth excavation immediately with the construction of the retaining walls. Moreover, the contract provides that the contractor construct test sections of the wall when ordered by the engineer and before proceeding with the general construction. This would seem to indicate that the city engineers did not expect the contractor to follow up his earth excavation very closely with the retaining walls. It also seems to indicate that the city engineers themselves were not quite satisfied that the wall as designed was sufficiently strong for the purpose intended.

It is obvious from what has already occurred and from the present condition of the north bank in the earth section, that unless the wall construction followed the excavation very closely, the conduit would be greatly endangered, as there are points east of where the break occurred where the plans show that the excavation was to be carried much closer to the conduit than at points already excavated.

As one of the recommendations, made immediately after the first inspection of the conduit by the Board and confirmed by its interim report, was to the effect that all work on the north side of the aqueduct should be suspended by the contractor for the time being, we have felt obliged, in preparing this report, to make an analysis of the design of the reinforced concrete retaining wall which the Cook contract provides shall be built in the earth section. From this analysis we have found that the wall would not be stable for the loads which we believe it prudent to assume it would have to sustain.

Another apparent weakness in this design is that the bottom of the concrete base is only 1 ft. 9 in. below the bottom of the canal. If the structure were left exposed during construction in the winter time, or if, at a later period, the canal should be emptied of water in the winter time, there would, we believe, be great danger of frost penetrating under the base, causing serious damage to the wall.

Conclusions.—From a review of the features which have been described in this report, we have arrived at the following conclusions:—

1. That the plans and specifications of the conduit did not call for sufficient reinforcement, nor is the steel properly placed in the concrete section, to provide a sufficient factor of safety, especially in view of the fact that the conduit would be the only means of supplying the city with water during the enlargement of the aqueduct.

2. That in the construction of the conduit the quality of the concrete and the workmanship generally were good, but that the weight and strength of the steel reinforcement was much less than called for by the specifications submitted to us.

3. That the insecurity of the conduit was greatly increased by the proximity of the excavation involved in carrying out Enlargement No. 2.

4. That the method of performing the work by means of a heavy drag-line excavator travelling on top of the bank above the conduit imposing a heavy vibrating load concurrently with the removal of the earth which provided lateral support to the conduit further endangered the structure.

5. That the leakage of water from the conduit is an additional source of danger at points where the conduit is located in easily eroded soil, and the excavation carried sufficiently close to permit the water finding an outlet into the aqueduct.

6. That the failure of the conduit was due to the proximity of the excavation, to the methods employed in the execution of the work, and to the inherent weakness of the conduit itself.

7. That the conduit, as a permanent means of supplying water to the city, is not now to be depended upon.

8. That it would be unsafe to proceed with any further excavation in the earth section on the north side of the aqueduct with the conduit in its present condition and while there is no other water supply available.

9. That is is unsafe to do any blasting in the rock section on the north side of the aqueduct.

10. That it is unsafe to allow the travelling excavators or locomotives or any other similar heavy machinery to be operated on or moved at any point over the top of the conduit.

11. That the reinforced concrete retaining wall as designed by the city and to be built by the Cook Construction Company along the banks of the aqueduct in the earth section is not, as designed, a safe structure to build for the purposes intended.

12. That a revision of the design of this wall, in order to make it safe, will greatly increase the cost of the project.

With the above facts as a basis, we beg to make the following recommendations:—

1. That before any further work is proceeded with, at least on the north side of the aqueduct, an investigation be made by a commission of engineers into the entire aqueduct scheme, which will include revised estimates of the cost of construction, and the quantity and cost of the power developed.

2. That the city at the earliest date possible make arrangements for providing a new and independent water supply of a suitable character, so located that it cannot be affected by any further accident which might happen to the present conduit.

3. That a permanent coffer-dam or intake be at once constructed at the entrance to the aqueduct including proper gates or sluices that may be required, so that the flow of water into the aqueduct may be at all times under control.

