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STORAGE ON THE UPPER ST. MAURICE RIVER

PROPOSED MASONRY DAM AND STORAGE WORKS NEAR LA LOUTRE FALLS FOR THE REGULATION OF RIVER FLOW—TO BE ERECTED UNDER EXTREME CONDITIONS OF TRANSPORTATION AND CLIMATE.

A DIFFICULT storage undertaking, but one that will have an important bearing upon power development and the lumbering industry in northern Quebec, is under construction. The consideration of flow regulation of this river was adopted by the Provincial Legislature in 1912, and an act was passed granting additional powers to the Quebec Streams Commission for the execution of the works provided for. Since that time, the engineers of the commission have gathered all available data concerning precipitation, run-off and evaporation on the watershed, as well as the stream flow of the river and its tributaries. This information was, generally speaking, too meagre to be of much value, necessitating the establishment of gauging stations all along the river, as well as other careful data compilation.

Records of daily observation at Shawinigan from 1900 to 1912 had shown that the minimum flow of the river was 6,000 cu. ft. per sec., representing 0.37 cu. ft. per sec. for every square mile of drainage basin. The proportion of the flood to the minimum flow on the St. Maurice is, generally speaking, 30 to 1. The commission, after careful study, ascertained that, by a storage dam above the La Loutre rapids a volume of water estimated at 160 billion cu. ft. could be stored. The flow thereof could be made as follows:

For 150 days	....	12,345 cu. ft. per sec.
" 200 "	....	9,317 " "
" 250 "	....	7,407 " "
" 300 "	....	6,172 " "

The present storage reservoirs on the Manouan River, a tributary of the St. Maurice, give a total storage of 590 square-mile-feet, or 16,448,256,000 cubic feet, equal to a flow of:

For 150 days	....	1,269 cu. ft. per sec.
" 200 "	....	952 " "
" 250 "	....	761 " "
" 300 "	....	635 " "

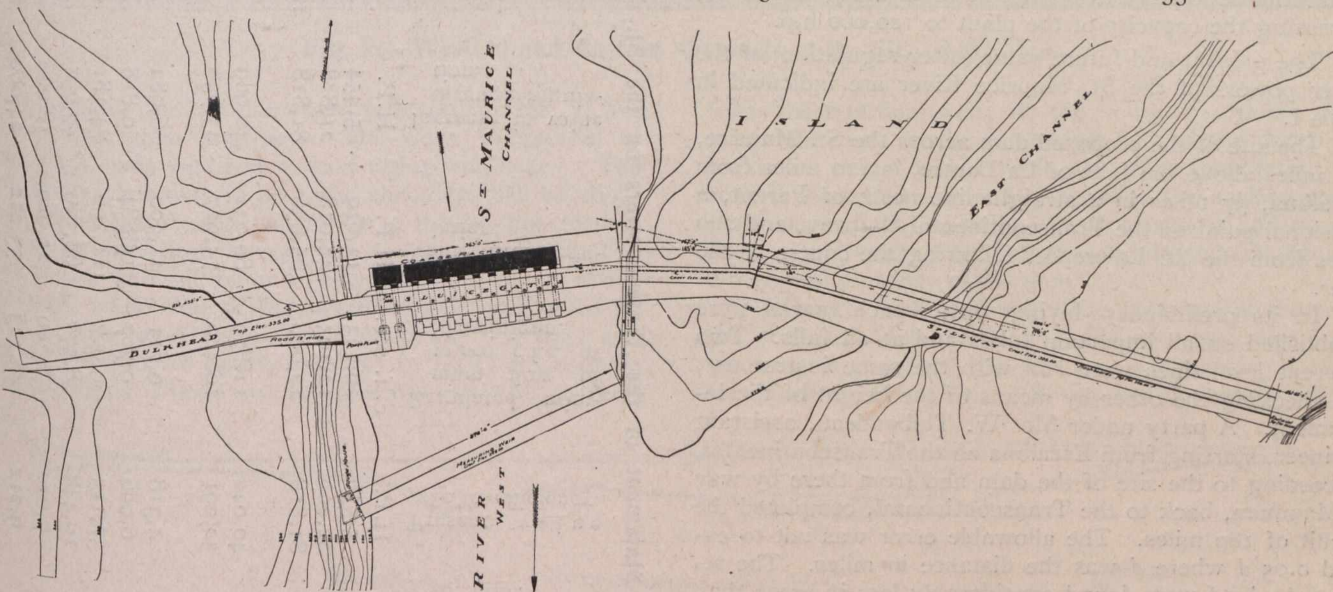


Fig. 1.—Plan of the Proposed Dam on the St. Maurice River.

