PAGES

MISSING

Volume 26 Toronto, March 26, 1914

Contents of this issue on page 509

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

THE FIELD WORK OF THE LETHBRIDGE VIADUCT

With some Notes on the Construction of the Substructure

By B. RIPLEY, M. Can. Soc. C.E., M. Am. Soc. C.E.
Engineer of Grade Separation, Canadian Pacific Railway, Toronto.

IN the issue for September 17th, 1909, of *The Canadian Engineer* in an article entitled "Great Engineering Works on the Canadian Pacific Railway," the late J. E. Schwitzer, then Assistant Chief Engineer of C.P.R., western lines, dealt briefly on the construction of the Lethbridge viaduct and the spiral tunnels between Field and Hector. Subsequently, shortly after the opening of the Lethbridge viaduct for traffic, a most interesting and valuable paper was read before the Canadian Society of Civil Engineers by C. N. Monsarrat, Esq., a member of that society, now chairman of the Board of Engineers for the Quebec Bridge. This latter paper dealt chiefly with the design of the viaduct and its erection, touching briefly on the laying out of the substructure.

The author will endeavor to describe fully, the procedure adopted in connection with the laying out of the work, and the manner in which it was carried out in the field; also to describe some features of interest in connection with the construction of the foundations.

Up till 1894, the City of Lethbridge was the western terminus of a narrow gauge railway between that city and Dunmore Junction on the C.P.R. main line near Medicine Hat, then operated by the Alberta Railway and Coal Company, who, if the author remembers correctly, held the original charter for the building of the Crow's Nest Pass Railway. The Alberta Railway and Coal Company, also, before being taken over by the Canadian Pacific Railway, made extensive surveys to effect a crossing over the Belly River in the neighborhood of where the Lethbridge viaduct now stands.

The narrow gauge railway between Dunmore Jct. and Lethbridge was finally bought out by the C.P.R. and standardized, and the Crow's Nest Pass branch was built by them during 1897 and 1898, connecting Medicine Hat, on the main line, with Kootenay Landing, on the south end of Kootenay Lake. The Lethbridge-Macleod cut-off is a portion, approximately 31¾ mi. long, of the Crow's Nest Pass Branch of the Canadian Pacific Railway which was opened for traffic on November 1st, 1909.

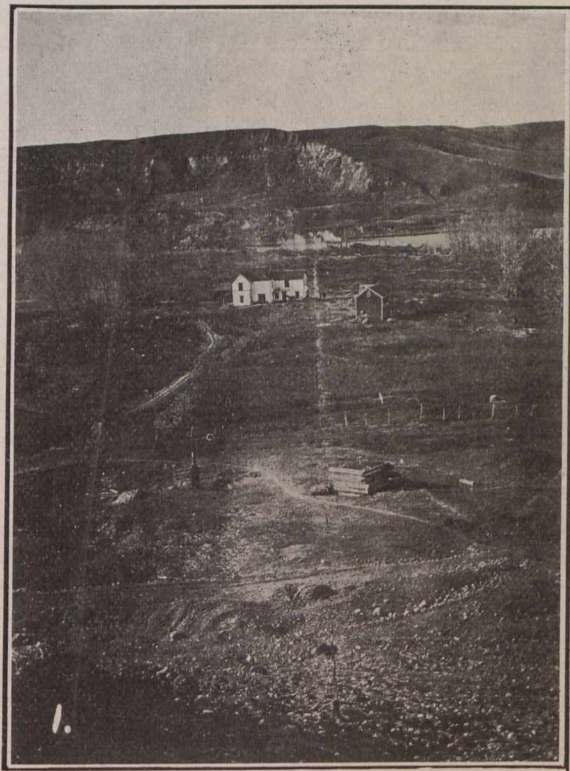
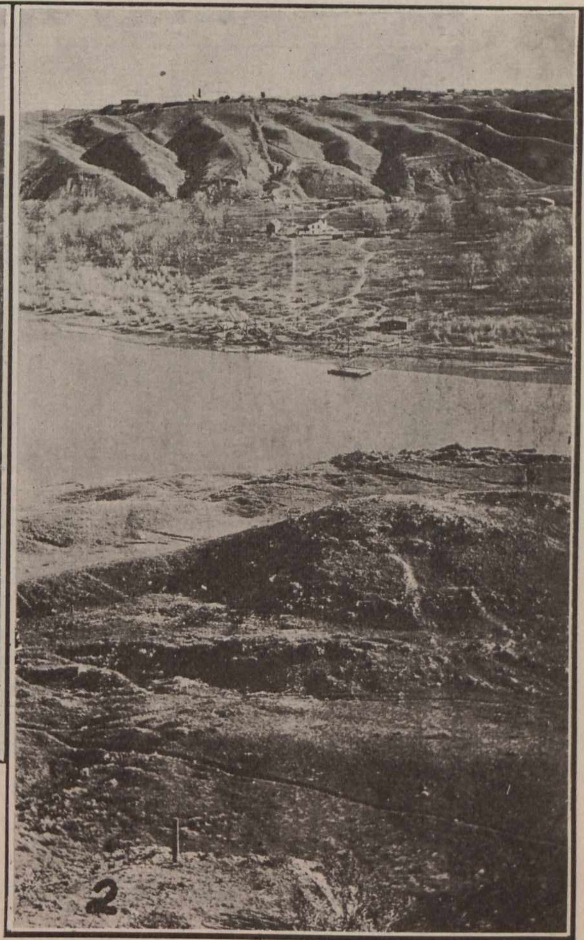
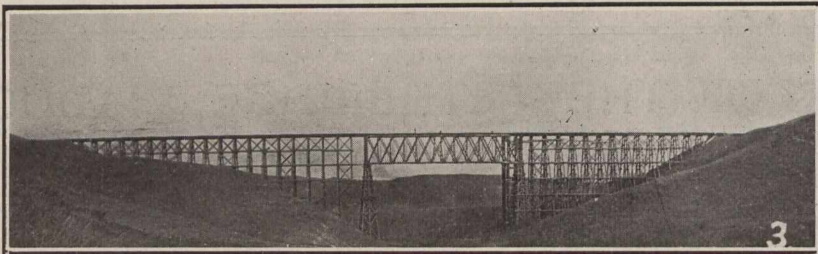
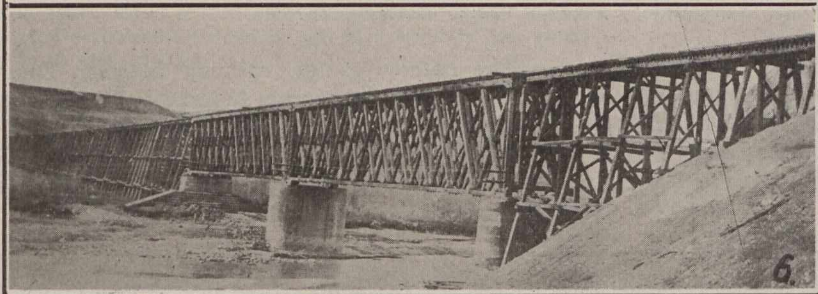



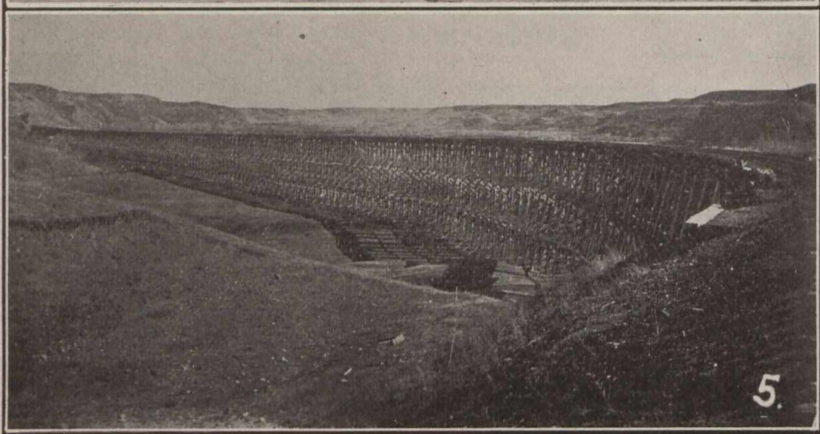
Fig. 1.—Site of the Viaduct Looking West.

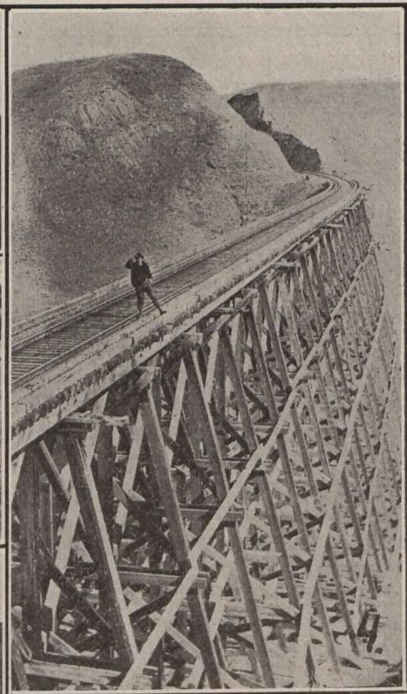
Fig. 2.—Site Looking East.

The old line between Lethbridge and Macleod, which was built during 1897 and 1898, was approximately 37 mi. long and included, besides very heavy earthwork, the construction of some 20 trestles and bridges, containing approximately 15,000,000 ft. B.M. of timber. Only two streams were crossed, and these with low-level crossings, but in getting down to the adopted level for these, it was necessary to build other 18 trestles and trestle bridges across the mouths of deep coulees or valleys, which were tributary to the main valley or gorge. Some idea of these coulees and of the main gorge can be had from Figs. 1 and 2, and of the trestles and bridges which were built from Figs. 3, 4, 5 and 6, the two last mentioned showing the crossing of the St. Mary's River, about twelve miles above Lethbridge.



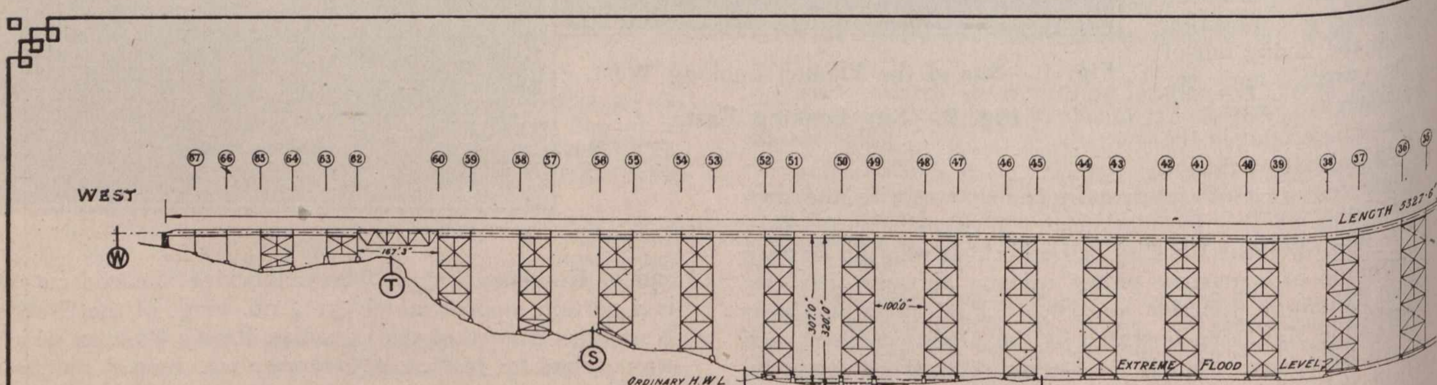






Figs. 3. and 4.—Trestles and Span Bridge over deep coulees. Figs. 5 and 6.—St. Mary's River Bridge, taken from west and east ends respectively. Piles 100 to 120 feet in length were used.

Operating expenses on the old line were very heavy. The life of a great many of the old structures had almost expired, making the maintenance of these excessive; and in the majority of cases the problem of complete renewal was presenting itself. Contemplating the event of such a condition, the management of the company had extensive surveys made, covering several years, to determine whether any advantage could be had by the construction of any possible alternative line, and finally one located by F. M. Young, Esq., M.Can.Soc.C.E., now engineer in charge of construction on the Kootenay Central Railway, approximately 31¾ mi. long, with a gradient of 0.4 per cent., was chosen. On this line were two heavy high-level crossings—one over the Belly River at Lethbridge, and the other over the Old Man



River near Macleod. The first-mentioned crossing required a structure 5,327 ft. long and 300 ft. high, and it was decided to erect a steel viaduct with 67-ft. deck girder spans on towers and 100-ft. similar girders spanning the openings between the towers. The second of these two crossings was over the Old Man River near Macleod. This required a structure 1,890 ft. long and 150 ft. high, and it was decided to erect a steel viaduct with 45-ft. deck girder spans on towers and 60-ft. deck girders between the towers. Plate 7 shows a profile of the Lethbridge viaduct.

On the centre line, which was tangent throughout, permanent hubs were established at *W* and *F* (Plate 7), which were points near enough to the ends of the viaduct to be of value throughout the building of the bridge, but far enough from the structure that they would not be disturbed during construction. Holes, similar to post holes, were dug to a depth of between four and five feet, and pieces of 8 x 8-in. timber were inserted in these, so that about two inches projected above the surface of the ground, which had been carefully levelled off. These were firmly tamped around with concrete, and after being centered, constituted the hubs from which the true centre line was established.

These were securely fenced, leaving a sufficient space within the enclosure to permit the setting up of a transit, and by a special arrangement, shown in Plate 8, a sighting rod was always left standing over the centre on these hubs, which was established on a small brass brad. These sighting arrangements saved considerable time, as otherwise it would have been necessary to have sent a picket man to the hubs every time they were used. As it was, the sighting rods were inspected from time to time to see that they were in true position, and were always carefully replaced after having been removed for a transit set-up.

After having carefully adjusted the transit, it was set up on *F*. Hubs *E*, *C* and *X* were established by using *W* as a foresight, then *T*, *S* and *R* were established from the west end of the line, using *F* as the foresight. Needless to say, all hubs were established in a manner similar to that of *W* and *F*, just described.

It will be noticed from the profile that in centering these points there would often be a great difference between elevations; and, in addition to having the lining hair of the transit truly vertical, and the standards carefully adjusted so that a vertical plane would be followed in depressing or elevating the telescope, double centering was used to further eliminate errors.

After having these main hubs or stations set up at the most commanding or useful points, Station *X* was chosen as the starting point for all measurements. There were several reasons for this. From *X* there was an excellent opportunity to get a sufficiently long base line for triangulation. More of the centre line could be seen from this than from any other point. At it, also, the triangulation base could be laid out at right angles to the centre line of the bridge, making it equally valuable for work in the direction of *W* as in the direction of *F*. The ground was fairly level, affording a good opportunity of measuring and checking the base line, and as it was of most importance to have the river work started first, Hub *X* would be close at hand and no delay would be had in laying out excavations for the river piers, the contractors for the substructure being already on the ground.

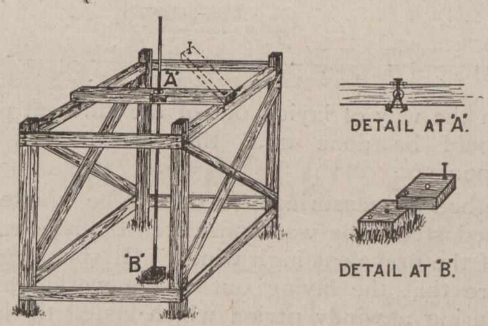


PLATE 8.

Although the centre line of the bridge had been measured both by the location engineer and the engineer making the preliminary survey from which the bridge was designed, no measurement across the gorge was made with sufficient accuracy for the construction of the foundations. It might be noted here that during the winter of 1906 and 1907, a special party was put into the field to make a preliminary survey of the site just referred to, and although extreme care was used, the final measurement, made with a steel tape, was slightly over three feet in error, as was found when the ultimate measurement was decided upon.

The banks of the gorge were very steep and irregular in places, and it was decided to start measurements in both directions from *X*, so that any error in the

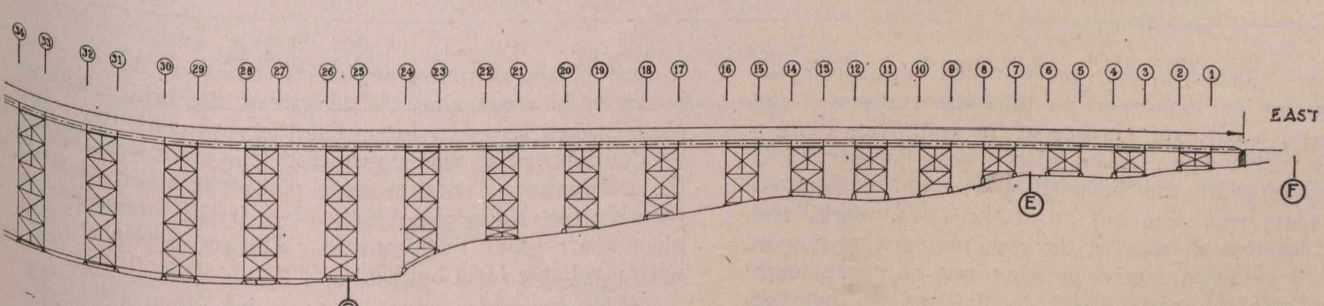


PLATE 7.

measurement of the centre line would be distributed on both banks, instead of being thrown upon one.

It might be mentioned that the actual work in connection with the laying out of the substructure was commenced during September, 1907, and at that time no detailed plans of the structure were available. Therefore, it was not safe to figure on any small errors in the total length of the viaduct being taken up by the erection of steel. It was therefore decided that nothing would be left undone in the matter of securing a correct chainage throughout the whole length of the bridge, and that nothing in the way of laying out of the different piers or bents should be done until this length was finally decided upon.

A method of measuring was then to be adopted. An unsupported steel tape was considered of little value on account of the prevalent high winds. (It should be mentioned here that the laying out of the work was commenced during a windy period which lasted till late the following April.) Neither was it considered advisable to use a supported tape for the reason that this method was not considered practicable. Therefore, on account of the wind and fluctuations in temperature, something less sensitive to both was required, and a graduated wooden rod was chosen.

A well-seasoned piece of cedar, 16 ft. long, 2 x 4-in. in section was obtained, and dressed to 1⅜ x 3 in. A supply of brass plates 2½ in. long, 1 in. wide and about 3/32 of an inch in thickness, bevelled on one long side, were made and set into the rod to receive graduations. About three inches from the end of the rod, the first one of these was placed so that the bevelled edge projected about 1/32 of an inch, and so that the surface of the plate was flush with the surface of the rod. See Plate 9 for details. This was marked with a very fine scratched line terminating at the bevelled edge, and designated zero. A plate was then put on at the 12-ft. mark, and from this point to the end of the rod, plates were put on at intervals so as to receive graduations at every tenth of a foot from the 12-ft. mark to the end of the rod.

A 100-ft. steel tape was procured, and compared with the standard of the company. Supported throughout its entire length at a temperature of 70 deg., with a 10-pd. pull, it was found to be 100.025 ft. in length. From this it was desired to establish a 90-ft. base from which to graduate the measuring rod for 15-ft. measurements. A suitable piece of ground was found, and a heavy 12 x 12-in. post about six feet long, was set into the ground about five feet, and so the top projected 12 in. above the ground, and a similar one was placed at the 90-ft. mark. Between these, other smaller stakes were firmly fixed, and on these 2 x 4-in. scantlings were nailed so that a straight line could be run on the level surface. The scantlings were left free from the 12 x 12-in. end posts so that any contraction or expansion caused by differences of humidity would not affect the main hubs on which the 90-ft. standard base was made. See Plate 10. A fine brass tack or brad, similar to those used by a shoemaker, was placed in the first post and a fine scratch made across its face. This was the zero of the standard 90-ft. base. The 90-ft. tack was set after having the tape stretched with the proper tension, calculation having been made for error in tape, also for difference of temperature, and marked as was the zero end by making a very fine scratch across the tack. Tacks were then lined in on the scantling edge that had previously been used to support the tape, and at 15-ft. intervals.

The 15-ft. mark was made very lightly on the proper plate on the measuring rod, as accurately as could be done with the steel tape. The measurement of the 90-ft. base was then attempted with the rod, and the 15-ft. graduation changed till six lengths of the rod exactly reached the 90-ft. mark on the standard base. When this was accomplished, the rod was considered correct at its 15-ft. length. The other graduations were put on by use of the common engineers' boxwood scale. The intention in measuring the length of the bridge was to place stakes at 15-ft. intervals, thereby using the 15-ft. graduation, as it was considered the more accurate of the graduations. Stakes were placed at other intervals from 12 feet to 15.5 feet only when it was impossible to place the regular 15-ft. stakes. The rod was also fitted with a reliable level bubble.

The measurement of *X* to *C* was then attempted, and the ground being fairly even and level, it was possible to measure horizontally, and without the use of a plumb-bob with one or two exceptions. Stakes were carefully lined in, stationed at 15-ft. centres, and levelled at the same time. After about five hundred feet of the

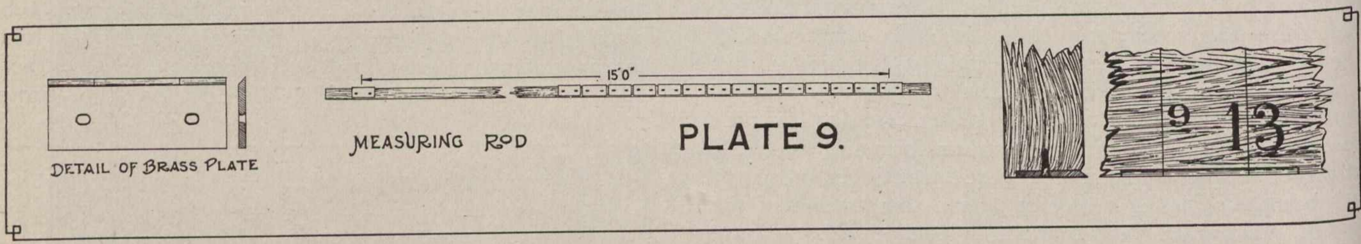


PLATE 9.