4. That until another suitable water supply has been provided, the present one should be kept continuously under observation so that in case the present leaks become serious prompt remedial measures may be taken.

5. That the suction pipes of the pumps at the pumping station be lowered by at least six feet as soon as possible so that the conduit may be run partly full or may be quickly emptied.

Respectfully submitted,

(Signed) J. A. JAMIESON,
R. S. LEA,
G. R. HECKLE.

[A detailed description of the emergency repairs to the break and the subsequent repair work is to follow as an appendix to the report.—Editor.]

A proposition, recently announced, which will ease considerably the meagre traffic facilities of Iceland, is a million-dollar railroad to be started in Iceland at an early date, extending from the capital, Reykjavik, in an easterly direction across the plain of Thingvala, a distance of about 58 miles, to the Olfusa Bridge. Ultimately it is proposed to extend this line to Thorsjaa, where the line will branch off in two directions, one going to the geysers and the other to Cerbak.

Coast to Coast

Bassano, Alta.—It is stated that the C.P.R.'s $9,000,000 dam will be completed at Bassano early in the spring, and water will be turned into the vast network of trenches.

Fort William, Ont.—The amended plans for the new C.N.R. station at Fort William show a brick and stone building, 143 by 24 feet; and the cost of the structure is estimated at $38,000.

Port Nelson, Ont.—Wireless signals from the new station at Port Nelson have been received at Le Pas, some 450 miles distant, showing that the plant of the new Hudson Bay terminal is now installed.

Windsor, Ont.—The towers of the Niagara power transmission line have reached Chatham, and all the tower foundations are constructed to Windsor, so that it is believed that by June, power will be in use in the latter city.

Fort William, Ont.—It is expected that this week will see the end of construction on the Stanley Avenue sewer at Fort William. The cost will be about $35,000 more than the original estimate of $54,000, due to an additional length of 600 feet added to the sewer since the contract was let, and also to the peculiar soil conditions which were encountered along the route of the sewer.

Montreal, Que.—At a recent meeting of the Montreal Chambre de Commerce, Mr. P. E. Lamarche, member for Nicolet, spoke in favor of the construction of the Georgian Bay canal, referring to the water power that might be developed from the project and which might earn enough to pay the interest and some of the sinking fund on the $150,000,000 which would be required to construct it. He also argued in reply to those who say the work will cost too much that it will justify itself just as the railways have done; that it will foster interprovincial trade, and besides forming a passage-way for the wheat, will enable coal to be sent to the West from Nova Scotia.

Toronto, Ont.—At the meeting of the Associated Boards of Trade on February 25 at Toronto, Mr. J. F. Black, Sudbury, advocated that the Hydro-Electric Commission be asked to proceed with the development of power in New Ontario, and that the Federal and Provincial Governments arrange to adopt this policy at an early date. A proposal to reforest waste lands that are useless for farming was approved by the board, and a resolution of five boards—Fort William, Port Arthur, Soo, Steelton, North Bay and Sudbury—was adopted, favoring Government assistance in mining and treatment of Canadian iron ore, such as will keep this trade in the Dominion, to be developed for the benefit of the Canadian people.

Montreal, Que.—The improvements to the harbor and terminal facilities at Montreal, contemplated by the Harbor Commissioners of Montreal to be carried out during the next 4 years, will call for an expenditure of $15,000,000. This year $3,500,000 will be utilized in developing the port, whereas last year $2,600,000 was consumed in this work. The exact programme for this year has not yet been decided, though it is believed that it will include the construction of two new freight and transportation sheds to accommodate the Hamburg-American and Canadian Northern weekly services; the electrification of the entire system of harbor railways; the elevation of the railway tracks between McGill Street and Victoria Pier; and the erection of a new mammoth warehouse at the foot of Morau Street and another at the foot of Beaudry Street. Plans adopted by the board call also for the extension of several piers, the erection of a new St. Lawrence bridge and the building of a new grain elevator, so as to give Montreal the largest storage capacity in the world.