But a close analysis of the records giving the flow at Shawinigan shows that, for the year 1906, the lowest year for the period from 1900 to 1912, it was as follows:

Under	12,000 c. f. s.	—230 days	—Average	8,000 c. f. s.
"	15,000 c. f. s.	255 "	"	8,558 c. f. s.
"	18,000 c. f. s.	270 "	"	9,030 c. f. s

The records for 1911 show practically the same conditions. To regulate the flow to 12,000 cubic feet per second would have required an average of 4,000 cubic feet per second for 230 days. The storage of the two reservoirs will give, for the same period, 8,051 and 828 cubic feet per second respectively, leaving in the reservoirs 4,879 cubic feet per second, or 55% of the water stored.

The regulating of the flow to 15,000 cubic feet per second would, in the same year, have required an average of 6,442 cubic feet per second during 255 days. The two storage reservoirs could give for that length of time 7,262 and 746 cubic feet per second respectively, leaving 1,566 cubic feet per second, or 19½% stored water not needed.

The regulating of the flow to 18,000 c. f. s. would have required an average of 9,000 c. f. s. for 270 days. During that period the reservoirs would only give 6,859 and 705 c. f. s. respectively, say, a deficiency of 1,437 c. f. s. The river could not be regulated to that high figure in a year when the rainfall is very low.

The river could, however, be regulated at 15,000 c. f. s. at Shawinigan, leaving an over-supply of the stored water in a very low year. But the commission deem it advisable to provide for the loss in the volume of water from the storage reservoirs, especially in winter, while coming down the distance of 220 miles to Shawinigan. And the fact also is not overlooked that water may be needed for floating logs at a time when it would not be wanted for power purposes.

For these reasons the commission adopted a flow of 12,000 c. f. s. to compute the increased value of the water powers concerned. A scheme was accordingly worked out, as outlined below, for storage above La Loutre falls.

It should be remembered that at present 206,300 h.p. are being developed on the river; viz., Shawinigan, 163,000; Grand'Mère, 19,500; La Tuque, 3,500. In addition, the Shawinigan Power Company is adding two units of a capacity of 37,000 h.p., while the plant of the Laurentide Company at Grand'Mère is being added to, increasing the capacity of the plant to 120,000 h.p.

The present and future value (after regulation) of the water powers of the St. Maurice River are indicated in Table I.

The site of the proposed dam across the St. Maurice, 2⅓ miles above the falls of La Loutre, is 120 miles from Escalona, 37 miles in a straight line north of Parent, a divisional point on the Transcontinental Railway, and 240 miles from the St. Lawrence, following the course of the river.

In its preliminary laying out, bench marks were established on all important lakes and at all falls. Two different level lines were run with the same instrument, one checking the other by means of the height of the instrument. A party under Mr. W. Thibaudeau, assistant engineer, starting from Escalona on the Transcontinental, proceeding to the site of the dam and from there by way of Manouan, back to the Transcontinental, completed the circuit of 180 miles. The allowable error was not to exceed 0.05 d where d was the distance in miles. The results obtained were found considerably less in error than that amount. These levels checked figures previously obtained respecting the elevation of various lakes forming part of the drainage basin whose waters it is proposed to store. Some 35 bench marks were established at the falls and on the various lakes during 1913.

Another party proceeded to the site of the dam to investigate the nature of the ground. Its borings were made with the use of a McKiernan-Terry core-drill mounted on a raft 20 ft. x 20 ft. and moored by cables and pulleys to a steel cable across the river. Each boring was located by triangulation and was carried down to a depth of 12 ft. to 15 ft. They were made at 20 points in the western and 8 points in the eastern channel of the river, the total length of rock examined being 323 linear ft.