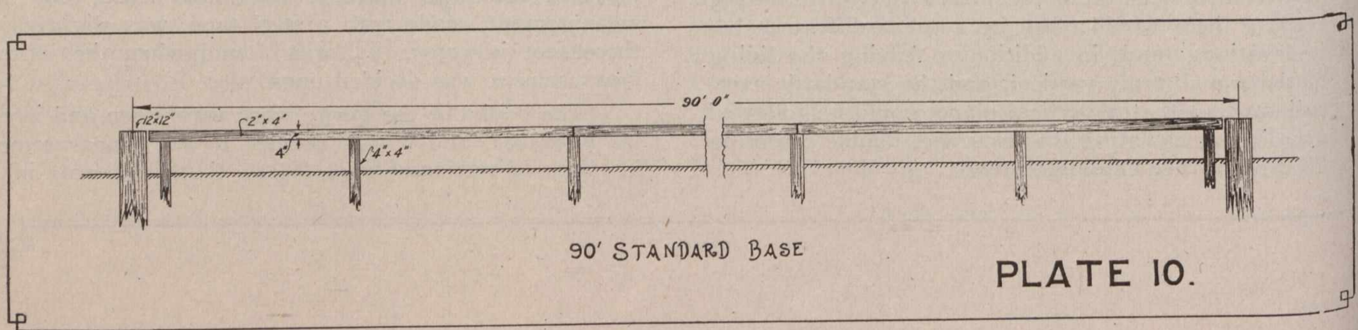


PLATE 10.

15-ft. stations were set, it was found necessary to start a new level of stakes about two feet lower than the first set, as the ground was found to be falling slightly in the direction of *C*. It was also found necessary, after this level of stations had been set for about six hundred feet, to raise the balance of the distance to a higher level. Measurement was carried from one level to another by using a fine plumb-bob protected by a canvas wind shield. See plumbing arrangement, Plate 11.

The method of measurement was as follows: Hub *X*, being the initial point, was set in concrete deeply planted in the ground as a safeguard against its being shifted, and a fine tack with a scratch across its face was made to indicate its chainage. The first set of level stations was measured after two transit points had been taken on the head of each stake, and these joined by a pencil line. This was in order that the transit need not be used while measuring was being done, so that the transitman could keep notes carefully and watch the work. With the zero end of the rod at the starting point, a tack was placed in the first station so that the 15-ft. distance would come upon its head, a fine scratch in the form of a sharp arrow was made on the tack with a small blade of a pocket knife, and this was checked to see that the 15-ft. graduation on the rod exactly coincided with the point of the arrow on the tack. To avoid confusion, no two marks were made on the same tack. The rod was then moved ahead to the second pair of stakes, and so on until a portion of the line was measured, but in no case was this distance too great to be checked three times the same day. Measurements were recorded by the transitman. The man at the zero end of the rod was then moved to the front end, the front end man being moved back to take the rear end, and the measurement checked carefully through. If any discrepancy was found, the recorder took one end of the rod and both rodmen jointly took the other end. When any differences were found, new tacks were used to receive

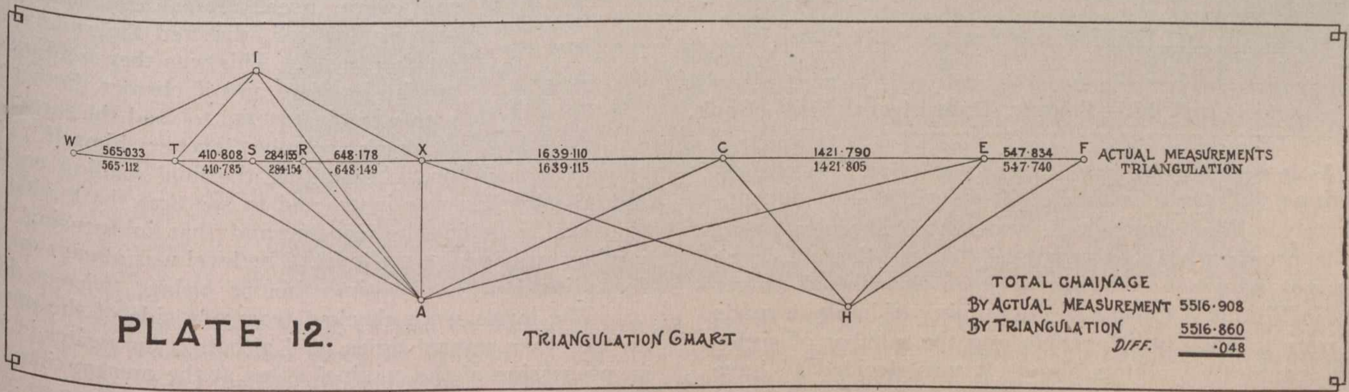


PLATE 12.

the scratches. After a chainage was decided upon, the measuring rod was again checked into the standard 90-ft. base, and if found to be correct, the chainage previously agreed upon was allowed to stand.

After a final measurement had been agreed upon as far as hub *C*, a triangulation base was laid off south of, and at 90 degrees to the centre line from hub *X*, and this was carefully measured—759.270 feet in length, and from triangulation *X-C* was found to be 1639.115 as against 1639.110 measured with the measuring rod. See triangulation chart, Plate 12.

From *C* to *E* a great deal of steep and irregular ground was encountered, and on account of the small distance measured each time, and of the frequent uses of the plumb-bob as well as the winds, it was decided that no horizontal measurements should be taken. Some of the ground was as steep as 1 to 1½, and it would not have been practicable to have shielded the plumb line each time a measurement was taken. Slope measurements were taken in all cases, careful levels were taken over the stations and the horizontal measurements calculated. (See sample of notes, Fig. 13.) Wherever it was

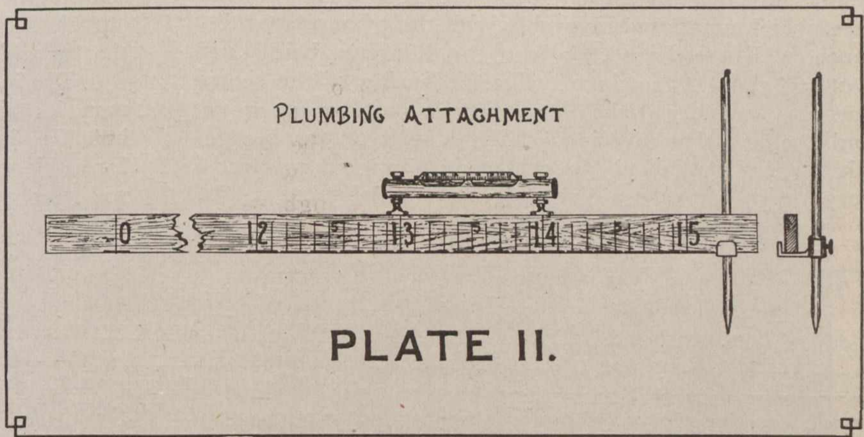


PLATE 11.

possible with some little grading to get two or more stations on the same slope, this was done. This simplified calculations, also reduced liability of error. On some slopes that were somewhat uniform, by a little grading it was possible to get as many as five or six stations on the same slope. The tops of these stakes were carefully lined in to the uniform slope by using a level and target rod. Wherever a change was made from one slope to another, the station where the change took place was called a "change," and this was written on the stake so that when levels were taken for the calculation of the horizontal measurements, the respective elevations of the changes only were required. The measured chainage of this portion of the bridge length was 1421.790 feet, as compared with 1421.805 feet which was computed from triangulation.

From *E* to *F*, the distance measured with the measuring rod was 547.834 feet, compared with 547.740 feet from triangulation. The west end of the work which was in the direction of *X-W*, was measured and triangulated in a similar way to the way in which the east end was done, the only difference being that point *W* was not visible from either *X* or *A*, and for this reason, a secondary base line had to be established by triangula tion, and from this secondary base, the distance from T to W was had. The fact that W was not accessible from X will perhaps explain the discrepancy of .079 feet between the actual and triangulated distance between T and W, as a very slight error in the alignment of T which was accessible, would account for the difference.

Actual measurements were relied upon for the laying out of the work, and the triangulation was simply used as a means of detecting any large and appreciable errors that might possibly have come into the actual measurements, so small a measuring standard being used. Actual distance measured with the rod was 5516.908 feet, which compared favorably with the triangulated distance, which was 5516.860 feet, the difference being .048 foot, or about ½ an inch. The measuring of the centre line was considered the most difficult part of the work, and the actual measuring of the length of the bridge, slightly over a mile in length, took about six weeks of very trying time, especially on account of high winds.

7

Station	Slope	Total slope	Vertical	Slope²	Vert.²	S² - V²	Hor.	Station	Remarks
22		14·8						1666+66·892	Oct 5th
	15·2								Temperature +44°
									No wind - Conditions
Change 8 23		30·0	11·685	900·1200	136·5392	763·5808	27·633	1666+39·259	favourable.
Change 8	15·0								
24									Note: At 5 pm measuring rod checked into 90' Base & found correct
	14·9								
Change 9 25		29·9	13·967	894·0698	195·0771	698·9927	26·438	1666+12·821	
Change 9	14·9								
26									
	15·2								
Change 10 27		30·1	12·019	906·1304	144·4564	761·6740	27·598	1665+85·223	
Change 10	14·7								
28									
	15·3								
Change 11 29		30·0	19·081	900·1200	364·0846	536·0354	23·152	1665+62·071	
Change 11	14·9								
30									
	15·3								
Change 12 31		30·2	15·909	912·1608	253·0963	659·0645	25·672	1665+36·399	
Change 12	14·7								
32									
	15·0								
Change 13 33		29·7	8·607	882·2088	74·0804	808·1284	28·427	1665+07·972	

Fig. 13.—Sample Page from Field Book.

As it was necessary to proceed at once with the excavations, a great many of these were laid out immediately. The "bent" hubs were established by laying off the proper distances from the "change" stakes, the chainages of which had already been established as per notes in Fig. 13. Owing to the number of haulage roads that were to have been opened, and the number of sightseers constantly walking about, it was decided to have all bent hubs protected by a railing on four good posts set firmly into the ground, and enclosing a space sufficiently large to allow the setting up of a transit inside, and all intermediate stakes pulled out so as to avoid confusion, and to give the workmen, teams, etc., an opportunity of working without disturbing stakes. The preservation of permanent stakes and hubs was an important question on this work, and a great deal of pains was taken to protect them. The "bent" hubs were also referenced by means of other hubs set out at considerable distances, and approximately at right angles to the centre line. It will not be necessary to describe fully the actual laying out of the foundations, but it might be said that it was only necessary to turn off an angle of 90° 00″ from the centre line, and to measure out the given distance to the centre of the particular foundation. This was done by the tape on fairly level ground, but the measuring rod, and plumbing arrangement was used on irregular ground. This was generally done before the ground had been disturbed, and by setting up the transit over the centre of the foundations and turning off other angles of 90° 00″, four hubs were set that were sufficient for the contractors to carry out the work. When the ice was out of the river, the river piers were located by triangulation, which scarcely need be described. When it was possible to lay out piers from the ice, this was done in a similar way to that in which the land piers were laid out.

The initial bench mark was established from preliminary location bench marks, and inside the enclosure at hub X a hole similar to one which would have been dug for a telephone post, was made. Into this, a ⅝ inch steel rod was driven so that the top of it would be slightly below the original ground. Then concrete was dumped into the hole around the steel rod. The hole was then filled in with earth, and the bar carefully referenced, so that no unnecessary digging would have to be done in finding the rod. After the concrete had firmly set, the rod was examined to see that it had a well-defined top, on which a bench mark was established. Other bench marks were established at convenient points, from which, with one "turn," elevations could be given for the finishing of a pedestal near same. It was so arranged that it was never necessary to make more than one turn from any bench mark in setting elevations for the finishing of the tops of any of the pedestals.

In levelling to establish a system of benches, difficulty was had in the getting of fine calm days, and it was rarely possible to get two good days in succession. A Gurley level and sliding target rod were used. The levelman, after reading the rod, directed the rodman to set the target. This was then read again by the leveller, and if correct, both rodmen were instructed to read the target as a check on the leveller himself. As another precaution, after taking the final reading on the rod, the leveller was instructed to see that the bubble of the level was in the centre, and that in focusing, no jarring was done to the level. The level was always tested for adjustment every time before using, twice a day.

The levels were checked from one side of the gorge to the other several times, and although the writer is not in possession of the original notes at the present time, as far as he can remember, a check was had as close as .025 of one foot, which, considering the nature of the ground and the weather that was contended with, seems rather to have justified the care taken. The writer considers, for similar work, that a one-piece target rod is superior to the two-piece one that was used. With one of these there would be no danger of the slipping that has to be guarded against with the two-piece rod. Constant use also has a tendency to wear the mechanism of the two-piece rod, thereby making it less accurate for careful work. The sun being fairly dull at this time of the season, no sun shade was used. One precaution that was taken was that the leveling rod was, as far as possible, kept in a place where the atmosphere was almost constant as to humidity.

Owing to the design of the steel work, it was necessary to have a precision of ⅛ inch in the finishing of the tops of the piers. Points were set for the forms, and after considerable concrete had been put in, points were set with fine nails for the finishing of the top of the pier.

The transit used was a Gurley light mountain transit that was used by the author on the harbor work of the G.T.P. at Prince Rupert, B.C., and afterwards remodelled point. The alidade was unclamped and swung over the necessary arc, and the telescope sighted carefully on the other point and the alidade clamped. Without reading the vernier, the limb was unclamped and the telescope carefully sighted on the first point and the limb clamped. The alidade was again unclamped and swung through the arc, and the telescope carefully sighted again on the second point and the alidade clamped. The vernier has now travelled twice over the arc, and the value of the angle is therefore one-half of the reading. This was

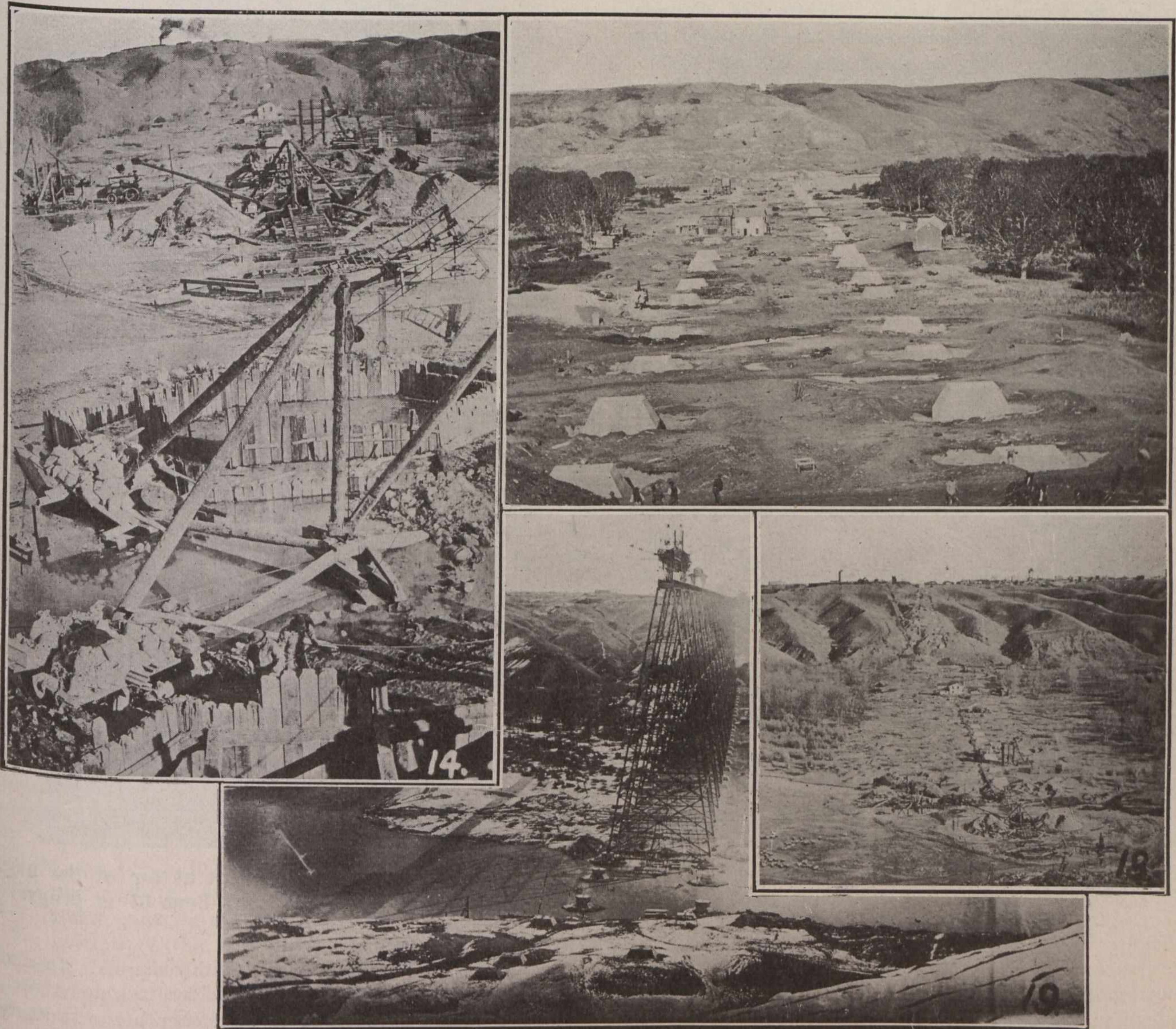


Fig. 14.—River work being carried on during winter of 1907-08. Fig. 15.—Pedestals complete on river bottom with work on west bank in progress. Fig. 18.—Looking eastward, showing sub-structure in progress. Fig. 19.—Erection of steel-work. Bent 47 just completed.

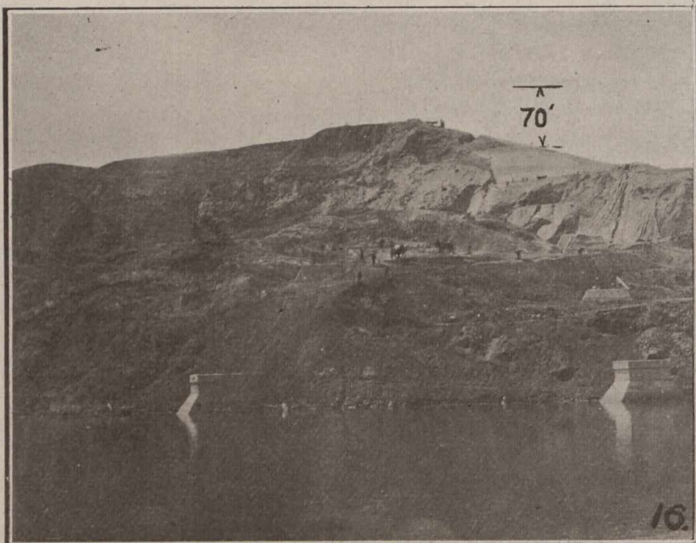
to suit the conditions at Lethbridge. The horizontal limb and verniers were graduated to read to 20 seconds, and attached to the standards were special magnifiers for reading both limbs. These were attached to the standards by means of universal three-joint arms, allowing the lens to be placed over any point on either vernier. To further facilitate the determining of the angles required in triangulation, the process of "repetition" was used so as to distribute any inaccuracies of the graduations of the horizontal limbs, over several readings. After setting the vernier at zero, the telescope was sighted on the first done until the vernier indicated six times the actual value of the reading, and of course, this reading divided by six gave the value of the angles used in the computations. The angles were also read from both verniers, and in case of any difference, the mean was used. Errors due to angular distance between the verniers and to eccentricity of the graduated limb were largely eliminated by this method.

The plant used by the contractors for the substructure was as follows: 2 orange peel dredges, 1 clam shell dredge, 1 drag line dredge or excavator, 3 stiff leg derricks, three 6-inch submerged centrifugal pumps, one 8-inch suction centrifugal pump, 3 traction engines, for steaming and driving pumps; 2 traction engines, to furnish steam for thawing out the bottoms of frozen excavations during the winter; 2 hoisting engines for handling concrete, 2 Raymond concrete pile drivers, 1 crusher with elevated bin, 2 Smith mixers, 1 Ransome mixer, and a great deal of smaller plant.

The first few feet of almost all of the land excavations were taken out by teams and scrapers, and the balance by pick and shovel. After this was done, the excavations were staked out, ready for piles, which were driven by the Raymond Concrete Pile Co. of Canada. It might be as well to describe briefly the Raymond concrete pile. A thin casing of sheet steel is made to fit a collapsible tapering core which is driven into the ground after it has received the sheet steel casing, by a heavy steam hammer. After the core with its casing has been driven to the required resistance, the core, which is made in three sections, and expanded by toggle joints before having received the casing, is collapsed and pulled out again. The casing remains in the ground, and concrete of a 1:2:4 mixture is poured into the casing, forming the concrete pile. These piles were chosen as the most suitable for the work, and gave excellent satisfaction.

bolted at the corners. The footings were filled neat to the ground wherever it was found possible to take out the excavation to the size required by the plans. On account of the formation it was rarely ever necessary to shore or timber any of the land excavations; the material invariably being stiff clay, and sometimes almost marl.