Medicine Hat, Alta.—Contracts have been awarded by the city council of Medicine Hat for $65,000 worth of machinery and equipment at the new municipal power station, which will bring the total cost of that utility to approximately $500,000, including the modern and up-to-date pumping, generating and filtration system. Originally the new station was equipped with 2,400 h.p. gas-fired boilers, two 750 k.w. turbine alternators, and four 1,000,000-gallon filter beds, with the requisite high and low-lift pumping equipment. When the new machinery is installed and in running order later in the year, the station will be capable of generating about 4,000 h.p., and the filtration plant will handle 9,000,000 gallons of water each 24 hours. While the new power station has only been in commission two or three months, the steady and substantial industrial and municipal expansion has been such that additional machinery and equipment were essential, in order that the plant should not be seriously strained or rendered less effective by overloading in the immediate future.

Vancouver, B.C.—Mr. Frank Bowser, chairman of the Burrard Peninsula Joint Sewers Commission, has stated that approximately $2,000,000 will be expended in sewers for Greater Vancouver this year. Of this amount the approximate outlays will be $1,000,000 in Vancouver, $750,000 in South Vancouver, $100,000 in Point Grey, and $100,000 in Burnaby. In Vancouver the expenditures will include the purchase by the commission of the Balaclava Street, the Bridge Street and the China Street trunk sewers, at a cost of about $300,000. The work on the extension of the China Creek trunk will claim the expenditure of about $250,000, and the Clarke Drive outfall will entail an expenditure of something like $325,000. The Balaclava Street trunk sewer will be carried on from Ninth Avenue to the city boundary at Sixteenth Avenue, and a branch will be laid, probably along Tenth Avenue, as far east as the base of Shaughnessy Heights, to serve the territory in the declivity between the Kitsilano Hill and the Heights. In the extension of the main trunk sewer out to Central Park, this year's expenditures include work to cost something over $350,000, while another $200,000 will be paid for branches connecting with this work, all in South Vancouver. In Point Grey the commission will take over the Key Road sewer from the municipality at a cost of about $50,000, as well as undertake new work.

Sarnia, Ont.—As has been announced, plans are under consideration for an electric railway from a point in or near the town of Sarnia, down the scenic route along the bank of the St. Clair River through Corunna, Mooretown, Courtright, Sombra and Port Lambton, hence to Wallaceburg, where it will connect with MacKenzie and Mann's Wallaceburg, Chatham and Lake Erie Railway. From the village of Corunna a branch line will be constructed into Petrolea and probably further. The company contemplates the purchase of a charter already extant, which would give it power to construct the line of standard gauge railway; to acquire, charter and dispose of steam and other vessels, etc.; to construct, acquire and lease wharves, docks, elevators, warehouses, etc.; to operate a ferry line between Sarnia and Port Huron, and between Corunna, Stag Island and Marysville, Mich.; to operate a line of steamers from Sarnia down the St. Clair River; to erect and operate telephone and telegraph lines; and also to generate, transmit and sell power to the municipalities through which the line will pass. It is estimated that including all equipment, the construction of the line will cost about $1,000,000.

NEWS OF THE ENGINEERING SOCIETIES

Brief items relating to the activities of associations for men in engineering and closely allied practice. THE CANADIAN ENGINEER publishes, on page 90, a directory of such societies and their chief officials.

OTTAWA BRANCH—CAN. SOC. C.E.

On February 5th, Mr. C. P. Edwards, general superintendent of Government Radio-telegraphs, Department of Naval Service, gave an illustrated address to the Ottawa members of the Canadian Society of Civil Engineers. About 350 were in attendance at the meeting, which was held in the Normal School hall. The lecture was accompanied by some practical demonstration by means of apparatus set up for the purpose.

Mr. J. W. W. Drysdale, of Glasgow, Scotland, read a paper before the branch on February 12th. His subject was Centrifugal Pumping Machinery* and brought out some interesting discussion.

The February 19th meeting took the form of a luncheon at the Russell Hotel. About 50 were in attendance. Mr. G. A. Mountain, chairman of the Branch, presided.