Gaugings were recorded at La Loutre to supplement those available at Shawinigan, 220 miles distant. The flow of the river was measured by determining the velocity and the cross-section, the velocity being measured by a Gurley current meter. The average velocity was determined at 3 points; viz., 0.2, 0.6 and 0.8 of the depth as per the method commonly used. The maximum flow was observed to be 14,500 cu. ft. per sec. and the minimum

Table I.—Statement of the Water-powers on the St. Maurice River.

NAMES.	Distance from St. Lawrence, (miles.)	Head in feet.	Approximate area of drainage basin above (sq. miles.)	Actual minimum flow, 0.37 cu. ft. per sec. per sq. mile.	Present value 80% efficiency.	Regulated minimum flow of 12,000 c.f.s. at Shawinigan.	Value after regulation.	Increase in value through regulation.	Power installed.	Increased primary power which will be used.	Increased power left unused.	Increased water-power yet unsold.	Present owner.
	Miles.	Ft.	Sq. M.	c. f. sec.	H.P.	c. f. sec.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	
La Gabelle	13	10	16,550	6,123	5,556	19,123	11,010	5,454	.....	.....	5,454	.....	Grès Falls
Les Grès	15.5	40	16,500	6,105	22,200	12,105	44,018	21,818	.....	.....	21,818	.....	" "
Shawinigan ..	21	150	16,200	6,000	81,818	12,000	163,636	81,818	183,300	81,818	....	.....	Shawinigan W. & P. Co.
Grand'Mère ..	33	75	15,860	5,870	40,022	11,870	80,931	40,909	19,500	40,909	....	.....	Laurentide Co.
La Tuque ...	103	80	12,000	4,440	32,291	10,440	75,927	43,636	3,500	.....	43,636	.....	Q.&St.Maurice Industrial Co.
Sans Nom	110	128	10,030	3,711	4,318	9,711	11,300	6,982	.....	.....	.....	6,982	Crown.
Vermillon	119	16	10,020	3,707	6,066	9,707	15,884	9,818	.....	.....	.....	9,818	"
Blancs	138	136	8,115	3,002	37,115	9,002	111,296	74,181	.....	.....	.....	74,181	"
Grands-Cœurs .	171	90	6,425	2,377	19,448	8,377	68,539	49,091	.....	.....	.....	49,091	"
La Grâce	183	33	6,325	2,340	7,020	8,340	25,020	18,000	.....	.....	.....	18,000	"
De L'Ile	191	44	6,225	2,303	9,212	8,303	33,212	24,000	.....	.....	.....	24,000	"
									206,300	122,727	70,908	182,072	

flow 3,500 cu. ft. per sec. While the proportion between flood water and low water at Shawinigan was 27 to 1, at La Loutre it was found to be 4.6 to 1.

Excavation revealed the existence of from 6 ft. to 8 ft. of sand on the west side of the site, quite suitable for concrete. Test pits 8 ft. square were dug at various points, revealing a mixture of sand and stones overlying rock within a depth of from 6 in. to 16 ft. of the surface. Several of the pits had to be abandoned owing to the excessive seepage.