The river work, of course, was somewhat different. At the first pier, a clam shell dredge was set to work to clear off the gravel and sand from a bed of shale, which lay about 20 feet below the water, so that an open caisson when sunk would fit close to the surface of the shale. A solid 10-inch by 10-inch timber caisson was then sunk



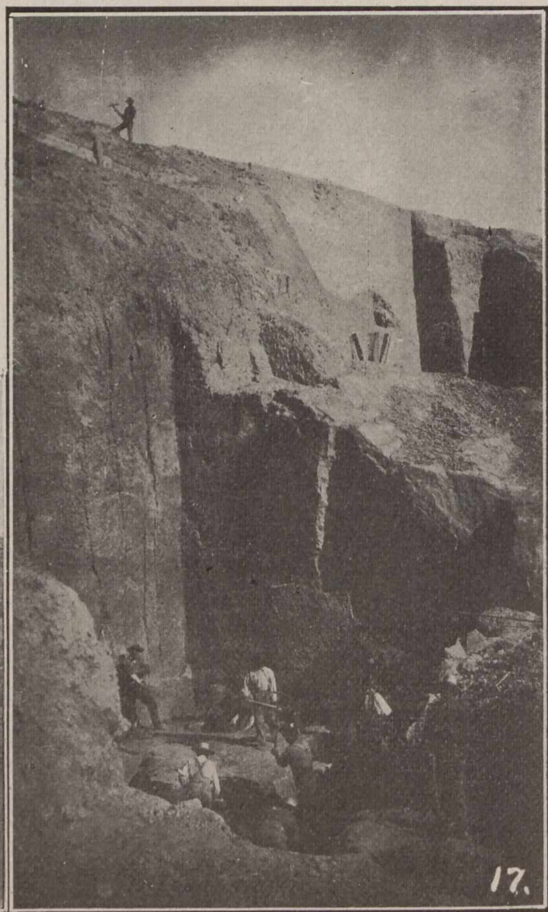


Fig. 16.—River Piers as seen from Bent 52; cutting of west bank in progress. Height at top of the bank indicated. There is another bank not shown. Fig. 17.—Excavation for pedestals of Bent 61 in progress.

As soon as the piles were driven, any loose earth in the bottom of the excavations was taken out, and after the piles had set sufficiently, they were cut off with heavy cold chisels to allow one foot of the pile to remain in the footing of the piers. Forms were then put into place, and concrete operations commenced. The land piers being all of the same widths, and of various lengths, the forms were made so that they could be used over and over until worn out. In order that these could be readily moved about, they were made lighter than is usually the case. Good quality British Columbia flooring, ⅞ inch by 4-inch, was nailed to scantlings 2-inch by 6-inch, spaced at 18-inch centres. After the forms were placed in position, walings 6-inch by 8-inch, or 8-inch by 8-inch, were spaced around about the forms at sufficient intervals to keep the forms from bulging, and ½ inch iron tie rods were run through these and tightened up. After this, any loose scantlings or ribs were wedged so that all had a bearing on the walings. The walings were also

into place and weighted down with old rails. In making this caisson, caulking was done by tacking a strip of folded cotton to each layer of timber before putting on each successive layer of timber. Soundings with an iron rod showed up points at which the caisson was any considerable distance from the shale, and at these, light sheet piles were driven so as to scribe the shale, and in a way prevent leaks. Puddling was then done around about the bottom of the caisson, with gravel and clay. The caisson was then pumped out with two 6-inch pumps, and after making the necessary borings the footing was prepared for the placing of concrete. Before the placing of concrete was commenced, a trough was placed about one foot from the inner edge of the caisson, and caulked, and the pumping was confined to this area, so that nothing would be pumped out of the concrete.

On one or two of the other piers, another method was used. A skeleton was first made of successive rows of walings securely fastened together, conforming to the shape of the pier to be built. These walings were placed at intervals to suit the pressure. The skeleton was then sunk into place and weighted down with steel rails. The walings referred to served a dual purpose; first as a guide to the sheet piling which was driven around them, and to receive the struts which were put in as pumping proceeded. Before any pumping was started, however, a second row of sheet piling was driven from four to five

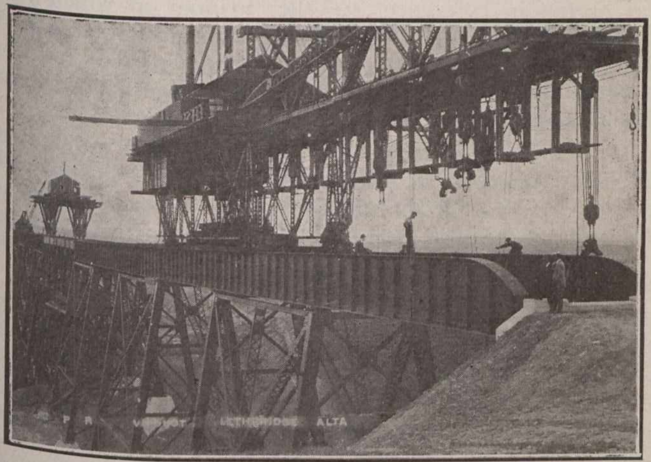


Fig. 20.—Erection Traveller Placing the Last Girder.

feet outside of the first row, and the intervening space was puddled.

From Fig. 14 a partly sunk skeleton is shown, and completed dams are shown on other parts of the work with both rows of piling driven, and one of the dams pumped out.

A third method was used where it was known to be impossible to pump out a cofferdam. Dredging was resorted to and continued until nothing further could be taken out by this method. An open caisson was then sunk into place, and as close to the shale as possible, and weighted down with old rails. Further preparation of the footing was made by divers. After a few feet of concrete had been placed in the bottom by bottom dumping buckets, the mass was allowed to set for a few days, and then pumping was resorted to. In the winter weather, steam was blown into the water near the bottom of the dam from boilers nearby, and this accelerated the setting up of the concrete. Little difficulty was found in pumping out any of the dams attempted in this manner, and after a dam was pumped out, it was a simple matter to place concrete.

The cement used was Buffalo Brand, made near Calgary, and the Exshaw Brand, made at Exshaw, Alberta. These cements were used and gave excellent satisfaction. One of the redeeming features of both brands was that they would set up fairly quickly, relieving to a great extent the pressure on the forms. When concrete was placed under water by means of bottom dumping buckets, a 1:2:4 mixture was used, and when water was not to be contended with, the concrete was of a 1:3:6 mixture.

A great deal of the gravel used came from the excavations along the river bottom proper, and was found with the proper proportion of sand, so that no screening was necessary. This proved to be very profitable for the contractors, and in one of the river piers, sufficient coal was taken from one of the excavations to feed the boilers furnishing steam for several river piers. Fig. 15 shows the pedestals at the bottom of the valley, also work proceeding on the west bank.

The large house in the centre of the picture was perhaps one of the first houses of any importance built in the North-west. It was built previous to the North-west Rebellion of 1885, and occupied by Mr. E. T. Galt, the first president of the North Western Coal and Navigation Co., which was later the Alberta Railway and Coal Co. This is the same house that is shown on Figs. 1 and 2.

Fig. 16 shows river piers for bent No. 52, with the grading of the west bank in progress.

Fig. 17 shows the excavation for foundations at piers No. 60. The necessity for the exceptional depth for these foundations was to get clear of some sliding ground indicated by cracks shown in the photograph.

Fig. 14 shows the river work in progress during the winter of 1907. A cofferdam is seen at the bottom of the picture, being pumped out. This is the excavation from which the coal was taken out. The next cofferdam above has been sheet piled, ready for pumping. Beyond this, two of the skeletons previously referred to are shown; one has been sunk into place, and the other is being sunk.

Fig. 18 shows the east bank at the Lethbridge end of the viaduct. The pedestals on the side hill are shown completed, and one row on the river bottom partly completed.

Fig. 21.—Cantilever Arm of Traveller. Note the erection cage suspended at the top of the tower.

The erection traveller has been so fully described in Mr. Monsarrat's paper, that nothing further can be said. Fig. 19, however, shows the traveller, which is also shown on Figs. 20 and 21.

This was certainly a very elaborate traveller, and so complete that the Canadian Bridge Company, who erected it, could have done nothing further to manufacture a machine for handling the steel, and provide safety for their men. The working of the traveller need not be explained, but can be seen from Figs. 19, 20 and 21.

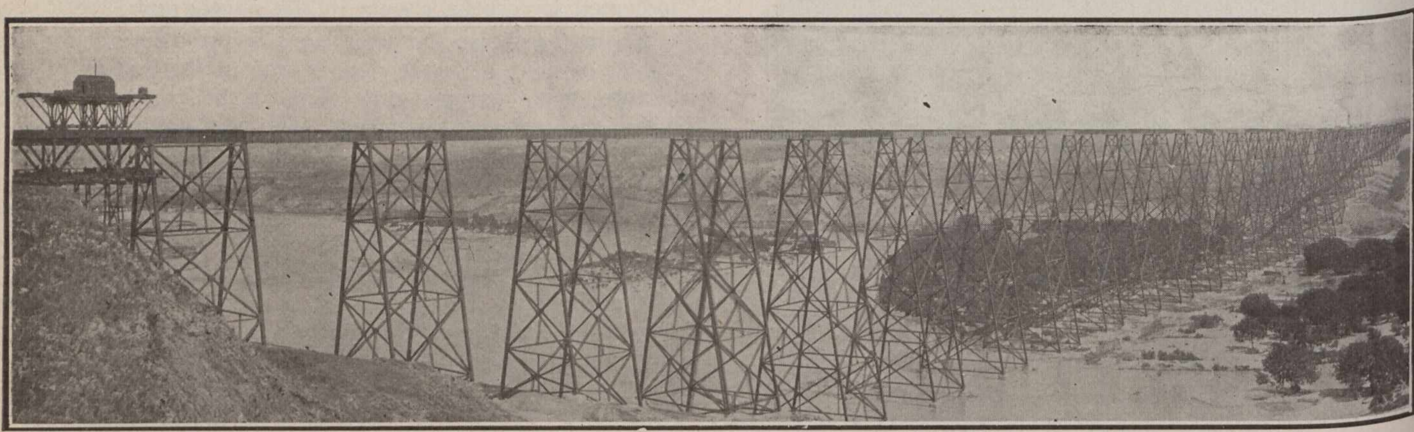
The whole work was carried out with very few accidents. One of the Canadian Bridge Company's workmen fell from the traveller, near bent No. 45 and, of course, was instantly killed, and two more men lost their lives by asphyxiation in a test hole that was sunk into the workings of an old coal mine on the east bank of the river.

The actual construction of the substructure started during September, 1907, and the bridge was opened for traffic on the 1st of November, 1909. Something like about 300 working days were required for the erection of the steel.

The bridge was designed by C. N. Monsarrat, Esq., M.Can.Soc.C.E., with Mr. C. C. Schneider, M.Can.Soc. C.E., consulting engineer. The work was handled from the office of the assistant chief engineer, Mr. J. E. Schwitzer, at Winnipeg, with Mr. F. St.C. Farran as engineer in charge of construction. The writer was assistant to Mr. Farran, and had immediate charge of the field work, in which he was ably assisted by Mr. A. T. MacDonald, now resident engineer of Bear River bridge, Dominion Atlantic Railway, and Mr. J. R. Middleton, resident engineer of Pitt River bridge, near Vancouver.

The contractors for the substructure were Messrs. John Gunn and Sons, of whom the writer cannot speak too highly in reference to the manner in which they carried out the work. This remark would apply to both the Canadian Bridge Company, who carried out the erection of the steel work, and the Raymond Concrete Pile Company, who drove the concrete piles.

Everything in connection with the work went along smoothly, and Fig. 20 shows the last girder being placed. The girder, of course, exactly reached the mark that had been set by the field party on the bridge seat of the west abutment, which was finished during the spring of 1908.



General View of Viaduct. The Riveting Traveller is seen over the Span between Bents 60 and 62.

PRODUCTION OF IRON IN CANADA IN 1913.

The iron ore shipments from Canadian mines during 1913 amounted to 307,634 short tons, valued at $629,843. These shipments included 92,386 tons of hematite and roasted siderite, 209,886 tons of magnetite and concentrates and 5,362 tons of titaniferous ore. The total ore shipments in 1912 were 215,883 short tons, valued at $523,315, and included 128,912 tons classed as magnetite and 86,971 as hematite.

Exports of iron ore from Canada during 1913 were recorded by the Customs Department as 126,124 tons, valued at $426,681. These were from Ontario, New Brunswick, Nova Scotia and Quebec. Imports, according to Customs records, in 1913 were 1,942,325 tons, valued at $3,877,824.

Shipments from the Wabana mines, Newfoundland, in 1913 by the two Canadian mines operating there were 1,605,920 short tons, of which 1,048,432 tons were shipped to Sydney and 557,488 tons to the United States and Europe.

The total production of pig iron in Canadian blast furnaces in 1913 was 1,128,967 tons of 2,000 pounds, valued at approximately $16,540,012 as compared with 1,014,587 tons, valued at $14,550,990, in 1912. Of the total production of 1913, 23,696 tons were made with charcoal as fuel and 1,105,271 tons with coke.

The classification of the production according to the purposes for which it was intended was as follows: Bessemer 265,685 tons, basic 614,845 tons, foundry and miscellaneous 248,437 tons. The amount of Canadian ore used during 1913 was 139,436 tons, imported ore 2,110,828 tons, mill cinder, etc., 33,583 tons.

The amount of coke used during the year was 1,417,148 tons, comprising 710,260 tons from Canadian coal and 706,888 tons of imported coke or coke made from imported coal. There were also used 2,206,191 bushels of charcoal. Limestone flux used amounted to 630,119 tons.

In connection with blast furnace operations there were employed 1,589 men and $1,149,345 were paid in wages.

The production of pig iron by provinces in 1912 and 1913 was as follows:—

	1912. Tons.	1912. Value. $	1912. Value per Ton. $	1913. Tons.	1913. Value $	1913. Value per Ton. $
Nova Scotia........	424.994	6 374,910	15 00	480,068	7,201.020	15 00
Ontario............	589 593	8 176.089	13 87	648.899	9,338,992	14 39

There was also a production in 1913 in electric furnaces of 8,075 tons of ferro alloys, valued at $493,018, compared with 7,834 tons, valued at $465,225, in 1912.

The exports of pig iron during the year are reported as 6,326 tons, valued at $351,646, an average of $55.58 per ton. Probably the greater part of this is ferro-phosphorous, produced at Buckingham, and ferro-silicon and ferro-manganese, produced at Welland.

There were imported during the year 253,843 tons of pig iron, valued at $3,234,877, charcoal pig iron 926 tons, valued at $12,528 and ferro-manganese, ferro-silicon, etc., 30,355 tons valued at $940,443.

ORGANIZATION AND METHODS OF STREET CLEANING DEPARTMENTS.*

By William H. Connell,
Chief, Bureau of Highways and Street Cleaning, Philadelphia.

(Continued from last issue.)

THE general methods of street cleaning in this country and abroad come under the following headings:—

1. Cleaning by gangs, consisting of 10 or 12 men equipped with hand brooms and the necessary appliances to clean the streets from curb to curb.

2. The blockman or patrol system in which each man is equipped with a bag or can carrier, a supply of cans or bags, broom, hand scraper or pan, sprinkler can, fire plug wrench, etc.

3. Cleaning with rotary machine brooms.

4. Flushing with squeegees which carry a tank through which water is sprinkled on the pavement and by the use of a rubber broom scraper cleanses the street.

5. Flushing with pressure flushers through which the water strikes the pavement under a pressure of 30 to 40 lbs.

6. Flushing with hose with the necessary pressure to thoroughly cleanse the pavements.

Methods of Cleaning.—In some of the larger cities in this country the method of doing this work during the past year was as follows:—

In New York the street cleaning force in the Borough of Manhattan, Bronx and Brooklyn, consisted of approximately 500 officers and 7,300 men. Each Borough was divided into districts supervised by a district superintendent and these districts sub-divided into sections supervised by section foremen. Manhattan had 13 districts and 60 sections; the Bronx 2 districts and 8 sections; Brooklyn 8 districts and 40 sections. The district superintendent covered his district in a buggy, and the section foremen used bicycles. Each district had a stable which was also the headquarters of the district superintendent, and each section had a section station, which was the office of the foreman, and where the equipment of the sweepers was stored. At 6.30 a.m. each day the sweepers, averaging about 2,875, assembled at the various section stations for roll call. They were uniformed in white suits and wore helmets in the summer time and caps in the winter. After roll call each sweeper, equipped with a can carrier and cans for the deposit of the sweepings, a scraper, broom and shovel proceeded to his designated route and covered the territory assigned to him. These routes varied in area from 5,384 square yards on the average in Manhattan, to 12,916 in Brooklyn. The sweeper first picked up the litter, then cleaned the gutters, and then swept from the centre of the street to the gutter. All the material gathered was placed in the cans, which were put on the sidewalk at the curb to await the arrival of the ash cart for their removal. In the purely business districts, as well as in the congested tenement districts, the work was done at night by cleaning gangs instead of blockmen. The method of machine broom cleaning, preceded by a sprinkling cart, was used as was also flushing by squeegees, pressure flushing machines and hose.

*Lecture delivered by Mr. William H. Connell before the Graduate Students in Highway Engineering at Columbia University on January 15th, 1914.

In New York City the ashes are collected daily except Sunday, one-horse metal carts with a capacity of 1½ cubic yards being used for the purpose.

Rubbish is called for when a sign is displayed in a window or other prominent place notifying the collector that rubbish is on the premises. The wagons used for this purpose are wooden carts with a capacity of 7½ cubic yards.

The department does not collect any trade waste or ashes from either office buildings or factories.

In the Borough of Manhattan the material is dumped on scows and transported to the low-lands where it is used for filling purposes. In the Borough of the Bronx, some of the material is dumped on scows and transported to the low-lands and in other cases it is hauled directly to meadows and vacant lots. In Brooklyn the material is transported by scows and also hauled by railroad to the low-lands and used for fill.

When the material is dumped on the scows it is heaped up and for transportation purposes it is necessary to trim the load so it will ride properly. During this trimming it is possible to reclaim a lot of saleable material such as paper, bottles, rubber, leather and miscellaneous junk. So valuable is this part of the work that the department sells the privilege and the contractor to whom the work is let furnishes all the labor free, and in addition pays an amount of money which brings the payment in labor and money up to approximately $300,000 per annum, according to E. H. Very, sanitary engineer, formerly of the New York Street Cleaning Department.

The garbage is collected daily except Sunday, one-horse metal carts of 1½ cubic yards capacity being used. It is loaded on scows and transported to a reduction plant at Barren Island, where it is put through the usual process of this method for the purpose of extracting the marketable products, such as grease, which is used for the manufacture of glycerine, cold creams, etc., and the tankage which is used for the filler in fertilizer.

Snow Removal.—In New York City snow is removed more extensively than in any other city in this country or probably in the world. The snow is hauled to the river front, vacant lots, etc., and the removal is paid for on the cubic yard basis.

All collections and street cleaning work in New York City are by municipal labor, the only contracts being those for the final disposal of rubbish, ashes and garbage.

City of Washington.—Street cleaning in the City of Washington is under the Street Department and is done by municipal labor. Only the blockmen are in uniform, wearing white suits and white canvas hats. The work is subdivided as follows:—

1. Hand patrol.
2. Machine broom cleaning.
3. Squeegeeing.
4. Flushing.
5. Alley cleaning.
6. Suburban cleaning.

The hand patrol or blockmen area covers approximately 2,750,000 square yards or 55% of the area of the city, and includes the entire business section, the downtown residential section and a great deal of the better class of residential suburbs. The entire area is cleaned daily by blockmen, and 219 men are employed for this purpose. In addition, a large portion of it is either squeegeed or flushed about twice each week. This area is divided into six sections, each section having a foreman, 2 or 3 wagons, and from 19 to 49 men, the areas ranging from 398,000 to 523,000 square yards. Each foreman is given absolute control over the forces under him and is directly responsible to the superintendent for the condition of the streets in his section.

The equipment used in hand patrol work consists of hand machines, bag carriers, burlap sacks, push brooms, hand scrapers, sprinkling cans and shovels. The dirt collected is placed in sacks and left at convenient points to be collected by special wagons and taken to the dump in sacks, these being returned by the drivers. Sacks are used in preference to cans because of the weight, bulk and noisiness of the latter.

After all the hard material has been removed from the streets by the blockmen, a hand machine broom is used, which picks up all the fine dust and loose droppings. In other words, the machine broom is used to polish the street and if properly used does away with the necessity for using horse-drawn machine brooms.

Machine Broom Cleaning.—The area swept with machine brooms consists of 2,220,000 square yards, or 45% of the paved area of the city, being almost entirely residential and each street being swept every other day. The force employed consists of 4 gangs, each composed of 1 sprinkler, 3 machines, 4 carts, and from 4 to 7 broomers, depending upon the conditions in the particular sections.

Streets are always swept from the centre toward the curb, the machines following one another and overlapping slightly. If the street is too broad to be swept solid in one operation, the machines turn in rotation, each taking a block, as may be required.

Squeegee Cleaning.—The area included in squeegee cleaning comprises a large portion of the smoothly paved streets in the white wing or patrol sections, amounting to about 1,786,000 square yards or 64% of the total white wing area. At the present time the method of operation is 1 sprinkler, followed by 3 machines. The sprinkler precedes the squeegees some slight distance, which allows the baked dirt to be softened by absorption, the sprinkler throwing as much water as possible without flooding the pavement. The squeegees brush the dirt to the curb, after which it is swept into piles by the white wings and hauled away.

Street Flushing.—Flushing machines are used on poorly paved streets and block pavements in the white wing area, each street being flushed about twice weekly by a high-pressure flushing machine.

Alley Cleaning.—The majority of the alleys in Washington are wide enough to be cleaned by a one-horse street sweeping machine, cleaning a 5-foot swath. Alleys are cleaned about once each week. Alleys too narrow to permit of the use of machine brooms are cleaned by hand gangs, usually consisting of a foreman and 6 men. These alleys are cleaned once per week and at stated periods are flushed with a hose.

Suburban Cleaning.—The cleaning of the suburban streets consists in keeping the gutters clear, removing all trash, loose stones and leaves.

Collection and Disposal of Ashes, Rubbish and Garbage.—The collection and disposal of ashes, rubbish and garbage in the City of Washington is done by contract. The ashes are collected semi-weekly between November 1st and April 15th, and weekly during the rest of the year, within the thickly populated districts; the remainder of the city receives weekly collections from residences, boarding houses, apartment houses containing not more than 4 families, etc. Two-horse wooden wagons of about 4 cubic yards capacity, with canvas covers, are provided for this purpose. All ashes are hauled to the authorized dumps, mostly low-lands.