Some very promising papers have been arranged for presentation during the balance of the season. The "New Welland Ship Canal" will be described by Mr. J. L. Weller, of St. Catharines, chief engineer of the project, on the evening of March 5th. The paper will deal with the location, the history, and the most interesting engineering features of the canal, and will be illustrated with lantern views. Mr. E. S. Mattice, of Montreal, will lecture at a later date on "Steel Building Construction"; and Mr. Walter J. Francis, of Montreal, will give an address on Engineering Ethics.

*See *The Canadian Engineer*, February 12th, 1914.

CANADIAN MINING INSTITUTE.

The seventeenth annual meeting of the western branch of the Canadian Mining Institute was held in Vancouver, on February 20th. Delegates were present from all parts of the province, and several instructive papers and discussions on mining matters particularly affecting the province of British Columbia were heard.

INSTITUTE OF MINING ENGINEERS.

Before the American Institute of Mining Engineers in New York on Friday, February 20, Eugene Coste, M.E., geologist and mining engineer, of Calgary, read a paper dealing somewhat exhaustively with certain phases of oil and gas strata under the general title "Rock Disturbances Theory of Petroleum Emanations vs. the Anticlinal or Structural Theory of Petroleum Accumulations."

AMERICAN SOCIETY FOR TESTING MATERIALS.

The executive committee of the American Society for Testing Materials has announced that the seventeenth annual meeting will be held at Atlantic City, N.J., June 30 to July 4, 1914, with headquarters at the Hotel Traymore. As it is desired that papers and committee reports be printed and circulated in advance of the meeting, all manuscripts should be in the hands of the secretary-treasurer by April 15.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-fourth Annual Meeting to be held in Philadelphia, Pa., May 11-15, 1914. Secretary, J. M. Deven, 47 Slate Street, Troy, N.Y.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—To be held in Montreal, May 18th to 23rd. 1914. Mr. G. A. McNamee, 909 New Birks Building, Montreal, General Secretary.

AMERICAN SOCIETY FOR TESTING MATERIALS. —Seventeenth Annual Meeting to be held in Atlantic City, N.J., June 30 to July 4, 1914. Edgar Marburg, Secretary-Treasurer, University of Pennsylvania, Philadelphia, Pa.

PERSONALS.

J. CHALMERS, Commissioner of Public Works, Edmonton, is on a trip through Eastern Canada.

CYRIL G. SAVAGE was appointed secretary-treasurer of the Canadian British Insulated Co., Limited, Montreal, at a recent directors' meeting. Mr. Savage succeeds HAROLD BROWN, resigned.

E. BRYDONE-JACK, Winnipeg; H. J. DUFFIELD, Calgary; and A. BROOM, Montreal, are reported to have been recently elected to membership in the Institution of Civil Engineers of Great Britain.

W. J. WALKER, A.M.I.E.E., is delivering a series of eight weekly lectures to the members of the Electrical Society of Vancouver, dealing with the construction and maintenance of storage batteries and their practical application.

W. T. WOODROOFE, for the past 1½ years superintendent of the Edmonton Street Railway, has recently sent in his resignation, to take effect April 1st. Mr. Woodroofe was previously with the British Columbia Electric Railway Company.

FRANK DITCHFIELD, formerly general superintendent of the Canadian Car and Foundry Co., Limited, has joined the staff of the Mechanical Engineering Co., Limited, of Montreal, and will direct the affairs of the company's consulting engineering department.

ARTHUR H. BLANCHARD, M.Am.Soc.C.E., Professor in Charge of the Graduate Course in Highway Engineering at Columbia University, on February 19, 1914, delivered illustrated lectures at the Ohio State University on the subjects: —"Road Legislation, Present and Future," "Bituminous Surfaces and Bituminous Pavements" and "Foreign Highways."

OBITUARY.