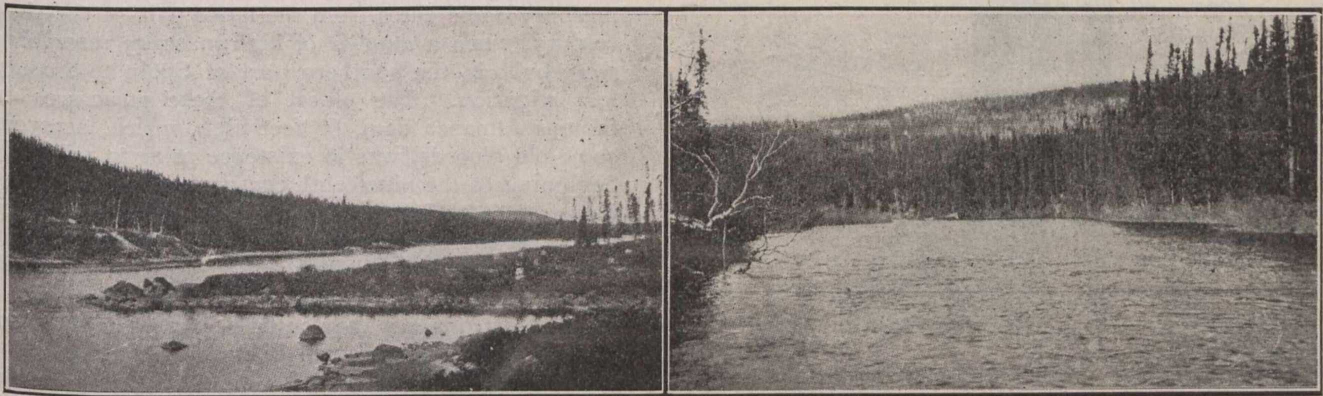


Fig. 2.—Western and Eastern Channels at the Site of the Dam.

The plans for the dam were prepared by Mr. J. W. Thurso, hydraulic engineer. Mr. Edw. Wegmann, of New York, was retained as consulting engineer. The dam, shown herewith in plan and elevation, will be about 1,720 ft. in length and will follow a broken line formed by four straight lines intersecting at obtuse angles. The crest of the dam will be at an elevation of 1,335 ft. above sea level, while that of the overflow weir will be 10 ft. lower. The plan comprises a sluiceway for logs and floating rubbish, 10 gates, each 7½ ft. by 12 ft., capable of discharging 18,000 cu. ft. of water per sec., a reinforced concrete measuring weir 375 ft. in length with abutments and wing walls. In addition, the development will include a power house, two gate houses, a gauge-house, a 12-ft. roadway and a telephone line from Manouan. These will be described in a later article.

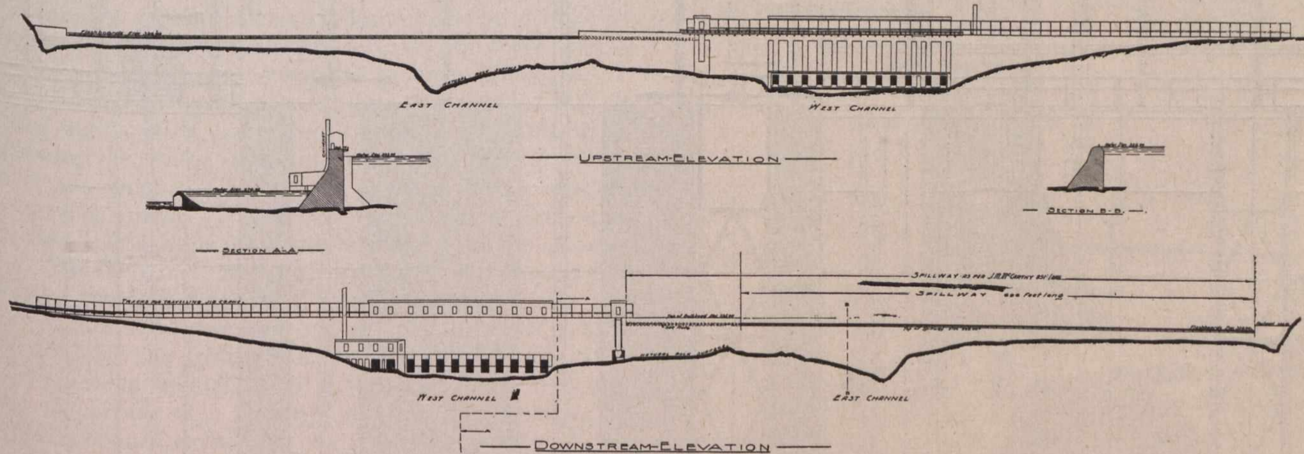


Fig. 3.—Elevations and Sections of the Proposed Dam.