Waste is collected weekly throughout the city. Single horse wagons with latticed sides, holding about 7½ cubic yards, are used for the collections. The waste is hauled to the reclamation station maintained by the contractor, where the saleable products are sorted and the balance incinerated. The paper is sorted and baled; bottles separated and crated; the other materials reclaimed are leather, rubber, tin cans and metal scraps.

Garbage is collected daily except Sundays between May 15th and October 16th, in all sections of the city within the thickly populated districts. Between October 15th and May 15th, the garbage is collected but three times a week. Outside the thickly populated sections, collections are made three times each week, both winter and summer. Hotels, hospitals, market houses, etc., are given daily service, including Sundays, throughout the year. The wagons used are one-horse metal-bodied wagons, water-tight, and with a capacity of approximately 1½ cubic yards. Garbage is disposed of by the reduction method.

Philadelphia.—Street cleaning in the City of Philadelphia is done under annual contracts, the city being divided into 8 districts and the work in under the supervision of the district engineers of the Highway Bureau and their corps of inspectors.

The specifications provide for the removal of ashes, waste and rubbish at least once each week from all buildings, and for the cleaning of all streets 6 ft. 6 in. in width or over, either by machine brooms, squeegees or flushers, in accordance with the schedule. All equipment to be operated in accordance with a schedule which specifies the streets in the order in which they are to be cleaned with the various types of equipment. Squeegee machines, high-pressure flushing machines and sprinklers are not used when the temperature conditions are such as to make their use undesirable, due to causing slippery streets in freezing weather. During the winter when this work cannot be done, additional machine brooms and gangmen must be provided to clean the streets with the frequency called for.

The total amount of yardage cleaned every day is 1,354,364 yds.; cleaned every two days, 9,898,918 yds.; cleaned every three days, 5,380,711 yds.; and cleaned once per week, 425,552 yds.; which makes an average cleaned per day of 8,134,987 yds. The total yardage of streets to be cleaned in this manner is 17,059,545. In addition to this the specifications provide for the cleaning of all alleys from one to six times per week, depending upon the necessity. There are approximately 12,000 alleys in the city under 6 ft. 6 in. in width.

The specifications also stipulate that the contractor must furnish a certain number of blockmen for each district, fully equipped with the necessary bags and bag carriers, scrapers, brooms, sprinklers, etc. The number of blockmen ranges from 57 to 140 per district. A certain number of hand machine brooms, squeegees, and flushers are also specified for each street cleaning district.

All blockmen and gangmen wear white uniforms with white helmet in the summer months and white caps in the winter months. All drivers and helpers wear khaki uniforms with khaki canvas hats in the summer and caps in the winter. Superintendents and foremen wear dark gray uniforms and caps. Inlet gangs are uniformed in khaki with hats in the summer and caps in the winter.

The following is a description of the methods of handling this work, which is divided as follows:—

1. Hand patrol.
2. Machine broom cleaning.
3. Squeegeeing.
4. Flushing.
5. Alley cleaning.

Hand Patrol.—The blockmen are assigned to sections designated by the chief of the Bureau of Highways and Street Cleaning, the area to be covered depending upon the character and amount of traffic. The duties of the blockmen consist of patrolling these areas, gathering all paper or other refuse, and sweeping street dirt as fast as it accumulates and placing it in dust-proof bags or metal cans, after which these bags or cans are collected and loaded into special wagons and hauled to a collection station or dump.

The equipment used in the hand patrol work consists of hand machines, bag carriers, burlap sacks, push brooms, pan scrapers, sprinkling cans and shovels. The dirt collected is placed in sacks and left at convenient points to be collected by special wagons and taken to the dump in sacks, these being returned by the drivers. Sacks are used in preference to cans because of the weight, bulk and noisiness of the latter.

Machine Broom Cleaning.—All machine broom cleaning is done in batteries of two or three, preceded by sprinklers, the number of brooms in each battery depending upon the width and character of the streets to be cleaned, the average gang consisting of two machine brooms, one sprinkler, four to seven broomers, and a sufficient supply of carts or wagons to remove the sweepings, the number depending upon the haul to the dumps and the season of the year, together with the amount and character of traffic.

Squeegee Cleaning.—Squeegee cleaning is used on smooth pavements. The operation consists of batteries of two and three squeegee machines preceded by sprinklers to soften and loosen the material on the streets, the sprinklers using as much water as possible without flooding the pavement; the squeegees using just enough water to create a wash. The idea of sprinkling is to soften the surface and enable the squeegees to cleanse the streets of all slime as well as the coarser materials. The squeegees are followed by two men, who immediately sweep up the winddrows of dirt into piles, and a sufficient number of carts follow to remove the dirt from the streets.

Flushing.—Flushing machines are used only on the poorly paved streets and block pavements. The high-pressure flushing machines are usually operated singly, as most of the districts have but one flusher.

Alley Cleaning.—All alleys and streets whose width between curbs is too narrow to permit the use of machine brooms, are cleaned once each week with a hose. When such streets or alleys are required by schedule to be cleaned more than once a week, the additional cleaning is done by hand brooms.

All inlets on paved streets and alleys are cleaned as often as necessary to keep them at all times free from obstructions, this work being done by special inlet gangs consisting of three men and a sufficient number of carts.

Collection of Ashes.—The collection of ashes in the City of Philadelphia is done by contract, as is also the collection of rubbish and garbage.

Ashes from household fires are removed once each week from all buildings, two-horse wooden wagons of about 4 cu. yds. capacity being used for this purpose, and provided with canvas covers. All ashes are hauled to authorized dumps, mostly low-lands and streets requiring filling.

Waste is collected weekly throughout the entire city when a card is displayed in the window or some conspicuous place notifying the contractor that waste is on the premises. Two-horse wagons with latticed sides, holding 7½ cu. yds., are used for this purpose. The waste is hauled to dumps.

Collection of Garbage.—Collections are made daily, except Sunday, in all sections of the city, from residences. Garbage from retail groceries and fish dealers is collected daily in quantities not exceeding one bushel from each store or stand. Dead animals are also removed by the garbage contractor. The wagons used for the collection of garbage are one- and two-horse metal-bodied wagons, water-tight, and of a capacity of 1½ to 2½ cu. yds. The garbage is hauled to the plant of the contractor and disposed of by the reduction method.

Snow Removal.—The street cleaning specifications also provide, in case of snow, for the entire force of the contractor not engaged in the collection of ashes and rubbish, to be used in removing the snow, when and where directed. In order to remove the snow quickly from the central and business portion of the city, separate contracts are also entered into, in which removal of snow is paid for on the cubic yard basis and in most cases it is dumped into sewer manholes at convenient locations or in the rivers.

The following is a description of the equipment used in street cleaning work in Philadelphia:—

Hand Machine Broom.—A revolving broom encased in a sheet iron box, so constructed as to receive the materials swept up by the machine. The broom is approximately three feet in length.

Squeegee Machines.—These consist of a tank for water with a capacity of 500 gallons, a cleaning roller set obliquely, geared or chain-belted to the rear axle, having a steel axis and rubber spiral fins.

High-Pressure Flushing Machines.—A machine having a tank for water with a capacity of 500 to 700 gallons, with a gasoline pump by which the water is discharged from the nozzles, with a pressure of at least 35 pounds per square inch. The nozzles are elongated and so constructed that their direction may be readily changed and adjusted as required.

Machine Brooms.—Machine brooms consist of a roller set obliquely and geared or chain-belted to the rear axle, the roller having a wooden axis and split bamboo bristles, whose length when new shall not exceed fourteen inches from the axis. These machines are provided with dust and mud guards.

Sprinkling Machines.—Consist of a tank for water with a capacity of 500 to 700 gallons, with adjustable valves, the water being delivered by gravity pressure.

There are other appliances, such as mechanical pick-up sweepers, which, however, are not in general use. The methods of cleaning and the equipment in use today are more or less crude and capable of very great improvement, and there is ample opportunity for engineers to show their ingenuity and initiative in devising improvements over the present methods used in this country and abroad, as street cleaning is still in the experimental stage.

The following comparison closely approximates the cost of street cleaning, collection of ashes, rubbish and garbage in Philadelphia, New York and Chicago for the year 1912:—

	Area, sq. miles.	Area, sq. yds. pavements.	Population.	Total cost.	Cost per capita.
Philadelphia	.129.5	17,059,545	1,610,000	$1,812,310	$1,125
New York	...134.1	26,454,553	4,743,771	8,367,845	1,764
Chicago	....191.5	18,618,155	2,307,638	2,795,077	1,211

It is very important that street cleaning work should be effective, but it should be carried on efficiently and economically as well. We must not lose sight of the fact that this work, as well as any other branch of municipal work can be overdone as well as underdone. The methods, cost, and character of cleaning in the different cities vary so much at the present time that it would appear to be desirable to carry on a country-wide investigation, with a view to determining upon more or less standard methods and degrees of cleanliness for the different characters of streets and types of pavement. The cost, in each case, would always vary with the kind and amount of traffic and labor conditions in different localities, and in making comparisons these allowances should be made. This investigation should also go into the question of the collection and disposal of garbage, ashes and rubbish, taking into consideration the proper number of collections to insure carrying on the work not only in a sanitary but an efficient and economical manner.

The following schedules of collections in some of the municipalities indicate that there is considerable diversity of opinion at the present time as to the frequency with which collections should be made:—

	Ashes.	Rubbish.	Garbage.
New York	Daily	Daily	Daily
Philadelphia	Weekly	Weekly	Daily
Chicago	3 times per week		
Washington	Weekly and semi-weekly		
Boston	3 times per week		

A great many of the methods in our cities in connection with the disposal of ashes, garbage and refuse are both crude and unsanitary, and show the lack of scientific research in connection with these matters. The present status of street cleaning work, including the collection of ashes, garbage and rubbish throughout this country is not entirely due, as has often been stated, to the newness of the problem, but to the fact that the work has been more generally under the control of men who have not had any particular qualifications for the job, and have not been in office a sufficient length of time to familiarize themselves with the work, or carry on constructive studies with a view to improving conditions. If the work is put more generally under permanent engineering organizations, much greater advance will be made within the next twenty years than has been in the past twenty years. This was illustrated by the complete change in personnel, methods and character of work inaugurated in the New York Street Cleaning Department by Col. Waring, who might well be termed "the Father of Modern Street Cleaning Methods in this Country."

Sir William Willcocks, supervising engineer of the Assouan dam, has chosen Hugh L. Cooper, the engineer who constructed the Keokuk power dam across the Mississippi, as a consulting engineer for the Egyptian Government in the construction of a new hydro-electric dam across the Nile. Mr. Cooper has specialized in the direction of long dams of small heads; and this is the problem of the engineers who are seeking to control the waters of the Nile.

THE RELATION BETWEEN THE MELTING POINT AND THE VISCOSITY OF REFINED TARS.*

By Philip P. Sharples,
Chief Chemist, Barrett Manufacturing Company, Boston, Mass.

THE rough dependence of the viscosity of refined tars, as determined by any of the standard instruments and their melting point, has been long recognized. Many discrepancies have, however, been noted, and apparently little thought has been given to the relation between the two in making specifications.

Table I. shows a series of samples taken from refined tars made on a manufacturing scale from the same raw tars. The methods used in analysis are those described by S. R. Church in the Journal of Industrial and Engineering Chemistry, Vol. 3, No. 4, April, 1911, and Vol. 5, No. 3, March, 1913.

The melting point is the half-inch cube method in water, starting, however, at 40 deg. F. instead of 60 deg. F.

The Schutte penetrometer is, strictly speaking, not a penetrometer, but a modified melting point. An arbitrary melting point is assigned, and the time taken at the assumed melting point to force out under constant pressure a plug of the material cooled to 40 deg. F. is noted. The arbitrary melting point is so chosen on a 10 deg. F. scale that the number of seconds is as near as possible 100 deg.

The float test is the New York Testing Laboratory test. The plug was cooled to 41 deg. F. before floating. The Engler test is made under standard conditions with the exception that 100 c.c. were run off instead of 200 c.c. The reduction of the number of cubic centimeters with viscous materials allows more concordant results to be obtained and gives lower figures.

A comparison of the three melting points and the Schutte penetrometer figures show that they advance quite reguarly together. Other experiments have shown this same relation to hold true, provided the free carbon content is very nearly the same. Samples 7 and 8 may then be included in our further examination of the results without introducing undue error.

An examination of the float test shows an increasing interval between samples as we ascend in the series. Between 7 and 8 the interval is 20 sec., while between 10 and 11 the interval is 60 sec.

The results with the Engler viscosimeter show the same tendency much more accentuated. The interval between the samples 7 and 8 is 32 sec., while between samples 10 and 11 it is 96 sec. It is interesting to note that the ratio is the same as in the float test.

A more careful consideration of temperature in testing tar materials with viscosimeters would seem to be indicated. The tars are more sensitive to temperature changes than oils or asphalts, and not enough attention has been paid to viscosity changes with temperature.

The work in Table II. was undertaken to show that, although a specification was rather closely drawn for the Engler reading at 60 deg. C., it yet failed in its object in that it admitted all mixtures of tar H and tar D from 40 per cent. H to 80 per cent. H. Testing the same mixtures at 50 deg. C. shows that the same limit in the upper part of the table would confine the mixture to

*Presented before Section D of the American Association for the Advancement of Science at the Atlanta Meeting, December, 1913.

within 20 per cent., while at 40 deg. C. the same limit would confine it to within 15 per cent.

The table also illustrates again the rapid increase in the time interval as the temperature of the determination of the viscosity approaches the melting point. Thus under 60 deg. C. the space interval is 4.6 for the 50 per cent. H mixture, but this is increased to 25.6 for the 80 per cent. H mixture at 40 deg. C.

The examples that have been cited have been in series of tars of nearly uniform composition. An illustration of the effect of free carbon on the relation between the melting point and the viscosity is given in Table III. The effect of the free carbon is very marked. In the Schutte and float test the times are markedly increased. With the Engler the results are more irregular, but show a marked increase with the high carbon tar. From a physical standpoint, the increase of free carbon might be expected to have this effect. It impedes the flow of the material with increase of temperature, and in that way up to the point at which the free carbon tends to weaken the binding and lasting qualities of the tar would seem to be a desirable addition.

The inclusion of both the melting point and the viscosity in a physical examination of refined tars to be used as binders would seem to be warranted. The viscosity at 100 deg. C. compared with the melting point would give an indication of the behaviour of the tar with uniform distributors, and also an indication of its resistance to temperature changes when used on the road.

In conclusion, first, the viscosity of tars of the same composition varies with the melting point, but not in direct ratio; second, the viscosity of tars of the same melting point but of different carbon content increased with the carbon content.

TABLE I.

A Series of Samples of Refined Tar Made from Same Raw Tar.

Sample No.	Free Carbon.	Distillation. Total to 315 C.	Melting Point.	Schutte Penetrometer.	Viscosity, Engler. 100 c.c. at 100° C.	Float Test at 50 C.
5	12.1	21.8	....	29 sec. at 40° F.	94 sec.	34 sec.
7	12.0	19.2	....	108 " at 40° F.	127 "	38 "
8	14.0	16.4	....	114 " at 50° F.	159 "	58 "
9	14.4	14.9	86.9	85 " at 60° F.	208 "	75 "
10	17.2	12.7	99.7	90 " at 70° F.	335 "	110 "
11	18.2	10.4	108.7	88 " at 80° F.	431 "	170 "

TABLE II.

Comparison of Mixtures of Tar H and Tar D on Engler Viscosimeter. 100 c.c. at Three Temperatures.

Mixture.	Carbon, Est.	40° C.	50° C.	60° C.
40 per cent. H 60 per cent. D	4.4	75.7 sec.	54.6 sec.	41.0 sec.
50 per cent. H 50 per cent. D	5.0	88.1 "	57.6 "	45.6 "
60 per cent. H 40 per cent. D	5.6	97.3 "	62.5 "	47.0 "
70 per cent. H 30 per cent. D	6.2	110.5 "	66.3 "	48.7 "
80 per cent. H 20 per cent. D	6.8	136.1 "	83.3 "	56.0 "

TABLE III.

Refined Tars—Relation of Viscosity to Carbon Content.

Sample.	Free Carbon.	Melting Point.	Schutte Penetrometer at 80° F.	Engler, 100 c.c. at 212° F.	Float Test at 212° F.
1	1.4	110° F.	42.2 sec.	302 sec.	158 sec.
2	14.5	109° F.	80.1 "	298 "	192 "
3	39.6	112° F.	144.9 "	739 "	337 "

The prevention of corrosion of iron in acid waters with an electrolytic method is proposed by the United States Bureau of Mines, which has made experiments with iron submerged in sulphuric-acid solutions. The metal structure to be protected is to be made the cathode of the circuit; that is, current flows from the water to it. The current density and the actual current required for protection can be calculated from experimental data on the loss in weight of the metal when unprotected under the given conditions reproduced as near as possible. This loss in weight per hour per unit area, divided by the electrochemical equivalent (weight dissolved or deposited per ampere-hour) gives the current density to be employed. This multiplied by the actual area to be protected gives the actual current needed. For good protection, the anodes should be distributed so that the current may not return to the protected structure at one point only.

Interest is being shown at Washington in the great water power possibilities of the St. John River, running between the State of Maine and the Dominion of Canada. Oscar Fellows of Bangor, an official of the St. John River Commission, created by the United States Congress some years ago, but now defunct, told the International Joint Commission at Washington last December that the St. John River ranked close to the Niagara River for its power possibilities. The commission is consequently interested in the question whether or not the river may not be added to its jurisdiction. However, the Webster-Ashburton treaty of the 50's provided that no obstruction should be placed in the St. John River on either side. That prevents power development on the river. But it is expected that in due season Great Britain will be asked to negotiate a new treaty; since Maine and also New Brunswick would benefit from the power developed.

EUROPEAN TUNNELS.

The following is a list of the principal railway tunnels in Europe, compiled by the "Engineer," London:—

Long Tunnels in Europe.

Name	Country	Length miles	Length yds.	Summit level ft.	Opened for traffic
Simplon*	Switzerland-Italy	12	458	2,313	1906
St. Gothard	Switzerland-Italy	9	564	3,788	1882
Löschberg	Switzerland	9	55	4,077	1913
Mont Cenis	France-Italy	7	1,730	4,248	1871
Arlberg	Austria	6	404	4,300	1885
Ricken*	Switzerland	5	610	650	1910
Tauern	Austria	5	546	4,020	1909
Ronco	Italy	5	277	....	1888
Tenda*	Italy	5	56	3,260	1899
Karawanken	Austria	4	1,683	2,088	1906
Jungfrau*†	Switzerland	4	834	11,220	1912
Borgallo	Italy	4	700	....	1887
Severn	England-Wales	4	636	....	1886
Turchino*	Italy	4	10	....	1900
Wocheiner	Austria	3	1,647	1,761	1909
Albula*†	Switzerland	3	1,150	6,133	1903
Totley	England	3	950	....	1893
Peloritana*	Sicily	3	686	....	1885
Gravehals*	Norway	3	516	2,844	1909
Standedge	England	3	60	....	1850
Woodhead	England	3	13	....	1845
Bosruck*	Austria	2	1,693	2,405	1906
La Nertho	France	2	1,581	....	....
Kaiser Wilhelm	Germany	2	1,069	....	1879
Echarmeaux	France	2	1,020	....	1895
Blaisy	France	2	990	....	....
Sudbury	England	2	913	....	1903
Credo	France	2	800	....	....
Vizzavona*†	Corsica	2	778	2,971	1889
Disley	England	2	346	....	1902
Co. de St. Michel*†	France	2	292	....	1901
Bramhope	England	2	234	....	1849
Festiniog*	Wales	2	206	....	1879
Cowburn	England	2	182	....	1893
Meudon	France	2	134	....	1900
Giovi	Italy	2	45	1,890	....
Col des Loges*	Switzerland	2		3,200	....
Cremolina*	Italy	1	1,748	....	....
Cairasca*	Italy	1	1,520	....	1906
Hauenstein	Switzerland	1	1,210	....	....
Semmering	Austria	0	1,333	2,940	1850

Long European Tunnels now Being Constructed.

Name	Country	Length miles	Length yds.
Hauenstein Base	Switzerland	5	0
Somport*	France-Spain	4	1,512
Grenchenberg	Switzerland	4	0
Puymorens*	France-Spain	3	317
Mont d'Or	France-Switzerland	3	1,395

*Single line tunnel. †One metre gauge railway.

It is reported that no less than 40,000 h.p. will be available from the new power site reserve in Boulder Canon, 2 miles east of Las Vegas, Nev., which the Federal Government of the United States has approved.

The Madrid Ministry of Commerce has ordered plans drawn for a standard gauge railroad of double-track from the French frontier to Madrid. It is calculated to reduce the time occupied in travelling this distance from 13 hours to 7, and from Paris to Madrid from 27½ to 20 hours. It will also be the first European trunk railroad to be operated solely by electricity, and will be state-owned.

Plans for an automobile speedway at Chicago, to cost $750,000, and to rival the one at Indianapolis, have been announced; and a 500-acre tract 27 miles from Chicago, near Joliet, has been purchased. At the head of the syndicate, which purposes undertaking this construction, is J. H. Palmer of the J. H. Palmer Steel and Iron Company. A track will be built 2 miles in length and so banked at the turns as to permit a speed of 100 miles; and stands of reinforced concrete will be constructed, which will seat at least 100,000 people.

FUEL SUPPLY FOR THE NAVY OBTAINED FROM CANADIAN OIL SHALES.

In his report, after making a close study of the oil shale fields of Newfoundland and Eastern Canada, in which the Royal Commission appointed by the British Government is interested, Mr. Harold C. E. Spence, says:—"Having regard to the importance attaching to the obtaining of large supplies of oil fuel for the navy from sources under the British flag and the comparatively few localities where such sources exist, it is considered of great national importance to preserve for the Empire, such areas of oil shales as are found to contain sufficient volatile matter to prove workable on a commercial scale; and a powerful group of financiers have associated themselves together in London to provide the necessary capital to develop such fields as Sir Boverton Redwood, the technical adviser to the Commission, passes upon.