JOHN O. BROWN, civil engineer and railway builder, died at Fredericton, N.B., on February 25th, at the age of 71. During his career he had been identified with the construction of several of the important lines in Canada and the United States. He built, owned, operated and finally sold out the Northern Railway, and was interested in the building of what is now a part of the Northern Division of the C.P.R. in Madawaska County, and also the Central Railway.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

21383—February 19—Approving location of Kettle Valley Ry., between mileages 19.7 and 27.2, Hydraulic Summit west to Penticton, B.C.

21384—February 19—Approving revised location C.N.O.R. line of railway and land required for yards, in Tp. Ferris, Dist. of Nipissing, Ont., mileage 337 to 338.15 from Montreal.

21385—February 19—Authorizing C.P.R. to use and operate six (6) bridges, namely,—Over North Saskatchewan River at Edmonton, Alta.; No. 33.9, Alta. Div. Edmonton Subdivision; over Saskatchewan Ave., Edmonton, Alta.; over Jasper Ave., Edmonton, Alta.; No. 49.4, Alta. Div., Red Deer Subdivision, and No. 88.0, Alta. Div., Red Deer subdivision.

21386—February 19—Authorizing C.P.R. to construct spur for Massey-Harris Co., Limited, from a point on the southwesterly limit of right-of-way of Ry. Co.'s Main Line, Sask. Div., in Lot 4, Block 3, Bett's Subdivision, Yorkton, Sask.

21387—February 16—Directing that C.N.O.R. construct a permanent undercrossing, not less than 15 ft. wide and 13 ft. high, at west bent of trestle constructed by Co. through Henry Ray's farm in S. ½ of Lot 25, Con. 3, Tp. March, Ont., subject to certain conditions.

21388—February 21—Authorizing C.P.R. to use and operate Nine (9) bridges, Province of Ontario, on Eastern and Ontario Divisions, and Havelock, St. Thomas, Toronto, Hamilton and London Sub. Div.

21389—February 21—Authorizing C.N.O.R. to construct spur to property of Sun Brick Co., Ltd., in Lot 11, Con. 3, F.B., Tp. York, Co. York, Ontario, to be completed within six months from date of this Order.

21390—February 21—Authorizing G.T.R. to use and operate bridge No. 346, at mileage 198.46, on Sixth Dist. Eastern Division, at Napanee, Ont.

21391—February 23—Approving detail plans of Edmonton, Dunvegan and B.C. Ry. Co.'s bridge proposed to be constructed across Athabasca River, at mileage 131 West of Edmonton.

21392—February 23—Authorizing Municipal Council of Village of Young, Sask., to construct, at own expense, Dublin St., in said Village, across C.P.R. tracks.

21393—February 23—Amending Order No. 19033, dated April 11th, 1913, by striking out words, "fifty per cent. of cost of work," in operative part of Order, and substituting words, "The C.L.O. and W. Ry. Co., and the G.T.R. Co. each to pay for span over its own track; fifty per cent. of cost of remainder of the work."

21394—February 23—Directing that C.P.R. flag all train movements over crossing of Atwater Ave., City of Montreal, Que., and locate highway crossing sign so that a good view can be had of same when approaching crossing in either direction.

21395—February 14—Approving City of Toronto Plan No. a-101, dated Nov. 8th, 1913, and marked Plan "A," showing bridge to be reconstructed over G.T.R. and C.P.R. at Strachan Ave., Toronto.

21396—Amending Order No. 21290, dated Jan. 29th, 1914, by striking out figures and words, "7.30 a.m. to 7.30 p.m." in third line of operative part of Order, and substituting therefor figures and words, "7 a.m. to 8 p.m."

21397—February 23—Authorizing G.T.R. to reconstruct bridge No. 63 carrying Ottawa Div. 31st Dist. of its railway over the Madawaska River, at Mile Post 171.41, near Arnprior, Ont. Provided pier to be abandoned be lowered to three feet below low water mark.

21398—February 23—Approving proposed changes and alterations in V.V. and E. R. and Nav. Co.'s Main Line, part of original Sec. East line, Section 15, Tp. 16, to West line Tp. 26, B.C.