Five different types of dams were investigated in regard to their adaptability for the proposed work, these types being plain gravity dam with buttresses acting as ice breakers, hollow ram with both reinforced and arched deck, retaining wall type with loaded upstream footing, and timber dam. Different types of gates were also investigated with the result that "Stoney" sluices, or those of a similar type, were considered the most suitable. Five different dam sections, of dimensions larger than usual, were investigated in regard to their stability under extremely severe assumptions of forces acting on the dam, these sections being, plain gravity section with vertical, also sloping, upstream face, hollow dam with deck at an angle of 45°, the same type with upper part of deck at 30° and lower part at 60° to the horizontal, and rock-fill dam with concrete shell. About 700 ft. of the dam is to form the overflow weir, its top being, as stated, 10 ft. below the crest of the remaining part of the dam. The maximum height will be 80 ft. above the foundation. The rock is Laurentian gneiss lying near the surface, rough from erosion, but entirely free from seams and fissures. It is an extremely hard stone, well adapted for the foundation and masonry of the dam.

It is proposed to unwater the river bed at the site of the proposed dam to permit of the necessary cleaning of the bed rock surface, the cutting of channels or checks for bending, etc. This will require the construction of cofferdams and the installation of pumping appliances. The surfaces of the rock foundations are to be sufficiently roughened to bond well with the masonry and cut to rough benches or steps.

The concrete for the body of the dam will be of 1:2½:5 mix, Portland cement, natural sand and broken stone respectively. Stones, varying in size up to 4 cu. yds., will be embedded in the concrete after thorough cleaning, placed 6 to 8 inches apart to allow thorough concreting between them. Reinforcement used is to be of square twisted bars, of extra soft open-hearth steel.

The site, though well adapted for a strong, watertight masonry dam, has the disadvantages of severity of

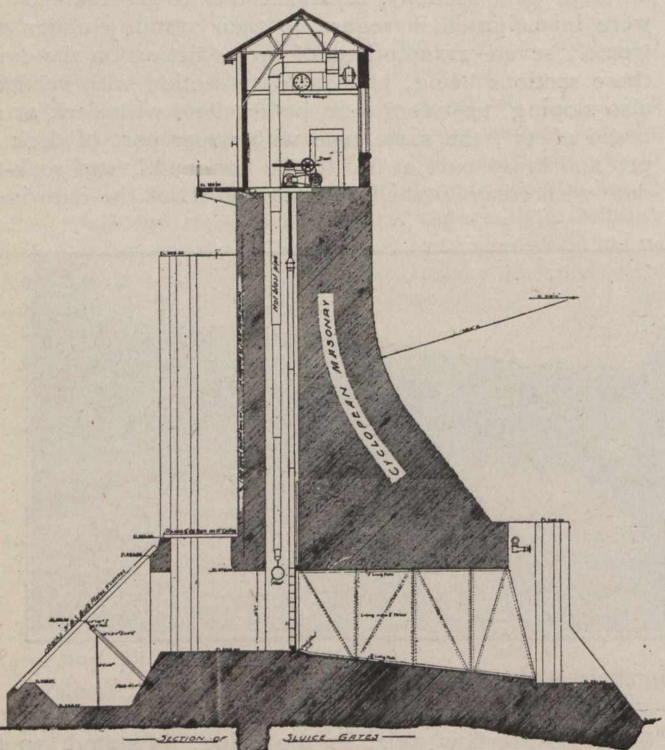


Fig. 4.—Section Through Sluice Gates.

winter weather, requiring extra strength to resist ice pressure, and inaccessibility, which will add materially to the cost of construction.

The plans have been prepared, and the work will be executed under the direction of the Quebec Streams Commission, of which Olivier Lefebvre, C.E., is chief engineer, and Ernest Bélanger, C.E., and Wm. I. Bishop, C.E., are commissioners. John W. Thurso is designing engineer of the dam, and Edward Wegmann and J. M. McCarthy consulting engineers.

In his report, Mr. Wegmann commented as follows on the design of masonry dams in general, and upon the application to the St. Maurice storage project:

Theory of Masonry Dams.—The construction of masonry dams dates from the latter part of the sixteenth century, when a number of high masonry reservoir walls were built in the southern part of Spain to store water for irrigation. The oldest of these structures is the famous Almanza dam, 68 feet high, which, according to some old records, was in existence prior to 1586. In the beginning of the nineteenth century a number of masonry dams, 30 to 75 feet high, were built in France in connection with the construction of canals. None of the early masonry dams were built according to correct principles. It has been shown that some of these reservoir walls would be stronger if they could be turned around, so that their upstream faces would be downstream.