"The Admiralty have made permanent contracts with the oil shale companies of Scotland to an extent which has caused them to increase the capacity of their plants. These Scotch shales have been worked for 50 years and produce about 60,-000,000 gallons of oil per annum with valuable by-products of sulphate of ammonia, etc. The value of oil shales compared with oil wells, is on account of the assured permanency of the output, as on account of the deposits lying almost identically in the manner of coal deposits. The tonnage can be measured approximately and the contents gauged by a system of bore holes, whereas in oil wells there is no way of arriving at the permanency of the flow, some wells and fields becoming exhausted in a few months. In Newfoundland and other places in Eastern Canada, some billions of tons of payable oil shales are assured; and some hundreds of millions of tons are known to contain a far greater percentage of oil to the ton than the successful Scotch fields. There is, therefore, a reasonable hope of a very important industry being inaugurated in the extraction and the refining of oil and the by-products from these shales in the near future."

METHODS OF CHECKING THE ANEROID.

An aneroid barometer is the fastest and most easily portable device for determining elevations. But even during constant weather conditions, it is subjected to changes in pressure equivalent to 50 or 100 feet of elevation, the pressure becoming lowest in the afternoon. It is subject also to the more irregular changes caused by the passage of the cyclonic and anticyclonic pressure areas. (Econ. Geol., October, 1913.) These discrepancies are partly overcome by checking at intervals over points of known elevation, by having a second observer record the readings of another instrument kept fixed, and by keeping the instrument fixed occasionally for short periods of time and noting the rate of change of the readings. A much neater and more satisfactory method of correcting is to use the barograph or recording barometer. This is made in easily portable form and gives an accurate paper record of pressure changes. The instrument can be left at headquarters when a day's work is begun. By noting the times of all readings taken with the field barometer and comparing them with the barograph record for the time in question, the proper correction due to atmospheric changes can be obtained.

Messrs. Ross and Macdonald, architects, have moved their western office from 928 Union Bank Building, to 506 Tribune Building, Winnipeg.

The construction of tank cars, specially equipped for fire fighting, is a new departure on the part of the C.P.R. They are, in general, of the standard construction. They have been built to the designs of the company by the American Car Company; and the idea is to operate them in pairs. Apart from the end arrangement of the auxiliary equipment, they are of identical construction. Each car carries a tank of 8,438 imperial gallons, and on the end of each car there is a 20 by 10 inch duplex fire pump, using steam from the locomotive boiler. The corresponding end of the other car has a rack construction on which can be carried 6,000 feet of fire hose. The car is designed for weight capacity of 100,000 pounds, so standard 50-ton trucks are employed. These tank cars have done good service in the United States.

The Canadian Engineer

ESTABLISHED 1893.

ISSUED WEEKLY in the interests of
CIVIL, STRUCTURAL, RAILROAD, MINING, MECHANICAL, MUNICIPAL, HYDRAULIC, HIGHWAY AND CONSULTING ENGINEERS, SURVEYORS, WATERWORKS SUPERINTENDENTS AND ENGINEERING-CONTRACTORS.

PRESENT TERMS OF SUBSCRIPTION
Postpaid to any address in the Postal Union:

One Year	Six Months	Three Months
$3.00	$1.75	$1.00

ADVERTISING RATES ON REQUEST.

JAMES J. SALMOND—MANAGING DIRECTOR.
HYNDMAN IRWIN, B.A.Sc., EDITOR. A. E. JENNINGS, BUSINESS MANAGER.

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

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

Winnipeg Office: Room 1008, McArthur Building. 'Phone Main 2914. G. W. Goodall, Western Manager.

Address al communications to the Company and not to individuals.

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

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

SUBSCRIBERS PLEASE NOTE:

When changing your mailing instructions be sure to state fully *both* your old and your new address.

Published by the Monetary Times Printing Company of Canada, Limited, Toronto, Ontario.

Vol. 26. TORONTO, CANADA, MAR. 26, 1914. No. 13

CONTENTS OF THIS ISSUE.

THE CAUSE OF RAIL CORRUGATION.

The corrugation of rails has become a rather serious problem in the operation of electric traction. There is considerable doubt as to whether the rail of to-day is sufficiently hard and tough in quality for its work. Investigations organized by numerous associations in various countries have not discovered a solution of the trouble and opinions differ widely as to its cause. Whether modern methods of manufacture, involving as they do the use of large ingots, rapid rolling at high temperature, and consequent absence of homogeneity are not themselves to blame to a large extent for the trouble which the electric railway engineer experiences in the matter of rail corrugation is a question. Of course, experience may have some part to play and it is possible that the railway engineer, after many years of steam railway experience, fails to some extent to grasp the fact that conditions of electric traction differ widely from those which are obtained in ordinary railway work.

In a paper which he read recently before the Institution of Civil Engineers of Great Britain, Mr. S. P. W. Sellon gave it as his opinion that the steel rail now used was not hard enough or tough enough for its work. The use of wheels of small diameter was evidently severe on the rails, but the conditions of electric traction forbade alteration, and the alternative was to find the material which would not yield to the action of the wheels which served to cause corrugation. He expressed his belief that rails with a high percentage of carbon are essential and that they resist corrugating effects as well as ordinary wear.

In his description of the general character of corrugation, Mr. Sellon states that the crests which develop have the appearance of planished or cold-rolled steel and that they are relatively hard and refractory to acid, while the hollows were dull and showed lateral detrusion and pitting. He drew the conclusion that the crests were cold-rolled and the hollows consisted of surface which had been crushed due to the vertical loads imposed by the wheels oscillating about the elastic limit of the steel in compression. It was pointed out that at ordinary speed the usual pitch of the corrugations corresponded with a frequency of about 100 feet per second.

Investigation seemed to show that a comparatively small increase in the compressive strength of the steel would prevent the particular kind of wear which created corrugation in the rail. Mr. Sellon, therefore, suggested that steel with an ultimate strength of 50 or 60 tons per square inch should be used to successfully resist the destructive stresses, the steel at the same time to be devoid of a high degree of ductility. The British Standard prescribes an ultimate tensile strength of 40 tons per square inch, while the actual wear of rails is apparently somewhat in excess of this strength.

The minimum pressure required to produce surface crushing and flowing is apparently in need of early determination. Clauses in rail specifications governing mechanical qualities should obviously bear a direct relation to the stresses which the rail will be called upon to resist. They should be clearly defined to ascertain what portion of rail corrugation is due to abrasion caused by the slip and what to the relative movement between the areas of contact of the wheel-tread and the rail-table in producing a grinding effect. More knowledge on these subjects will assist in finding a rail material that will withstand the actions producing the above defect.

NEW GOVERNMENTAL DEFINITION OF "ENGINEER" IN BRITISH COLUMBIA.

The British Columbia members of the Canadian Society of Civil Engineers have recently shown considerable activity in endeavoring to get the status of the Engineer recognized by the Provincial Government, and, in view of much new legislation involving large engineering projects, several influential deputations of the members, headed by Mr. F. C. Gamble, Chief Engineer of the Department of Railways, and Mr. G. R. G. Conway, Chief Engineer of the British Columbia Electric Railway Company, Limited, the respective chairmen of the Victoria and Vancouver Branches, met the Premier, Sir Richard McBride and the Executive Council and laid before them very strongly the views of the Western members.

It was pointed out that in numerous Acts of Parliament the definition of an Engineer was extremely unsatisfactory. One example given was quoted from the "Ditches and Water Courses Act, 1907," where an Engineer is defined as follows:—

"Engineer means Civil Engineer, Provincial Land Surveyor, or such a person as any municipality may deem competent and appoint to carry out the provisions of this Act."

The effect of this definition in one instance in British Columbia was the temporary appointment by resolution of the Municipal Council of a small contractor to sign plans, and the deputation pointed out to the Ministers that there was nothing in the Act to prevent a Municipal Council from appointing a gardener, blacksmith or carpenter to carry out the duties of the Act as Engineer.

The deputation were accorded a very sympathetic hearing from the members of the Government, and many private members supported their proposals.

Subsequent to the interviews with the Government, a petition was sent to the Premier, signed by every leading Engineer in the Province, asking that the word "Engineer" should be defined in the new Water Act as follows:—

"Engineer means an Engineer of the Water District, who shall be a Civil Engineer who is a member of the Canadian Society of Civil Engineers, or a member of the Institutions of Civil Engineers of Great Britain or of Ireland, or a member of a Civil Engineering Society of equal rank in the British Empire or any foreign country."

This definition was accepted by the Minister of Lands, Hon. W. R. Ross, who, however, felt that while entirely recognizing the principle of the definition, and expressing himself in hearty accord with the objections of the members of the Canadian Society, that special circumstances might arise in which he might be hampered by too strict an observance of the definition. He, therefore, suggested the addition of the following words, which was mutually agreed upon, and now, together with the foregoing, forms part of the Water Act of 1914:—

"But the foregoing definition shall not limit the power of the Lieutenant-Governor-in-Council or the Minister to appoint to any position created under this Act, any person who is, in his opinion, competent to fill such position."

The Western members feel that they are to be congratulated upon the success of their efforts, and hope during the next session to have a similar definition incorporated in the Municipal Act, the Railway Act, and other Acts dealing with engineering undertakings.

LETTER TO THE EDITOR.

Jointing of Water and Gas Mains.

THE spigot and faucet, or the hub and spigot joint, is universally adopted for jointing water and gas mains, and the old method of caulking the joints with spun yarn and lead is still in use everywhere on the globe. The lead melting pot still holds the field.

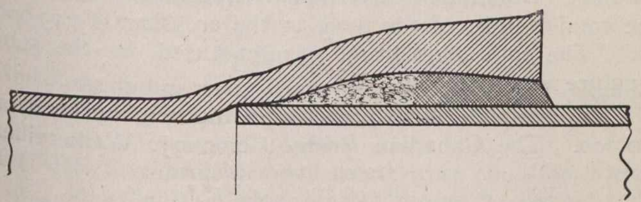
The reasons for sticking, the world over, to the old approved hub and spigot joint, are various: The easy method of laying; the standardization of fittings, etc., etc.; and last, but not least, the adaptability of the joint to absorb, to a sufficient extent, the contractions and expansions occurring in the mains. There can be little doubt that the hub and spigot joint is, so far, the best joint for municipal gas and waterworks, where the pressure does not exceed 200 lbs. per square inch, provided that the socket and spigot are made strong enough to allow the yarn and lead to be driven home in a proper way; and here lies the weak point about which many complaints are received.

In the case of cast iron pipes, the material is brittle and liable to breakages, i.e., the caulker must not try to strike the lead ring too hard, or else he runs the risk of breaking the socket. The caulking of cast iron pipes requires careful handling, and skilled labor, which is not always at hand in this country.

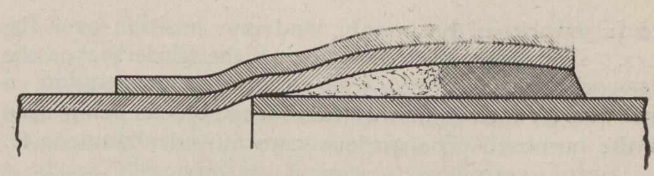
In the case of steel pipes, the socket is commonly formed by expanding the pipe end. It is quite patent that this is not a very satisfactory process, as the pipe wall is reduced in thickness when expanded, with the result that that part of the pipe which should be strongest, becomes weakest. Manufacturers have been trying to overcome this difficulty by doubling the end of the socket, or by having an iron band shrunk on to the socket end. However, this method of reinforcing has proved to be insufficient, as—especially in the case of the smaller sized pipes—the socket will vibrate during the caulking process; or is liable to deforming, or even splitting, thus causing unreliable or even leaky joints right from the start. Sockets of this kind have given very little satisfaction, and the many complaints have caused manufacturers of steel pipes to look for improvements in this direction.

One of the latest proposals is to weld the sockets by the oxy-acetylene process. This experiment, however, cannot be looked upon, seriously, as solving the problem. This idea, which provides for continuous mains, would do away with the principal reason for using hub and spigot joints; i.e., it would not allow of expansion and contraction; and, as iron or steel mains are liable to these movements, something would have to go, no matter how good the joints might be. Furthermore, the welding would be a very big item in the laying expenses, and requires an elaborate outfit, quite apart from the fact the welding of the joints will be very difficult in places. This experiment, therefore, can be discarded as being not practicable.

A strong and solid socket, which requires no delicate handling, and allows of driving home the yarn and lead in such a manner as to make sure of a tight and lasting joint, remains the only solution; i.e., the socket should be reinforced in such a way as to make vibration or deforming and splitting impossible; and the packing space must be of ample depth and sufficient width. The writer inspected, last year, pipes used by the British Columbia Electric Railway Company (Vancouver Gas Company), which were of a peculiar design. The smaller sizes had a socket reinforced as illustrated hereunder:—



On the larger sizes the sockets were reinforced by a shrunken-on ring, covering the whole length of the socket, and part of the pipe, as follows:—



These sockets looked assuringly strong and well designed, and the writer understands that the joints have given satisfactory results.

HYDRAULIC ENGINEER.

Montreal, March 21st, 1914.

C.N.O.R. BRIDGE OVER EAST STURGEON RIVER.

THE bridge across the East Sturgeon River, at mileage 250 from Ottawa, on the Ottawa-Capreol line of the Canadian Northern Ontario Railway, has just been completed. The accompanying drawings, showing the bridge in plan and elevation, together with the photographs, give some idea of its general design and methods of erection.

The deep and swift current which the river possesses at this point, together with the fact that it is subject to a rapid rise of several feet, rendered the construction of this crossing somewhat difficult. Accessory to these conditions the bridge is built at an angle of 60° with the centre line of flow of the stream.

Foundation work was rendered difficult owing to the presence of huge boulders and rock in deep water. In order to avoid, as far as possible, the necessity of constructing costly falsework for a truss, it was decided to use long deck plate girder spans. The crossing comprises four of them, two 130-ft. deck plate girder spans across the stream and one 80-ft. span of similar type at each end. After the contract had been awarded, however, the Canadian Bridge Company decided that it would be preferable to construct falsework over the stream, notwithstanding the fact that the contract had been awarded for the long spans with the expectation that only a small amount of falsework would be necessary.

The method of erection adopted was to unload the girders on blocking near the site and to completely rivet each pair before lowering them to the line of track. Two additional rails had been laid about 12 in. outside of the standard gauge rail, which gave a sufficiently wide and satisfactory base. Five bolsters of 14-in. x 14-in. timber, with steel shoe plates, were attached to the underside of the girders resting upon the rails, the latter being well lubricated. In this way a set of girders was moved through a distance of about 600 ft. over the approach

Fig. 1.—A 130-ft. Girder on Cars. Fig. 2.—Span (130 ft.) assembled.
Fig. 3.—Construction of Falsework. Fig. 4.—A 130-ft. Span being moved into position over piers.

and falsework in the stream, and into position over the piers. The power used for moving the girders over the falsework was obtained from a derrick car engine, a three-quarter-inch cable with two sheave blocks being used for the purpose. The girders were moved about 100 ft.

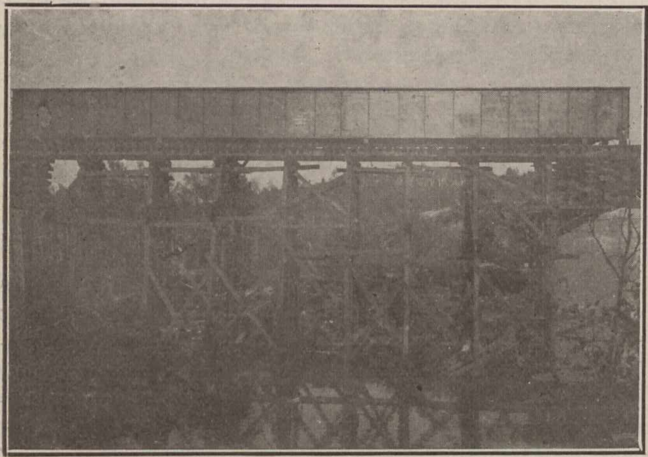


Fig. 5.—One of the 130-ft. Deck Plate Girder Spans Resting on Blocking on Piers, over Falsework.

without adjusting the blocking and cable, the whole operation of moving these over 600 ft. taking about one and one-half days. The high blocking over the piers, being at a height of about 35 ft. above water level, made the process of lowering the girders somewhat slow. To prevent any undue stress being brought on any of the parts of girders a harness was made of timber, which served the purpose quite well. One end was lowered 14 inches at a time, the lowering being accomplished by the use of four 40-ton jacks. The weight of each 130-ft. span is approximately 280,000 lbs. The 130-ft. girders are spaced 9 ft. centre to centre with ties 10 in. x 12 in. x 14 ft. The bridge is designed for Class "Heavy" Loading, Dominion Government Specifications, 1908. The total weight of the steel in the crossing is 745,000 lbs. The total amount of concrete used in the substructure was 1,725 cu. yds.

The complete structure cost in the neighborhood of $70,000. The Canadian Bridge Company, Walkerville,

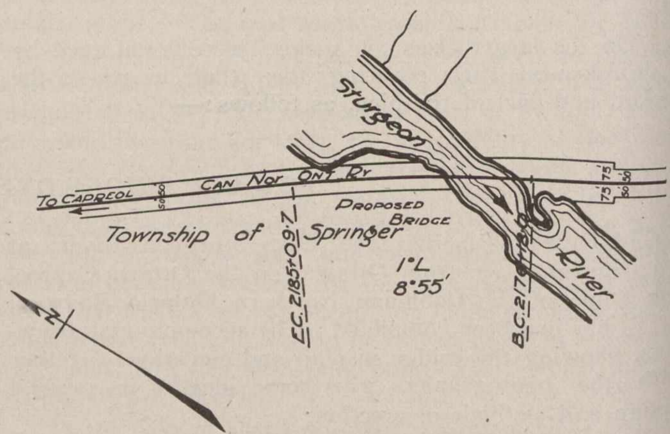
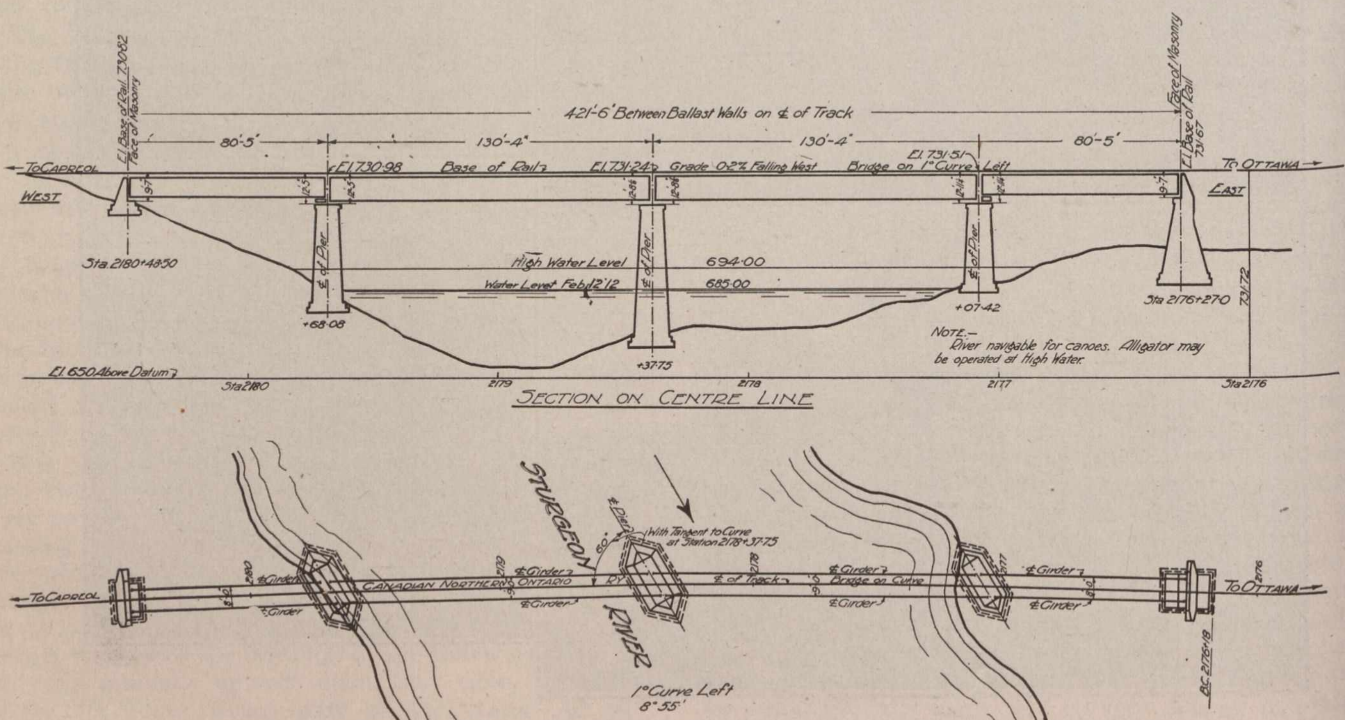


Fig. 7.—Showing Bridge Location.

was awarded the contract for the furnishing and erecting of the superstructure, which was delivered and erected without mishap, despite the difficulties which the site presented. The substructure was built by R. S. and J. H. Henderson, sub-contractors under The Angus Sinclair Company. Mr. J. C. Smith had charge of the erection for the Canadian Bridge Company. The work was carried out under the direction of A. F. Stewart, Chief Engineer, Canadian Northern Ontario Railway, and W. P. Chapman, Engineer of Bridges, Mackenzie, Mann & Company, Limited. We are indebted to the latter for the description of this work and the photos accompanying it.



Plan

Fig. 6.—Plan and Elevation of Sturgeon River Bridge.

HISTORY OF THE CONSTRUCTION OF BROKEN STONE ROADS.*

By R. L. Morrison,
Graduate Student in Highway Engineering, Columbia University, New York City.