21399—February 23—Approving Can. Nor. Alta. Ry. Co.'s plans of stress sheet and general design of bridge at mileage 209.3, across Stony River, Sec. 35, Tp. 48, R. 28, W. 5 M., Alta.

21400—February 20—Authorizing T., H. and B. Ry. to divert two highways between Lot 5, Con. 12, and Lot 5, Con. 13, and Lots 6 and 5, Con. 12; to construct a right-angle crossing half-way between two crossings at present constructed between said Lots 6 and 5, Con. 12, and Lot 5, Cons. 12 and 13; And 2, Rescinding Order No. 20134, dated Aug. 16th, 1913, in so far as it authorizes diversion of highway between Lot 5, Con. 12, and Lot 5, Con. 13, Tp. Pelham, as set out in paragraph 4 of said Order.

21401—February 24—Approving locations of C.P.R. stations on Bassano Easterly Branch, Alta., namely, 1. Millicent, in S.W. ¼ Sec. 20-20-13, W. 4 M., and 2. Rosemary, N.E. ¼ Sec. 1-21-16, W. 4 M.

21402—February 24—Suspending, for present and pending investigation by Board, increased minima on building papers and pulpwood published in Supplement No. 40 to C.P.R. C.R.C. No. E. 2353, and supplement No. 28, to G.T.R. Tariff C.R.C. No. 2513.

21403—February 24—Authorizing the C.P.R. to construct, by means of a grade crossing, a diversion of road allowance across C.P.R. Main Line, Medicine Hat Subdiv., in Sec. 12, Twp. 12, Rge. 4, W. 4 M., Alta.

21404—February 24—Further extending until May 31st, 1914, the time within which sidings for the Otis-Fensom Elevator Co., at Hamilton, Ont., be constructed and completed.

21405—February 26—Further extending until June 30th, 1914, the time within which to complete the sidings for the Godson Contracting Co., in Lot No. 16, Con. 19, Twp. Darlington, Ont.

21406—February 24—Authorizing the C.P.R. to construct, maintain and operate a branch line of railway, or spur, for the International Harvester Co., Lethbridge, Alta., from a point on the westerly limit of the C.P.R. Alta. Division, thence across Tenth Avenue, West, and along lane 206 in said City of Lethbridge.

21407—February 24—Authorizing the C.P.R. to construct, maintain, and operate an extension to siding for the C. S. Hyman Co., Ltmited, on Subdiv. Lots 3, 4, and 5, Block 304 A, London, Ont.

21408—February 26—Authorizing the Twp. of McKim, at its own expense, to construct and maintain highway crossing over the tracks of the C.P.R. in Lot 9, Con. 5, Twp. of McKim.

21409—February 26—Limiting the speed of trains over the crossing of Long St., by the G.T.R., at Chesley, to a rate not exceeding ten miles an hour.

21410—February 24—Authorizing the G.T.R. to construct, maintain, and operate extension of siding serving the premises of the British American Oil Co., Limited, commencing at a point on the G.T.R. tracks on the 150-foot roadway reservation, north of Keating's Channel, Ashbridge's Bay, Toronto, Ont., thence extending in a westerly direction to and into part of Block E, leased to B. A. Oil Co., Limited.

21411—February 24—Authorizing the G.T.R. to construct, maintain and operate branch line of railway, or siding, commencing at a point on the N. Div. of its railway on Lot 8, in the 1st Con. of Twp. of Chaffey, Dist. of Muskoka, Ont., and near Huntsville Station, thence extending in a northeasterly direction to and into the premises of Steven Brothers and Holmes, Brick Mnfs., on said Lot 8, thence extending easterly and adjoining the G.T.R. railway on said Lot 8.

21412—February 24—Authorizing C.N.R. to construct, maintain and operate a spur to serve the Alberta Agencies in Block 22, Glenora Subdiv., crossing Coot Street, Edmonton, Alta.