THE first broken stone roads were built in France in 1764 by Pierre Marie Jerome Treseguet, who was then Chief Engineer of the District of Limonges. Previous to that time there were few improved roads in France. The Corps de Ponts et Chaussees had been organized in 1716, the year of Treseguet's birth, but most of the roads, according to a writer of the time, were in a "state of nature or worse." Where road improvement was attempted at all it was done by what was known as the Roman method. An excavation was made, forming a flat sub-grade, and on this was placed the foundation of the road, which consisted of two or more layers of large, flat stones. This foundation was eighteen feet wide and about ten inches deep, and was covered with a layer of small stones, which were spread and then beaten down and broken in place with hammers. The surface was finished with a thin layer of stones smaller than the underlying material and consolidated by traffic. The total thickness of the road was usually 18 to 20 inches at the centre and about 12 inches at the sides. While these roads, when completed, contained more or less broken stone, it was not an essential feature of their construction.

The large amount of material used made these roads very expensive to build, and, owing to the lack of proper maintenance, they were soon cut by deep ruts. All road work was done by means of the corvee, a system of compulsory labor, which was available only twice a year, so that when repairs were made, large quantities of stone were required.

In the District of Limonges the corvee was abolished in 1764, so cheaper methods of construction and maintenance became necessary, and this necessity was met by Treseguet with the broken stone road. His method of construction was a modification of the Roman method, and is described by the originator as follows: "The bottom of the foundation is to be made parallel to the surface of the road. The first bed on the foundation is to be placed on edge, and not on the flat, in the form of a rough pavement, and consolidated by beating with a large hammer, but it is unnecessary that the stones should be even, one with another. The second bed is to be likewise arranged by hand, layer by layer, and beaten and broken coarsely with a large hammer, so that the stones may wedge together and no empty space may remain. The last bed, three inches in thickness, is to be broken to about the size of a walnut, with a small hammer, on one side of a sort of anvil, and thrown upon the road with a shovel to form the curved surface. Great attention must be given to choose the hardest stone for the last bed, even if one is required to go to more distant quarries than those which furnish stone for the body of the road; the solidity of the road depending on this latter bed, one cannot be too scrupulous as to the quality of materials which are used for it."

Treseguet was also the first to propose a system of continuous maintenance, and fought with energy the old method of intermittent repairs.

In 1775 he was made Inspecteur General des Ponts et Chaussees. In the same year the corvee was abolished in all of France, and the following year Treseguet's method of construction was officially adopted.

England failed to profit by Treseguet's invention, and at the beginning of the nineteenth century the methods of road improvement and repair were similar to those discarded in France a generation before. In building a road a trench was dug and large masses of stone put into it. Over this foundation were spread thick layers of broken stone, and the surface was finished with an extremely high crown, approaching a semi-circle in form. This crown was composed of earth, rushes, stones and various other materials, and was covered over with a small quantity of gravel. As a result all traffic was forced to keep to the centre of the road, the sides being dangerous.

Deep ruts were formed, which retained water and mud, and the road soon became impassable. On account of robbers and the bad state of the roads wills were always made previous to undertaking a long journey by stage-coach.

The man whose skill as a road builder changed this deplorable state of affairs, and whose name has been generally applied all over the world, in the form of noun, adjective and verb in connection with broken stone road construction, was John Loudon McAdam, who was born at Ayr, Scotland, in 1756. Much of his youth was passed in the United States but he returned to Scotland in 1783 and became road trustee and manager of a district in Ayrshire.

Between the years 1798 and 1814 McAdam travelled about 30,000 miles over the roads of Great Britain making investigations, and during this time he originated the system of road-making now known by his name. In 1815 he was appointed surveyor of roads in Bristol, and there his system of construction and repairing reached its highest development.

This system was founded upon the theory, as stated by McAdam, that "The roads can never be rendered perfectly secure until the following principles be fully understood, admitted, and acted upon, namely, that it is the native soil which really supports the weight of traffic; that while it is preserved in a dry state, it will carry any weight without sinking, and that it does, in fact, carry the road, and the carriages also; that this native soil must previously be made quite dry, and a covering, impenetrable to rain, must then be placed over it, to preserve it in that dry state; that the thickness of a road should only be regulated by the quantity of material necessary to form such impervious covering, and never by any reference to its *own* power of carrying weight."

He severely condemned the use of large stones under any circumstances, in any part of the road, and said that every stone exceeding one inch in any dimension was mischievous.

Regarding the body of the road, the report of a special committee of parliament in 1823 says: "It appears that Mr. McAdam first directed the public attention to this important fact, that angular fragments of hard materials, sufficiently reduced in size, will coalesce or bind, without other mixture, into a compacted mass of stone nearly impenetrable to water, which, being laid almost flat, so as to allow of carriages passing freely upon all parts of the road, will wear evenly throughout, not exhibiting the appearance of ruts or of any other inequalities."

McAdam wrote several essays and reports on highways, and gave the following directions for road-building: "The first operation in making a road should be

*Presented before Section D of the American Association for the Advancement of Science at the Atlanta Meeting, Dec., 1913.

the reverse of digging a trench. The road should not be sunk below, but rather raised above, the ordinary level of the adjacent ground; care should at any rate be taken that there be sufficient fall to take off the water, so that it should always be some inches below the level of the ground upon which the road is intended to be placed; this must be done, either by making drains to lower ground, or if that be not practicable, from the nature of the country, then the soil upon which the road is proposed to be laid must be raised by addition, so as to be some inches above the level of the water.

"Having secured the soil from *under* water the road-maker is next to secure it from rain water, by a solid road, made of clean, dry stone, or flint, so selected, prepared, and laid, as to be perfectly impervious to water; and this cannot be effected unless the greatest care be taken, that no earth, clay, chalk, or other matter, that will hold or conduct water, be mixed with the broken stone; which must be so prepared and laid, as to unite by its own angles into a firm, compact, impenetrable body. Nothing is to be laid on the clean stone on pretence of *binding*."

As a rule the metal on McAdam's roads was 16 feet wide, with 6-foot shoulders of softer materials. The depth of the metal was from 7 to 10 inches, and the roads were usually built in three layers. The crown was 3 inches for a width of 18 feet.

The sizes of broken stone used he described as being of six ounces weight, and he always made his surveyors carry a pair of scales in their pockets to use in testing the sizes.

McAdam sometimes used gravel instead of broken stone, but it appears that this was done usually in cases where local conditions, including legal restrictions, made the use of broken stone impracticable. In his directions for road work, in 1811, he said: "Every road is to be made of broken stone," and in testimony before a committee of parliament in 1819 he said: "Now the principle of road-making I think the most valuable, is to put broken stone upon a road, which shall unite by its own angles, so as to form a solid, hard surface; and, therefore, it follows, that when that material is laid upon the road, it must remain in the situation in which it is placed without ever being moved again; and what I find fault with putting quantities of gravel on the road is, that before it becomes useful it must move its situation and be in constant motion.

"In digging the gravel near London, and places where there are vast quantities of loam, and that loam adhering to every particle of the gravel, however small, I should recommend to leave the very small or fine part of the gravel in the pits, and to make use of the larger part, which can be broken, for the double purpose of having the gravel laid on the road in an angular shape, and that the operation of breaking it is the most effectual operation for beating off the loam that adheres to the pieces of gravel."

It is obvious that this "gravel in angular shape" was really broken stone, and it is possible that in other cases where McAdam referred to gravel he meant broken gravel.

Where the substratum was unsound the usual custom was to cover it first with a layer of faggots and brush. On this was placed a layer of large, flat stones, then a layer of smaller stones, and finally eight or ten inches of broken stone. In such cases McAdam, however, used no faggots, large stones, or other special foundation, and he said that he would actually prefer a soft subgrade, or even a bog, for his ordinary roads. He claimed that a road on a hard foundation was quickly worn out, but that on the softest ground the foundation never sank.

Methods of repairing roads were carefully studied by McAdam, and he gives the following directions for this work:—

"No addition of materials is to be brought upon a road, unless in any part of it be found that there is not a quantity of clean stone equal to ten inches in thickness.

"The stone already in the road is to be loosened up and broken, so as no piece shall exceed six ounces in weight.

" . . . The stones when loosened in the road are to be gathered off by means of a strong, heavy rake, with teeth two and a half inches in length, to the side of the road, and there broken, and on no account are the stones to be broken on the road.

"When the great stones have been removed, and none left in the road exceeding six ounces, the road is to be put in shape and a rake employed to smooth the surface, which will at the same time bring to the surface the remaining stone, and will allow the dirt to go down.

"When the road is so prepared, the stone that has been broken by the side of the road is then to be carefully spread on it; this is rather a nice operation, and the future quality of the road will greatly depend on the manner in which it is prepared. The stone must not be laid on in shovels full, but scattered over the surface, one shovel full following another and spreading over a considerable space.

" . . . The object to be aimed at is to keep the natural soil dry, and this must be done both by defending it from ground water, and from that which falls from above. In the knowledge of the measures requisite to effect those objects consists the whole science of road-making."

McAdam turned his attention not only to methods of construction and maintenance, but to questions of road administration, legislation, and finance. He was engaged as general surveyor by many of the road trusts of England and Scotland, and his system proved so beneficial that he built up a world-wide reputation. In 1820 his work began to attract attention in France, and in 1830 his system was officially adopted in that country. He died in 1836.

It is very probable that McAdam was not actually the inventor of the method of construction he employed. The Westminster Review in 1825 states that this system had long been in use in Sweden, Switzerland and other countries, and in his testimony before the Parliamentary Committee in 1819 one John Cripps, Esq., said: "I had an opportunity of observing in Sweden that the roads were more beautiful than any I ever beheld; they are formed in the same manner as by Mr. McAdam, the materials broken extremely small. The material is the best in the world, as it is rocks of granite; and so well do they understand the necessity of breaking them small, that you never behold, throughout Sweden, a fragment of granite larger than the size of a walnut, for the purposes of the road. To the eye the roads appear perfectly flat; but upon trial by the spirit level there is a slight degree of convexity."

Another road builder, whose fame is exceeded only by that of his contemporary, McAdam, was Thomas Telford. He also was a Scotchman; he was born one year after McAdam and died two years earlier (1757-1834). He received the rudiments of an education in the parish school of Westerkirk, learned the trade of a mason, and later studied architecture in Edinburgh and London. It was as a bridge builder that he first became widely known. In 1787 he was appointed Surveyor of Public

Works in Shropshire, where he built many fine bridges and excellent roads. His greatest work was in the Highlands of Scotland, where he was sent by the Government in 1802 to report on the best means of developing the country. He recommended an extensive road system, and under his direction nearly a thousand miles of gravel road were built and more than a thousand bridges. This work extended over a period of eighteen years and cost 2¼ million dollars. Telford's specifications for these roads are given by Aitken, and they include minute details of parapet walls, drains, etc.

Apparently the first broken stone road built by Telford was that between Glasgow and Carlisle. This work was done in 1816, and involved extensive reconstruction of the old road. The distance was reduced from 102 miles to 93 miles, which necessitated the entire reconstruction of 69 miles of the road and the building of fifteen new bridges. The maximum gradient of the new road was 1 in 30. The cost, exclusive of bridges, was $5,000 a mile.

It was specified that "the breadth was to be 34 feet between the fences, 18 of which were to be metalled, and the remaining 8 feet on each side to be covered with gravel.

" . . . The metalling to consist of two beds or layers, viz., a bottom course of stones, each 7 inches in depth, to be carefully set by hand, with broadest end downwards, all cross-bonded or jointed, and no stone to be more than 3 inches wide on the top. These stones to be either good whinstone, limestone, or hard freestone; the vacuities between to be carefully filled with smaller stones packed by hand, so as to bring the whole to an even and firm surface.

"The top course or bed to be 7 inches in depth, to consist of properly broken stones, none to exceed 6 ounces in weight, and each to pass through a circular ring 2½ inches in diameter in their largest dimension. These to be of hard whinstone, the quality of both bottom and top metal to be determined by the inspector. In every 100 yards in length on each side of the road, upon an average, there was to be a small drain from the bed of the bottom layer to the outside ditch, as directed by the inspector. When the height of the embankments exceeded 3 feet, they were to stand from 1 to 3 months, in proportion as they increased in depth, as determined by the inspector. Over the upper bed, or course, of metal to be a binding of gravel of 1 inch in thickness upon an average; the cross-section of the finished roadway to have a curvature of 6 inches; in the middle 18 feet, and from that on each side a declivity at the rate of half an inch in a foot, to within 18 inches of the fences; the remaining space of 18 inches to have a curvature of 3 inches, making, in all, about 9 inches on each side below the finished roadway."

Cross-drains, nine to every mile, were to be placed under the road, and were to be 18 inches wide and from 16 to 22 inches high. The manner of contructing these drains was carefully specified.

The principal difference between Telford's form of construction and that of Treseguet was that Treseguet made his sub-grade parallel to the finished surface of the roadway, while Telford used a flat sub-grade. McAdam differed from both in omitting the large foundation stones.

On a portion of the Highgate Archway Road Telford used a 6-inch concrete foundation, composed of one part Roman cement to eight parts of washed gravel and sand. Transverse channels were cut in the surface four inches apart, and inclined toward the sides. These channels were for drainage, and also served to keep the broken stone in place on the concrete.

This road was a great success, and on another road a similar foundation of a 1 to 4 lime and gravel mixture was used. This was covered with 6 inches of broken stone, built in two layers. Wherever used this method was successful, and ten years after Telford's first experiment in 1828, Thomas Hughes wrote: "I am decidedly of opinion that this material, if generally adopted as a foundation for roads, will effect one of the greatest improvements that has for many years been presented to the notice of the public."

Most of the stone-breaking for the McAdam and Telford roads was done by women, old men, and boys.

Edgeworth wrote in 1817: "Attempts have been made some years ago to break limestone for roads by the force of horses, wind, and water. Stampers, shod with iron, and raised by proper millwork, were employed, and they were let to fall upon blocks of whinstones. These mills . . . crushed the stone to dust rather than to fragments if lighter stampers were employed, they frequently failed to break the stone. Feeding the mill was also found difficult and dangerous."

Successful experiments with a steam-driven roller crusher were made previous to 1844.

Quarrying was done with crowbars and picks until about 1840, when blasting began to be used.

The spirit level was first used on highway work in 1790, and the later roads were often carefully surveyed.

In 1817 Philip Clay invented "a harrow which is intended to scarify the uneven part of the road." Little improvement was made in scarifiers until comparatively recent years.

Road templets were in use in 1838.

The machine which has had the greatest influence upon methods of road construction is the roller. In 1619 one John Shotebolte wrote of using "land stearnes, scowrers, trundlers, and other strong and massy engines," but the first practical horse-roller was made in France in 1787. Thirty years later the roller was introduced into England, but it was not widely used in that country until 1843, when Sir John Burgoyne wrote a pamphlet on the subject of road-rolling.

The first steam roller was invented in France in 1859, and their use soon spread to other countries.

France has always been the leader in road-building, and the French method of construction, as described in 1843, contained most of the essential elements of the modern road. These roads were from 4 inches to 8 inches in thickness, and when over 4 or 5 inches thick were built in two layers. The road was thoroughly watered and rolled, first with an empty roller weighing 3 tons, then with the cylinder filled to weigh 6 tons, and finally with the roller loaded to a weight of about 10 tons.

The stone was broken to a maximum size of 2½ inches. The smallest *debris* of broken stone was saved and spread on top, with water, at intervals during the rolling.

English writers a generation later had few improvements to suggest, and gave the above as the best practice known, except for minor changes due to the introduction of the steam roller and the improvement of other road machinery.

In fact, an attempt to trace the history of further development of construction methods would be more properly classed as a discussion of modern practice.

No allusion has been made to American roads, because, during the period covered, the improved roads of this country were very much like the famous snakes of Ireland—noted for their absence. Two events may be mentioned, however, as being of special importance in the history of broken stone roads in the United States. They are the building of the first road of this type, the Lancaster Turnpike, in 1792, which for several years was simply a gravel road; and the granting of the first patent for a steam roller in 1873.

COST OF LOS ANGELES AQUEDUCT.

AN article dealing with the completion and operation of the Los Angeles aqueduct was published in *The Canadian Engineer* for January 9th, 1913.

Recently some interesting figures have been published in the last annual report of the aqueduct organization and appear below. It would appear that the undertaking has been completed none too soon as the report describes the rapid increase in territory served by the city plant and the difficulties which the municipalities taken in have had in supplying themselves.

The report gives all the items of the cost as follows:

The first issue of Aqueduct bonds, expended in preliminary surveys, purchase of lands in and above Owens Valley, water rights, rights of way, etc.	$ 1,500,000.00
The second issue, $23,000,000, expended in construction of aqueduct, minus $61,000 on hand and $700,000 of salvage	22,239,000,00
Aqueduct liabilities unpaid as hereinbefore set forth	490,000.00
	$24,229,000.00
Paid out of Water Revenue Fund as follows:	
One-half of Mr. Mulholland's salary during period of construction of aqueduct	$ 52,500.00
Purchase price of San Fernando Reservoir site	126,000.00
Cost of San Fernando dam to date	319,785.73
Interest on Aqueduct bonds paid by tax moneys, up to May 12, 1913	3,110,057.93
Making total cost of the aqueduct	$27,837,343.66

The original estimates, represented by the $24,500,000, have been exceeded some 3⅓ million dollars, including the payments of interest. Work not included in those original estimates includes about a million dollars spent in additional cover over the aqueduct, and the San Fernando reservoir work in the table, in all some $1,500,000.

TREATMENT OF TITANIFEROUS ORES.

Many deposits of titaniferous magnetite, some of them very large, have attracted considerable attention as possible sources of iron. With present furnace practice, however, reduction of ores carrying more than a small percentage of titanium is difficult and expensive, and consequently such ores are refused by the furnaces. In its endeavor to bring about the utilization of undeveloped mineral resources in the United States, the Bureau of Mines completed an investigation in relation to the treatment of titaniferous iron ores by magnetic concentration. The results of this investigation, which was conducted by J. T. Singewald, Jr., have been transmitted for publication in bulletin form.

An investigation of the possibility of utilizing titaniferous magnetites in the electric furnace for the direct manufacture of iron-titanium alloys, such as being used in making special grades of steel, is to be undertaken by the bureau.

MUNICIPAL ELECTRIC POWER STATIONS IN THE UNITED STATES.

Preliminary figures of the forthcoming report on the municipal central electric light and power stations of the United States have been given out by Director Harris of the Bureau of the Census, Department of Commerce Municipal stations are those operated under the ownership of municipalities or other local governments. They do not include electric plants that were idle or in course of construction.

As a rule, no cash income is derived by municipal stations for electrical energy used for lighting streets and public buildings, and in order that the income shown may approximate the total consumption and sale of electric current by these stations the schedule required that the income for service of this character should be estimated on the basis of what would have been charged for similar service by commercial companies in nearby localities. The number of persons employed may fall short of the total number actually engaged in work in connection with the operation of the electric stations, because the services of employees for the electrical work often are not required for long or continued service, and they are reported with that branch of municipal work with which they are chiefly employed.

The figures as presented for the United States show substantial gains for the decade 1902-1912. The number of stations increased from 815 in 1902 to 1,562 in 1912, or 92%; the total income for 1912 amounted to $23,218,989 as compared with $6,965,105 in 1902, or an increase of 233%; the total expenses for 1912 amounted to $16,917,165 as compared with $5,245,987 in 1902, or an increase of 222%. The total number of persons employed numbered 7,940 in 1912 as compared with 3,417 in 1902, or an increase of 132%; the total horse-power of the power plants was 559,328 in 1912 as compared with 160,028 in 1902, or an increase of 249%; the horse-power of the water wheels increased from 11,218 in 1902 to 130,261 in 1912, or 1,061%; the output of stations in 1912 was 537,526,730 kw. hours as compared with 195,904,439 in 1902, or an increase of 174%. The estimated number of arc lamps wired for service was 91,851 in 1912 as compared with 50,795 in 1902, or an increase of 81%; all other varieties of lamps wired for service, numbered 7,057,849 in 1912 as compared with 1,577,451 in 1902, or an increase of 347%; the horse-power capacity of the stationary motors served with electric current was 164,291 in 1912 as compared with 3,324 in 1902, or an increase of 4,843%.

There was an increase of 310 stations in 1912 as compared with 1907, accounted for as follows: New stations, 301; from commercial to municipal stations, 106; from municipal to commercial, 80; and 17 stations reported in 1907 that were out of business or not in operation in 1912.

A comparison of the C.P.R. tunnel at Roger's Pass fame through the Selkirk with other tunnels of world-wide fame is interesting. The greatest tunnel in the world is the Simplon Pass tunnel, which is 13 miles long. Then comes the St. Gothard and the Mont Cenis. The longest tunnel in the United States is the Hoosac, which is 4 miles long. The C.P.R. tunnel in the mountains will be the biggest thing on this continent and the most difficult accomplishment. The C.P.R. has one great advantage over any other system in respect of the operating of the trains through the tunnel. It will make its own power from the electric energy stored in the heart of the mountains.

ENGINEERS' LIBRARY

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer.

CONTENTS.

BOOK REVIEWS.

Village Electrical Installations.—By W. T. Wardale. Published by Whittaker and Company, London and New York. 80 pages and 12 illustrations; 5½ x 7½ in.; cloth. Price, 58 cents net.

This book is written in very simple, non-technical language, and would no doubt prove interesting and useful to the members of a village council who wished to get a general idea as to what might be done in the way of providing electric lighting in their district.

The author rightly insists on the services of an engineer being requisitioned before proceeding with any particular scheme. On the whole, the book would not be of much use in this country owing to the entirely different practices obtaining here in electrical work as compared with England. The illustrations are good and the information given is, so far as it goes, accurate.

The "Mechanical World" Pocket Diary and Year Book for 1914.—Published by Emmott and Company, Limited, 65 King Street, Manchester, Eng. Norman and Remington, 308 North Charles Street, Baltimore, U.S.A., American selling agents. Price, 25 cents.

It speaks well for the popularity of this book that it is now in its twenty-seventh year of publication. Although no doubt somewhat more useful in Great Britain than on this side of the Atlantic, it will be found a handy reference book even here, as it contains a great deal of useful and reliable information.

Apparently since last year arrangements have been made for its sale on this continent as indicated above, and its low price is greatly in its favor.

Each year this little work is kept up to date by the re-writing of some sections and the addition of much new matter.

For 1914 the section on Steam Turbines has been re-written; new sections added are those on Milling and Gear-cutting on the Milling Machine and on Grinding, while among other things tables of American Screw Threads have been inserted. The publishers invite suggestions, hints and corrections.

The "Mechanical World" Electrical Pocket Book for 1914.—By the same publishers. Price 25 cents.

This is a publication on exactly similar lines at the same price as the "Mechanical World" Pocket Diary. Like its older companion, it is revised and brought up to date each year, the new features in the present issue including sections on Telephones, the Electrical Equipment of Ships, Lifting Magnets, Dry Batteries, etc.

Practical Pattern Making.—Second edition.—By F. W. Barrows. Published by Norman W. Henley Publishing Company, 132 Nassau Street, New York. 331 pages; 5 tables; 160 illustrations; 5 x 7 in.; cloth. Price, $2.00.

That practical knowledge and sound common sense are possessed by the author of this book is evident all the way through. The style, for it has a style of its own, is chatty without being vapid, and a great deal of useful information is imparted without our being aware of it.

Youths learning their trade could peruse the book with much profit, especially if they would take to heart the little bits of worldly wisdom which are peppered over the pages here and there, as well as merely the items which deal with the avowed subject-matter of the book; older heads will not be likely, of course, to gain so much, but as there are generally more ways of killing a pig than by hanging it, even they may find described some other, and perhaps better, method of doing a certain piece of work than their own. Information is given on Materials and Tools used in Pattern-making, as well as how best to utilize and handle them.

Examples, many of them clearly illustrated, of various kinds of wood and metal patterns, together with gating, plate work and plaster work, are given. The book closes with a section on the cost, marking and recording of patterns; depreciation tables showing the value in any given year, with a certain assumed life, are here included.

The author is not without a sense of humor, which crops up every now and then, as, for instance, where he tells us that when there are only two boards to choose from it is sometimes a difficult matter to decide which to use, for, "sometimes, it must be confessed, it seems as though each one of the two was a little *poorer* than the other."

Electro Thermal Methods of Iron and Steel Production.—By J. B. C. Kershaw, F.I.C. Published by Constable and Company, London. 233 pages; 100 illustrations; 50 tables; 6 x 9 in.; cloth. Price, $2.25.

Reviewed by T. R. Loudon, of James, Loudon and Hertzberg.

In the preface of this book it is pointed out that there has been a long-felt desire for a practical work on electric furnace iron and steel production. The point of this statement, of course, lies in the exact definition of the word "practical." It is well recognized by iron and steel men that, unfortunately, a great deal of the published material relating to electric furnaces is hardly unbiased, and that the results given are not what one might call practical from a commercial standpoint. It was evidently the author's intention to publish merely the data that was authentic and of a practical nature. The author states that he is not connected in any way with any of the patentees of the furnaces described.

The first chapter is purely introductory. Chapter II. is devoted to general principles and methods. The principles as outlined are well stated, but are necessarily fragmentary owing to limited space. It is emphatically pointed out that the function of the electric current is purely to give heat.

This, of course, is well understood by those experienced in metallurgical work, but, unfortunately, is not always sufficiently emphasized, with the result that in many cases a misapprehension often arises as to the effect of the electric current on the resultant metal itself.

Chapter III. deals with smelting furnaces. A description of the early attempts at smelting is given, together with the reported cost data of the various experiments. This is followed by descriptions of the Grönwall furnaces in Sweden and the smelting operations at Shosta, California. These descriptions and results are mostly taken from published articles which are very familiar to anyone interested in this question. There are also descriptions of the Frick and Chaplet furnaces. The Heroult steel refining furnace is described in Chapter IV., various installations which are well known being discussed. In the same way, Chapters V. and VI. deal with the Girod and Stassano furnaces, respectively. It is unfortunate that the Kjellin and Röechling-Rodenhauser furnaces have been described in the same chapter. As is well known, the latter furnace is not a true induction furnace, while the Kjellin is a perfect example of the much-debated induction furnace.

In Chapters VIII. to X. various furnaces, such as the Keller, and a number of furnaces not very well known, are described. The author describes the Colby furnace among this latter group, using, by the way, the same old familiar cut as an illustration. This furnace might better have been placed with the Kjellin.

Power consumption and running costs are discussed in Chapter XI.

The book is well published, the paper being high grade and the illustrations clear. The material is very largely taken from well-known descriptions in the various technical journals. The book is a good catalogue of these articles.

Mechanical Laboratory Methods of Testing Machines and Instruments.—By Professor Julian C. Smallwood, Syracuse University, N.Y. Published by D. Van Nostrand Company, New York, N.Y. 333 pages; illustrated; 5 x 7½ in.; cloth. Price, $2.50 net.

The author of this book has produced a brief treatise on the mechanical laboratory methods of testing apparatus and machines, and he has entered a field in which there appears to be ample room for a well-written book. So far, outside of a few comparatively large books, there are very few concise and handy works. There is still room for a good book specially written for the use of practising engineers.

The present book has been very nicely gotten up, and is printed in good type. It is divided into three main parts, dealing, respectively, with the calibration of instruments, the analysis of fuels and the products of combustion and the testing of power plant units, with an appendix discussing the reports of tests and methods of conducting students' tests.

In the part dealing with the calibration of instruments, and which occupies over 130 pages, almost every possible measuring device used in mechanical engineering has been taken up. The instruments include scales, gauges, brakes, dynamometers, indicators, planimeters, meters, nozzles, etc., calorimeters and oil and belt testers. To explain the method of treatment the Pilot tube may be taken as an example. In dealing wih this there is, first, a brief discussion of the principles on which it works, then the method of finding by its aid the mean velocity and the location of the point of mean velocity in the pipe. Each instrument is dealt with similarly.

The section on combustion is brief, but deals fairly fully with questions relating to the action of fuels and the calculations relating to their use.

In the last part, on the testing of power plant units, each type of unit is taken separately, and the standard methods of testing and analyzing the results are fully described. Taking the steam engine as an illustration, the matters dealt with are: clearance, valve-setting efficiency and economy, and the machines examined in this way include also steam pumps, boilers, gas engines, air-compressors, fans, water and steam turbines, centrifugal pumps, etc.

The book will prove of help to all engineering students, and the information contained is of such a nature as to be suggestive to engineers who do a reasonable amount of testing.

The Mechanical Engineers' Reference Book.—By Henry Harison Suplee, B.Sc., M.E. Fourth edition, revised and enlarged. Published by Charles Griffin and Company, Limited, London, and by J. B. Lippincott Company, Philadelphia, Pa. 1914. Price, $5.00.

This book differs, in some ways, from ordinary engineering hand-books. It is practically a book of tables, formulas and methods, for engineers, students and draughtsmen. It is intended to be the legitimate successor of Nystrom's Mechanics, which was, in its day, a most useful and handy compendium of information on all subjects connected with engineering. Suplee's work is of convenient size, and has a table of contents and a detailed index. The first page of each of the principal sections, fifteen in all, are "thumb-cut," so as to be easily found and opened without special reference to the index.

In dealing with mathematics—the first of the larger sections—short cuts are given, and handy "kinks" for quickly getting results, without a repetition of "what we may" call "common knowledge." In handling the subject of mechanics, the consideration of the theory of the science is taken up and developed so that it leads to the statics of framed structures, and thus deals with roofs of buildings and with bridges. Dynamics is included in this section, and explanations of all the units, such as that of force, work, power, momentum, etc., etc., are given.

In the section known as Mechinical Engineering, a mass of constantly used matter has been compressed into small space. There is, first, the materials of engineering, tables of weights of pipes, bars, bolts, etc., specific gravity of various substances, facts about pipes, couplings, bolts, nuts, wire rope, followed by the hundred-and-one things which crop up in the engineer's daily life. The strength of materials deals with matters concerning tension, compression, bending, shearing, torsion, and the elements of structural material. Machine design takes up a most important subject to the mechanical engineer. Formulas are given and methods indicated by which the strength of so simple a tool as a wrench may be calculated and properly designed. Keys, keyways, journals, shafts, bearings, teeth of wheels, belts, rope-drives, and many kindred topics are treated in this practical and easily understood way.

The sections on heat, air, and water give facts which are necessary to be known. Fuel contains many useful tables of the calorific value of combustibles, solid and liquid. Steam follows, with useful tables and information of a thoroughly practical kind. There is a section devoted to steam boilers, and in it tables of various kinds are set down, and information is placed before the reader concerning evaporative power, cost of gaining evaporative efficiency, chimneys and their function and effects. An important feature is the code of rules for conducting boiler tests, together with the results of numerous trials. This section is followed by one on steam engineering, in which horse-power is fully explained and its use made plain. Methods of testing steam engines are detailed and valve cut-off, proportions of cylinders for compound engines. The rules, or code, for steam engine testing are quoted in full, and the interpretation of indicator cards, and heat analysis, has a place in this section. Steam pipe diameters and port areas are gone into in their various sizes and relationships. Main valves, link motions and condensers are also dealt with. Among locomotive data, formulas for resistances are given, including speed on grades and curves. The tractive power of locomotive and the powering of steamships are discussed. The steam turbine, with "trial figures," are given; also internal combustion motors, the gas engine diagram and rules for conducting gas and oil engine tests.

Under the head of electric power there are tables of various kinds, and some neat and very clear explanations of the equivalents and expressions of electric and mechanical data, and the many analogies between the flow of water and the "flow" of electricity. The National Electric Code, wiring formulas, electric standardization, electric driving, with data sheet on motor power and standard machine tools, are duly set down, together with remarks on electric cranes and motor tests.

The last section is devoted to cost of power. This gives data concerning water plant, costs of water power, steam power as shown by a series of exhaustive tests made with fuel burned directly under the boiler, and with the use of producer gas and with blast furnace heat. Cost of gas power and cost of electric power are indirectly compared. An appendix of forty pages is added in the latest edition of this book, here reviewed. It contains a variety of useful information on many engineering topics. This has been included in the index, and is thus part and parcel of the book. Altogether, the Mechanical Engineer's Reference Book is most fully, what it purports to be, a ready, useful and comprehensive collection of all kinds of data required, and most likely to be used, by a mechanical engineer in the practice of his profession.

The Theory of Heat Engines.—By Wm. Inchley, B.Sc., A.M.I.M.E., University College, Nottingham, Eng. Published by Longmans, Green and Company, London and New York; Canadian Selling Agents, Renouf Publishing Company, Montreal. 492 pages; 246 illustrations; size, 6 x 9 in. Price, $5.00.

This book is largely a treatise on the Thermodynamics of Heat Engines, although it also gives a few chapters on mechanics, in which it deals with balancing, governing, etc. Following the usual practice of most books along the same line, the author first gives the properties of the various working fluids, viz., gases, steam and other vapors, and then takes up the application of these fluids to the various engines, e.g., the steam engine, steam turbine, air-compressor, refrigerating machine, gas engine, etc. The work then takes up the practical testing of these machines and gives examples.

The first forty pages are devoted to the gases, and their application is given to air engines more for the sake of illustration, presumably, than for any practical value the latter engines have. Then follow 113 pages on steam and reciprocating steam engines, this whole important matter being fully dealt with in detail and various points illustrated by numerical examples. In this discussion, as well as elsewhere in the book, the author has freely used higher mathematics, and, indeed, it is difficult to see how one can develop any valuable solution of the heat engine problem without a working knowledge of the calculus.

Chapters dealing with refrigeration, the flow of steam in nozzles, etc., the theory of the steam turbine, of air-compressors and motors contain much useful and well-arranged material. The theory of gas and oil engines is fully treated, and a chapter is specially devoted to the variable specific heat theory. Some attempt has also been made to explain the methods of testing engines and boilers.

The last 100 pages, dealing with the mechanics of the engine, almost seem out of place, considering the general nature of the rest of the book, although objection cannot be made to them, because the information given is of value and belongs to the theory of heat engines. These chapters deal with valve gears, twisting moment diagrams, balancing and governors, and in parts of this, more especially the moment diagrams, the author has treated a subject analytically which essentially belongs to the province of the drafting board.

While the diagrams in the book are well drawn, probably some improvement would have resulted from a number of illustrations of actual machines. The general treatment is, however, excellent, but can only be read by men of good technical training.

PUBLICATIONS RECEIVED.

Winnipeg Electric Railway Company.—Annual report for the year ending December 31st, 1913, showing gross earnings of $4,078,694.75.

5,000 Facts About Canada.—1914 edition.—Compiled by Mr. Frank Yeigh and published by the Canadian Facts Publishing Company, Toronto.

Shawinigan Water and Power Company.—Annual report for 1913 showing gross revenue of $1,690,882.81, outlining extensions for plant, water conservation, development of Cedar Rapids, etc.

The Mineral Production of Canada, 1913.—A preliminary report, prepared by John McLeish, B.A., chief of the division of mineral resources and statistics, Mines Branch, Department of Mines, Ottawa.

Mineral Production of British Columbia, 1913.—Bulletin No. 1, 1914, of the British Columbia Bureau of Mines, a preliminary view and estimate compiled by Wm. Fleet Robertson, Provincial Mineralogist.

Brandon.—A 72 page booklet, descriptive of the city of Brandon, Man., outlining its possibilities as the railway and distributing centre, and containing many photographs of streets, buildings, industrial plants, etc.

Levels of Lake of the Woods.—Progress Report of the National Joint Commission on the question between Canada and the United States of the Levels of Lake of the Woods and its tributary waters and their future regulation and control.

Department of Public Works, Province of Ontario.—Annual report for the year ending October 31st, 1912, of the works under the control of the Public Works Department, comprising the reports of the deputy minister, architect, engineer, superintendent, accountant, etc.

Fuel-Briquetting Investigations.—Bulletin No. 58, United States Bureau of Mines, outlining fuel-briquetting investigations since 1904; commercial aspects of the process; necessary equipment; costs; characteristics of briquets; tests; details of experiments, etc. 278 pages; illustrated.

Mineral Production of Canada during 1912.—Annual report of the Mines Branch, Department of Mines, compiled by John McLeish, B.A. The report covers metallic ores, non-metallic products, structural materials and clay products, besides a general summary of the mineral production and explanatory notes.

Effect of Smoke on Building Materials.—Bulletin No. 6, of the smoke investigation carried out by the Mellon Institute of Industrial Research and School of Specific Industries, University of Pittsburg. It contains chapters on the chemistry of soot and the corrosive products of combustion; the effect of smoke on exterior and interior paint coatings, stone, metals, etc.

Currents in the Gulf of St. Lawrence.—By W. Bell Dawson, Superintendent Tidal and Current Surveys, Department of Naval Service, Ottawa. The report gives a description of the currents on the surface as a mariner may expect to find them in any locality; and an account of the general circulation of water in the gulf, together with the characteristics of its waters in regard to temperature, density, etc.

Report of the Minister of Lands, British Columbia.—The annual report for 1913 of the Minister of Lands of British Columbia contains the report of office statistics, of the Superintendent, of the pre-emption branch; of dry farming experimental work, and various other reports from government agents. The volume is well illustrated by maps and photographs, and comprises over 500 pages.

Investigations at James Bay during 1912.—Report to the Temiskaming and Northern Ontario Railway Commission by J. G. McMillan, supplemented by investigations during 1913. The report covers ice conditions and a character of channels in the Estuary of the Moose Jaw river; Reconnaissance of the south coast of James Bay; Navigation and Reconnaissance of the south coast of James Bay; Tides and Currents. The report also contains an account of Reconnaissance for the extension of the T. and N.O. Railway to James Bay by W. R. Maher.

The Mortar-making Qualities of Illinois Sands.—Bulletin No. 70, by C. C. Wiley, Department of Civil Engineering, University of Illinois, Urbana, Ill. Issued by the Engineering Instrument Station of that University. The bulletin discusses the effect of the characteristics of sand upon the quality of mortar. The results of a series of tests on thirty-two representative Illinois sands are given in tabular form and discussed. The classification of different sands is also proposed and specifications for each class are suggested.

Industrial Training and Technical Education.—Report of the Royal Commission. Part 1 forms the report of the Commission's opinions and recommendations. Part 2 covers such phrases of the study as elementary, secondary and higher education in relation to industrial training and technical education, manual training, household science, vocational education; industrial training and technical education in relation to national problems, needs, duties and rights of citizens, etc.; industrial research; education for rural communities. Part 3 contains the report of the Commission on inquiry in various countries, while Part 4 is devoted to details of the inquiry in the various Provinces of Canada.

CATALOGUES RECEIVED.

Small Direct Current Generators.—Bulletin A-4188, Canadian General Electric Company, Toronto, descriptive of type C. V. C. belted generator.

Steam Power Plants.—A 42-page illustrated catalogue describing some steam power plant installations. Issued by Lockwood, Greene and Company, Boston.

Small Motor Generator Sets.—Bulletin No. A-4190, descriptive of types M I C and M C C, Canadian General Electric Company, Toronto.

Chain Belt Power.—A handsomely illustrated 16-page catalogue descriptive of powers and equipment manufactured by the Chain Belt Company, Milwaukee, Wis.

Excavators.—A handsomely illustrated 16-page catalogue descriptive of the P. and H. Excavator. Issued by Pawling and Harnischfeger Company, Milwaukee, Wis.

Westinghouse Electric Fans.—Circular No. 165 of the Canadian Westinghouse Company, Limited, Hamilton, descriptive of the various types of fans offered for 1914.

Single-Phase Induction Motors.—Bulletin A-4185. Issued by the Canadian General Electric Company, being a general description of type K S motors and the field for their use.

Chicago Coal Drills.—Bulletin No. 150 of the Chicago Pneumatic Tool Company, illustrating and describing the Chicago Coal Drill for compressed air, electrical or hand-operation.

Electric Fans.— large 42-page illustrated catalogue of the Canadian General Electric Company containing descriptive information concerning style and rating, etc., of fans for various uses.

Mesta Improved Pickling Machines.—An 8-page illustrated catalogue descriptive of machine adapted for pickling metal objects of any shape. Issued by the Mesta Machine Company, Pittsburg.

Deferential Pump-Governor.—Ronald Trist and Company, Limited, London, E.C., have issued a cleverly gotten up catalogue on the "Thermo Feed" deferential pump-governor, its uses and working details.

Phenix Sight-Flow Indicator.—Bulletin No. 57 of the Richardson-Phenix Company, of Milwaukee, Wis., descriptive of device which may be inserted in water lines to indicate electrically any interruption of flow.

Wiring Devices.—Electrical supply catalogue of Factory Products, Limited, Toronto. 112 pages of details and prizes of sockets, receptacles, plugs, fuse-blocks, clusters, outlet boxes, fuses, switches, cut-outs, cabinets, wall-boxes, etc.

Aluminium Low-tension Insulated Cables.—A 14-page pamphlet, issued by the British Aluminium Company, Limited, Toronto office, 60 Front Street West, being a reprint of an article in the Electric Review based on economical considerations.

Aluminium in the Construction of a Chemical Plant.—A 16-page catalogue, issued by the Toronto office of the British Aluminium Company, Limited, outlining economic possibilities offered by aluminium in its application to the plant and accessories of the chemical industry.

Cut-Off Valves.—The Lagonda Automatic Cut-Off Valves are described in the latest catalogue of the Lagonda Manufacturing Company, Springfield, Ohio. The catalogue also briefly describes water strainers, ball-bearing and thrust-bearing turbines for removal of scale, tube cutters and air or steam-driven cleaners.

Modern Methods of Heating, Ventilating, Sanitary and Electrical Design.—A 64 page pamphlet, published by the Canadian Domestic Engineering Company, Limited, Toronto, containing illustrations of installations and data descriptive of the engineering equipment in many recently constructed Canadian buildings.

Cranes.—Catalogue No. 26 of the Northern Engineering Works, Detroit, U.S.A., the Canadian branch of which is the Northern Crane Works, Walkerville, Ont. The catalogue illustrates electric and hand-power travelling cranes, electric and pneumatic hoists, bucket-handling and railway cranes. The catalogue is well illustrated and carefully condensed and occupies 64 pages.

Evershed's Electrical Instruments.—A 40-page catalogue descriptive of indicating and recording ammeters and voltmeters, switchboard and portable types; indicate and recording leakage instruments, capacity meters, pyrometers, speed indicators, testing sets, etc., as manufactured by Evershed and Vignoles, Limited, London, E.C., for whom R. H. Nichols, Dineen Building, Toronto, is Canadian selling agent.

Structural Steel and Iron.—The Manitoba Bridge and Iron Works, Limited, have issued a 216-page cloth-bound catalogue descriptive of beams, girders, lintels, trusses, columns, stand-pipes, ornamental iron, highway bridges, steel tanks and towers, contractors' supplies, etc. The catalogue is specially arranged for the practical use of architects, builders, contractors, etc., and contains tables and notes on the application of structural steel and iron in modern building construction.

Coast to Coast

Galt, Ont.—The Galt board of works has asked that $25,000 be placed to its credit to be expended in road improvements in 1914.

Toronto, Ont.—It is stated that by May the Timiskaming and Northern Ontario Railway's "Cobalt Special" will be composed of all steel equipment.

Victoria, B.C.—The engineering department of the city of Victoria has cut down its estimate on the local improvement work to be done in 1914 to about $425,000.

Newmarket, Ont.—Plenty of pure water is now being obtained from the 12 artesian wells supplying the town, and the flow amounts on an average to about 180,000 gallons per day.

Montreal, Que.—The Grand Trunk Pacific reports that work on the mountain section is proceeding day and night. There is a gap of some ninety miles to be filled up. This will be accomplished, it is believed, by the end of April.

Victoria, B.C.—The Victoria city council has approved the resolution forwarded to the mayor of Victoria by the mayor of Windsor, Ont., asking for the approval of the movement on foot to memorialize the Federal authorities to approve of the construction of a deep waterway from the Great Lakes to the Atlantic Ocean via the St. Lawrence River.

Calgary, Alta.—The first official train of the G.T.P. Calgary-Tofield branch has been pulled over the line from Mirror, the first divisional point west of Calgary. The road is pronounced to be in splendid running order, and a regular service will be inaugurated between Calgary and Edmonton as soon as spring opens.

Edmonton, Alta.—Last year the electric light department of Edmonton cleared a net profit of $100,000, or an approximate equivalent to 25 per cent. of the capital invested. As a consequence, the city council has a new light and power tariff; and a reduction will be made in light revenue of $32,000, in September change of $15,000, and in power revenue of $23,000.

Saanich, B.C.—The municipal council is taking action to restrain the Warren Construction Company from proceeding with work on the roads of the municipality. It is declared that the contract is invalid because the contemplated expenditure was beyond the municipal revenue for 1913, and that the city could not enter into the contract without a valid by-law for the provision of the money.

Vancouver, B.C.—It has been announced by J. G. Sullivan, chief engineer for the C.P.R., that approximately $20,000,000, exclusive of expenditure on terminals in Vancouver, will be spent in Western Canada in 1914. Of this amount, the larger portion will be required for the improvement work and double tracking proposed in British Columbia. However, new line to the extent of 600 miles is to be laid on the prairies; but the heaviest cost will be for the supply of rails and new ties.

Toronto, Ont.—The annual report for 1913 of the Hydro-Electric Commission was tabled in the Ontario House on March 16. A comparison was made showing the extent of the system at the end of 1913 and at the end of the previous year. The total annual expense for 1913 was given as $1,991,043, while for 1912 it was $1,377,168; the total revenue for 1913, $2,611,918, for 1912, $1,617,674; the net balance, or profits in excess of depreciation, in 1913, $390,395, and in 1912, $60,659; and the total plant value in 1913, $9,196,483, while in 1912 it was $6,349,711.

Port Moody, B.C.—Preparations are being made by the Imperial Oil Company for the establishment of storage tanks and a refining plant on the north shore of Burrard Inlet, near Port Moody; and construction work will be started at an early date. The C.P.R. is ballasting the spur line from Port Moody, which was built last year, so that the steel and cement for the tanks can be transported to the site. The Imperial Oil Company acquired some time ago a 100-acre tract for its Western British Columbia base, and three large tanks, a number of small reservoirs for storing the different kinds of oil and a big machine plant will be established. A wharf 750 feet long will be built for berthing the ocean-going steamships which will bring the crude oil from California to the company's new works. The big tanks will have a storage capacity of 150,000 barrels. It is expected that the plant will be in operation within three months from the time construction work is started.

Minnedosa, Man.—On March 10, a conference was held at Minnedosa between representatives of the three private power companies on the Little Saskatchewan River, the council of Minnedosa, the superintendent of the Dominion water power branch and the assistant cheif engineer of the Manitoba hydrographic survey, regarding the power situation on the Little Saskatchewan River. It was explained that the Manitoba hydrographic survey had made a complete reconnaissance investigation of the power possibilities on the Little Saskatchewan, and also of the possibilities for the control and conservation of the river in the interests of the present and prospective powers on the river. The general result of these investigations indicated that a comprehensive system of control could possibly be worked out by utilizing the various lakes in the upper waters of the Little Saskatchewan and within the Riding Mountain forest reserve. The Department of the Interior has for some time been considering the best means of working out such a comprehensive control system. but desired to have a full discussion in the matter with the various private interests involved before taking any definite action. After some discussion, a resolution was unanimously passed expressing the approbation of the town of Minnedosa and the three power companies on the river in the work already done by the Manitoba hydrographic survey, and urging that it be supplemented by such further investigations as would be necessary to enable a final definite policy of conservation.

Montreal, Que.—The report of the improvements effected by the Montreal Harbor Commission in 1913 shows the completion of the Harbor Commissioners' railway line to high level from Molson's Creek to Tarte pier; the completion of 2 permanent transit sheds; an advancement almost to completion of the work on the drydock site, providing a large basin for the new floating drydock Duke of Connaught, and a large area of made land for the shipyard; the completion to the length of 2,000 feet of new quay walls of cribwork and concrete, and the partial completion of 2,000 additional feet; the construction of 4 miles of new railway track as well as the improvement and relaying of one mile; and the advancement of the removal of the artificial works at Moffatt's Island. Further, construction of a large industrial wharf at Pointe-aux-Trembles, and of two new transit sheds on the high level bulkhead wharves sections 24 and 25, was also started; a new electric hoist, with bridges connecting with the upper stories of the sheds on the Alexandra pier was built; new paving was laid on portions of the wharves; a start was made in substituting concrete for the superstructure of some of the old wooden piers in the central portion of the harbor, and additions and improvements were made to the various harbor plants. Elevator No. 2 and its connecting conveyer system to all berths in the central part of the harbor was operated during the whole season; and elevator No. 1 also worked satisfactorily, though an addition of one and a half times its storage capacity was being installed.

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.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

A meeting of the Electrical Section of the Canadian Society of Civil Engineers was held in Montreal on March 19th. Mr. Julian C. Smith was the speaker, and his subject was the performance of electrical insulators. It was followed by a good, general discussion, in which many prominent engineers took part.

Ottawa Branch.—A paper on "Structural Steel Design from a Commercial Standpoint" was read on March 19th before a good attendance of the members of the Ottawa Branch, by Mr. E. S. Mattice, of the Dominion Bridge Company, Montreal, and Mr. W. F. Gronau, of the Structural Engineering Company, Montreal. Mr. Mattice dealt with the practical side of the subject, and Mr. Gronau dwelt upon the theoretical.

Toronto Branch.—This evening (March 26th) Mr. J. G. G. Kerry, of Kerry and Chace, Limited, Toronto, will address the Toronto Branch on "The Proposed Terminal of the T. and N.O. Railway System on James Bay."

Victoria Branch.—On March 12th a paper on "Modern Guns" was read to the members by Captain N. C. Sherman, of the Pacific Coast Ordnance Department, and created a great deal of interest.

At the next meeting of this Branch Mr. H. W. E. Canavan will give an illustrated paper on "Modern Irrigation in British Columbia." This meeting is scheduled for April 9th.

ANNUAL MEETING OF S.L.S. ASSOCIATION.

The Saskatchewan Land Surveyors held their annual meeting at Regina a few weeks ago. The following officers were elected for the ensuing year: President, A. C. Garner, D.L.S., S.L.S.; vice-president, W. A. Begg, D.L.S., S.L.S.; secretary-treasurer, H. G. Phillips, S.L.S.. Counsellors—Messrs. W. R. Reilley, D. Alpine Smith, W. M. Stewart, Saskatoon, and J. A. Morrier, Prince Albert. Auditors—Messrs. E. C. Brown, G.T.P., and O. F. Cummins, Regina.

A number of interesting addresses were given during the course of the convention. The general discussion emphasized the need for raising the standard of the work of the profession, and considerable time was devoted to an investigation of the ways and means of best accomplishing this end.

Last year the association obtained legislation giving them complete control of the examinations and discipline of the members. In securing this advanced legislation the members felt that they had made great strides in raising the standard of the association, but it was felt that even better discipline could be obtained and more efficient work accomplished.

Mr. A. T. Thompson, S.L.S., of Grenfell, contributed to the programme by reading a paper on his "Reminiscences of the Early Days in the North-West," with notes on the Indian Tribes, which described his own personal experiences in this country during the last 30 years, and which was well received. Mr. Thompson was asked if he would contribute to the biography of the members, and he consented to do so.

On Monday the president, Mr. A. C. Garner, D.L.S., S.L.S., spoke of the most important matters to be considered, and gave a general outline of the work of the association. The secretary then presented his report and financial statement, showing that the membership has materially increased since the last annual meeting, and that all the members were taking an active interest in the work of the organization.

A very interesting paper was read by Mr. R. H. Montgomery, S.L.S., of the firm of Morrier and Montgomery, of Prince Albert, on "Practical Astronomy," dealing particularly with "Equation of Time." The paper was well conceived, and dealt with some very technical matters.

Mr. Stewart, S.L.S., of the firm of Phillips, Stewart and Lee, of Saskatoon, read a paper on the "Design and Construction of Open Ditches," pointing out particularly the drainage work done in this province and the machinery most suitable or this particular kind of work, taking into consideration the conditions of the soil and the size of the ditches required to be constructed. After giving his paper he was asked to furnish particulars as to this kind of machinery. He promised to obtain information regarding a plan which he believed would in time lessen the cost of construction of ditches. It was pointed out that difficulties which heretofore prevented a great deal of drainage work in this province were being removed, and that in the very near future an enormous amount of drainage work would be accomplished.

It was decided to have these papers printed and distributed for the use of the members of the association; also a statement of the association generally covering the four years that it has been in existence, including all other papers that have been read by members on former occasions.

THE PANAMA CANAL.

Over 100 graduates of the Faculty of Applied Science and Engineering of the University of Toronto were present at a meeting of the Engineering Alumni Association on March 23rd, when David A. Molitor, C.E., gave an illustrated lecture on the Panama Canal. Mr. Molitor, previously professor of Civil Engineering at Cornell University, was designing engineer on locks and dams in the Canal engineering organization. He is thoroughly conversant with the history of the present and earlier projects, as well as with the engineering features of both design and construction. His lecture was accompanied by the exhibition of about 100 lantern views, showing details of concrete and steel construction of the Gatun Dam and spillway, the locks at Gatun, Pedro Miguel and Miraflores, the methods of excavation at Culebra Cut, etc. A description of the construction and operation of the emergency dams which have recently been installed, and which Mr. Molitor designed, created considerable interest.

At the conclusion of the address the members took advantage of a good opportunity to ask questions and an extra half hour was spent in discussion.

In the absence of Mr. E. W. Oliver, the chairman of the Association, the chair was occupied by Mr. T. H. Hogg.

About the middle of April the Association will hold another meeting, which will be addressed by J. L. Weller, C.E., of St. Catharines, on the design and construction of the New Welland Ship Canal, of which project he is chief engineer.

EDMONTON ENGINEERING SOCIETY.

The Edmonton Engineering Society, of which Mr. A. W. Haddow is Secretary-Treasurer, hold meetings, at which papers are read and discussed, on the second and fourth Thursdays of the month.

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.

AMERICAN PEAT SOCIETY.—Eighth Annual Meeting will be held in Duluth, Minn., on August 20, 21 and 22, 1914. Secretary-Treasurer, Julius Bordollo, 17 Battery Place, New York, N.Y.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9-13, 1914. J. E. Pennybacker, Secretary, Colorado Building, Washington, D.C.

PERSONALS.

VERNON C. LUCKNOW, consulting engineer, Victoria, B.C., is in Toronto this week in connection with the construction of the new Hudson Bay store building in the former city.

CHAS. CAMSELL, of the Geological Surveys Branch, Ottawa, recently addressed the Ottawa Field Naturalists' Club on the magnitude and navigability water-powers of the Mackenzie River.

FRED M. OSBORN, of Samuel Osborn and Co., Limited, Clyde Steel Works, Sheffield, England, has just completed a trip through Eastern Canada as the guest of A. E. Myles, manager of Heap and Partners, who are the Canadian representatives of Samuel Osborn and Company.

H. D. JOHNSON has joined the engineering staff of the Eugene F. Phillips Electrical Works, Limited, Montreal, as assistant contracting manager. Mr. Johnson, who is an authority on underground distribution systems, was previously with the Canadian British Insulated Company, Limited.

NELSON P. LEWIS, Chief Engineer, Board of Estimate and Apportionment, New York City, on March 9th delivered an illustrated lecture on "The Administration of Municipal Public Works" before the Graduate Students in Highway Engineering at Columbia University.

ERNEST BELANGER, of the firm of Marion and Marion, Montreal, has received an appointment from the Government of the French Republic. Mr. Belanger was a graduate of L'Ecole Polytechnic and a member of the Canadian Society of Civil Engineers, and of the Engineers' Club of Montreal. In his new position he will hold the title, "Officer of Public Instruction."

L. C. FRITCH, chief engineer of the Chicago Great-Western Railway, has been appointed assistant to the president of the Canadian Northern Railway. Mr. Fritch is a graduate of the University of Cincinnati, and entered railway service in 1884 on the Ohio and Mississippi Railway, of which he was later chief engineer. He was also with the Cincinnati and Deptford Railway as engineer in charge of construction, and division engineer of the Baltimore and Ohio South-Western. Later, he became assistant to the president of the Illinois Central.

Mr. Fritch will assume duties on April 1st. His headquarters will be in Toronto.

OBITUARY.

The death occurred last week of E. B. Temple, of Toronto, in his 77th year. Mr. Temple's career was largely devoted to engineering, and his work is well known to men of the profession throughout the Dominion. He took an active part in the construction of the Grand Trunk Railway between Montreal and Quebec, and upon its completion he joined the staff of the Canadian Pacific Railway at Toronto. A few years later he was placed in charge, by the Government, of harbor development and general waterfront construction work at Toronto, and it was under his direction that the walls and cribwork at the Eastern Gap were built.

Previous to his retirement from active work a year ago Mr. Temple was for 9 years harbor master at Port Arthur.

He was a member of the Canadian Society of Civil Engineers and of the Institution of Civil Engineers of Great Britain.

GEO. H. STREVEL, for many years a prominent Canadian railway contractor, died last week at Portage la Prairie at the age of 79 years.

BACK COPIES WANTED.

Copies of *The Canadian Engineer* for July 21st, 1910; November 3rd, 1910, and November 17th, 1910, are needed by a subscriber in order to complete a volume. Any reader who has one or more of these copies, and who will dispose of them, will confer a favor by communicating with the Editor.

ECONOMY IN HIGHWAY CONSTRUCTION.

Some interesting figures on the economical way of building highways are furnished by a prominent contractor, operating a system of portable railway in the highway construction work at Lockport, New York. They have about four miles of portable track, 40 cars, 36 x 24, and two 5-ton dinky locomotives. Most of this equipment is that of the Orenstein-Arthur Koppel Company of Pittsburg, Pa. The cars are hauled in trains of 12 cars each by one 5-ton dinky locomotive with an arrangement such that there is always one train of loaded cars on the way, one train of empties returning and one train of cars being loaded at the crusher.

The cost of operation is as follows:—

2 drivers' wages per day each $2.75	$ 5.50
2 brakemen (one for each train in transit) $1.75	3.50
Fuel and lubricating oil for two locomotives, and oil for all cars per day	8.00
2 brakemen for maintenance of track, one a foreman at $3 per day, and one at $1.75 per day, total	4.75
The above shows a total outlay for operation including a maintenance of track	$21.75

The amount of crushed stone carried in these cars is problematical, but the amount of stone actually in place spread and rolled and furnished with the equipment is 80 cu. yd. per day. The haul is three miles from quarry to road and, at the cost of $21.75 per day, equals 27 cents per cu. yd. for 3-mile haul—or 9 cents per cu. yd. mile.

The cost of laying portable track and grading up the shoulder of the road for this work will average between 2 and 3 cents per foot, this amount depending largely on the conditions of the road. If the road is of a clay substance, the cost will closely approximate the larger amount, but if the road is of a dry and sandy soil, the cost of laying the track, including grading, is not likely to exceed 2 cents per foot.

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.

21474—March 10—Authorizing Cedars Rapids Manufacturing and Power Company to take additional 25 feet for right of way for transmission line, making in all a width of 125 feet, in parishes of St. Polycarpe and St. Ignace du Coteau du Lac.

21475—March 12—Directing that yard limit at Algonquin Park Station, Ont., be discontinued within 60 days from date of this Order. That if G.T.R. desire to discontinue use of locomotive whistle at station, it shall, within 20 days from date of this Order, file plans for approval of Board, showing a signal system to be established at Algonquin Park Station, and instructions as to operating same; such signal system to be operated either electrically or manually.

21476—March 11—Authorizing G.T.R. to use and operate bridge over viaduct, near Port Hope Station, Ontario.

21477—March 13—Authorizing C.P.R. to construct Lacombe-Easterly Branch of Calgary and Edmonton Ry. across highway on East Boundary of S.E. ¼ of Sec. 24-33-28, W. 3 M., Sask., at mileage 188.26.

21478—March 12—Authorizing G.T.R. to construct siding into the premises of Canadian Clarendon Marble Co., Limited, on Lot 879-80; town of St. Johns, Que.

21479—March 13—Authorizing, subject to terms of consent of Chas. Young, C.P.R. to construct spur for Canadian General Electric Co., Limited, on Subdivision, Lots 21, 22, 23, 24, 25 and 26, Block 69, city of Calgary Alta.

21480—March 13—Authorizing C.L.O. and W. Ry. (C.P.R.) to construct a business spur from a point on its main line at mileage 0 to a point in Lot No. 1 on N.W. corner of Ontario and Dundas Streets at mileage 1.11 (spur mileage), town of Trenton, Ont.

21481—March 13—Authorizing C.L.O. and W. Ry. to construct, by means of grade crossings, its business spur across C.N.O.R. main line and spur at mileages 0.47 and 0.74, town of Trenton, Ont., subject to and upon certain conditions.

21482—March 12—Approving diversion as constructed by C.L.O. and W. Ry. (C.P.R.) at mileage 91.18 from Glen Tay; and rescinding Order No. 18282, dated December 11, 1912.

21483—March 13—Approving location G.T.P. Branch Lines Co.'s station on Moose Jaw Northwest Branch, at Siding No. 11, in Sec. 26-22-6, W. 3 M., Sask., at mileage 63.

21484—March 14—Authorizing G.T.R. to connect its tracks with and to operate its engines, trains, and cars over siding recently constructed by Dominion Iron and Steel Company, at its premises at Point St. Charles, near Wellington Basin, in city of Montreal.

21485—March 13—Postponing cancellation of special mileage rates on grain for milling and export, as published in C.P.R. Supplement No. 3 to C.R.C. No. E-2715 and G.T.R. Co.'s Supplement No. 16 to C.R.C. No. E-2566, and 2, that special mileage rates, as published in Sec. 3 of C.P.R. Tariff C.R.C. No. E-2715, and Sec. 4 of G.T.R. Tariff, C.R.C. No. E-2566 be continued in effect for a period of one year from 20th day of March, 1914. 3. Leave be granted Rly. Cos., to make application to Board at end of such period, for a revision of the rates.

21486—March 13—Directing that G.T.R. install, within 90 days from date of this Order, improved automatic bell at crossing of highway immediately west of Lorne Park Station, Ont., thereafter maintain bell at own expense: 20 per cent. of cost of installing bell be paid out of Rly. Grade Crossing Fund, remainder by Railway Co.

21487—March 13—Authorizing C.P.R. to construct spur for Adolph Lumber Co. at Bayne's Lake, B.C., from a point on Bayne's Lake spur, mileage 1.49, in Lot 6235 E.K.D. B.C. Ry. Co., to install derail on proposed spur 300 feet from crossing of Great Northern Ry. and connect it with interlocking plant. Spur to be completed within six months from date of this Order.

21488—March 16—Authorizing C.P.R. to construct road diversion under and across main line, Alta. Div. Aldersyde Sub- Div. in Sec. 5-14-23, W. 4 M., at Carmangay, Alberta.

21489—March 14—Authorizing C.P.R. to use and operate two bridges, namely, No. 62.8, Ont. Div., Windsor Sub. Div., and No. 79.1, Ont. Div., Windsor Sub. Div., Province of Ontario.

21490—March 14—Authorizing G.T.R. to operate over four bridges, No. 144 Trout Creek, St. Marys, Mileage 0.60; No. 90 Cull Drain, Blackwell, Mileage 161.40; No. 40, Stream, Tavistock,, Mileage 106.24, and No. 39, Stream, Tavistock, Mileage 104.01, all in Middle Div. 15th Dist., Ont.

21491—March 16—Approving plans showing location and details of freight shed and platform proposed to be constructed by G.T.R. at Prairie Siding, Ontario.

21492—March 16—Amending Order No. 20940, dated Dec. 3, 1913, by striking out figure "5" wherever it occurs in said Order and inserting therefor figures "25," so as to make same read, "Section 12, Tp. 25, Rge. 3, West of 4th Meridian?"

21493—March 17—Directing that C.P.R., within 60 days from date of this Order, install improved automatic bell at crossing of County Road No. 14, village of Hillsburg, Ont., and thereafter maintain bell at its own expense: 20 per cent. of cost of installing bell be paid out of "The Railway Grade Crossing Fund," remainder by Railway Company.

21494—March 16—Authorizing C.P.R. to construct spur for W. T. Williams and J. W. Davidson, Medicine Hat, Alta.

21495—March 17—Authorizing C.P.R. to construct Bassano Easterly Branch across highway between Secs. 5 and 6, Tp. 23-1, W. 4 M., Alberta, at mileage 112.47 of said Branch.

21496—March 17—Authorizing C.P.R. to construct Bassano Easterly Branch across highway between Secs. 25 and 26-21-6, W. 4 M., Alta., at mileage 83.6 of said Branch.

21497—March 16—Authorizing C.P.R. to construct spur to Newcastle Lumber Mills, at Newcastle, mileage 6.64 on Comox Extension of said Esquimalt and Nanaimo Railway, subject to certain conditions.

21498—March 17—Authorizing C.P.R. to re-construct bridge No. 109.36, on Mountain Subdivision, B.C. Division, B.C.

21499—March 17—Directing that on or before June 1st, 1914, the C.P.R. erect a shelter at Groverton, Ont., for the accommodation of passenger traffic.

21500—March 17—Approving revised location of C.P.R. main line, as at present constructed, Thomson Sub. Div., from mileage 24.76, at Savona, to mileage 30, and from mileage 32 to 40.62, at Semlin, B.C.; and authorizing construction of an additional track (double track) on said revision; also authorizing, subject to an inspection by Dept. of Public Works for B.C., construction of said additional track across four (4) highways, from mileage 24.76 to mileage 30 and from mileage 32 to 40.62.

21501—March 16—Authorizing G.T.R. to construct bridge 266, at mileage 48.25, over Credit River, near Inglewood, Ontario.

21502—March 16—Authorizing G.T.R. to construct siding, commencing at a point on Northern Div. on Lot 3, Con. 1, Tp. Macauley, Dist. Muskoka, Ont., thence in southeasterly direction across Lot No. 3, and Lot No. 3 in 13th Con. Tp. Draper, and a public highway, into premises of I. C. McLeod.

21503—March 16—Authorizing G.T.R. to operate trains across bridge 130, over Nith River, at mileage 75.64, 17th Dist. near Princeton, Ontario.

21504—March 17—Authorizing G.T.R. to re-construct nine (9) bridges on 4th District of its railway, in Province of Quebec.