The French engineer, M. de Sazilly, was the first to point out, in 1853, the correct principles upon which the design of the profile of a dam should be based. He was followed in the study of this subject by Delocre, Bouvier, Pelletreau, Lévy, etc., in France, and by Prof. Rankine, in England. According to these engineers there are three ways in which a masonry dam can fail; viz., by overturning; by sliding or shearing apart, or by the masonry or the foundation being crushed by the pressure it has to sustain. To insure safety, an ample factor of safety must

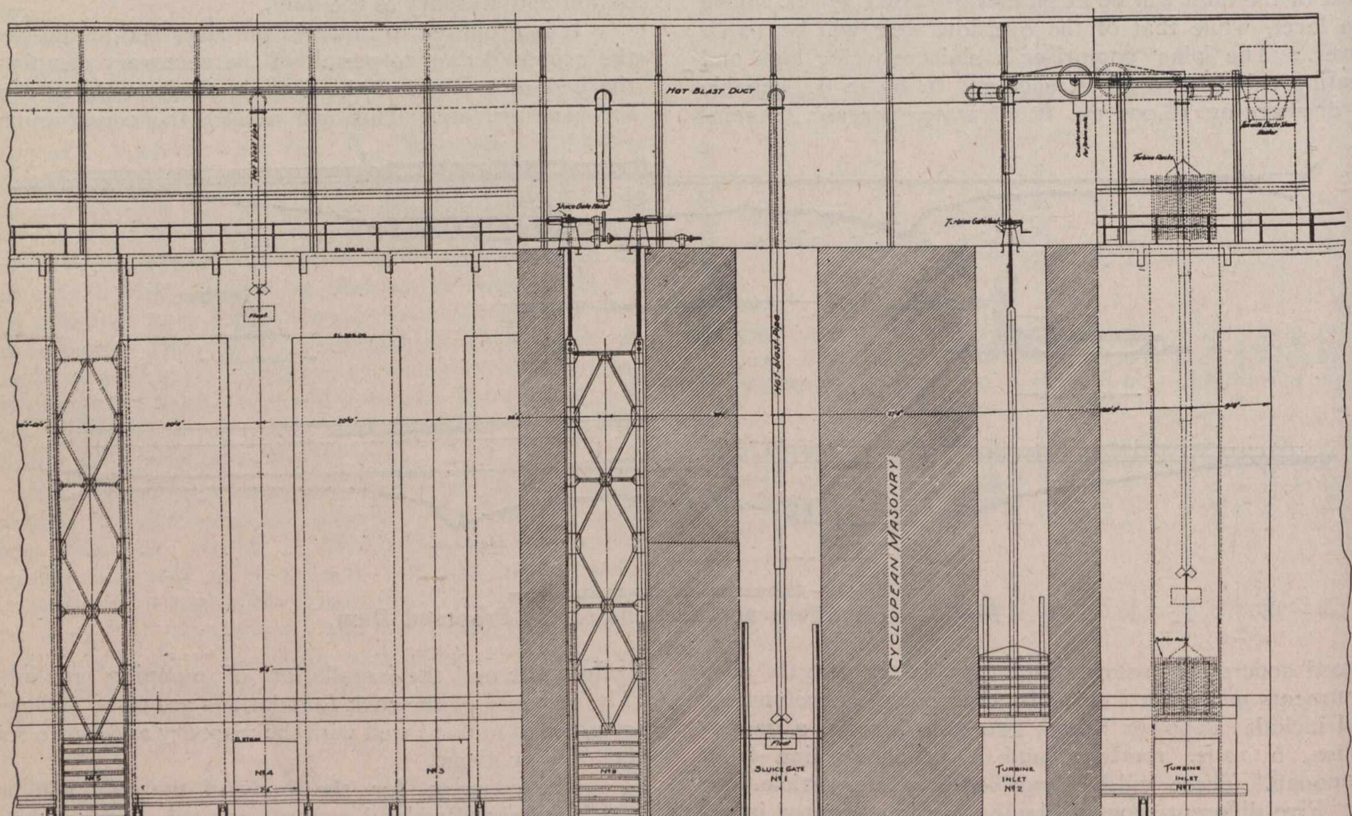
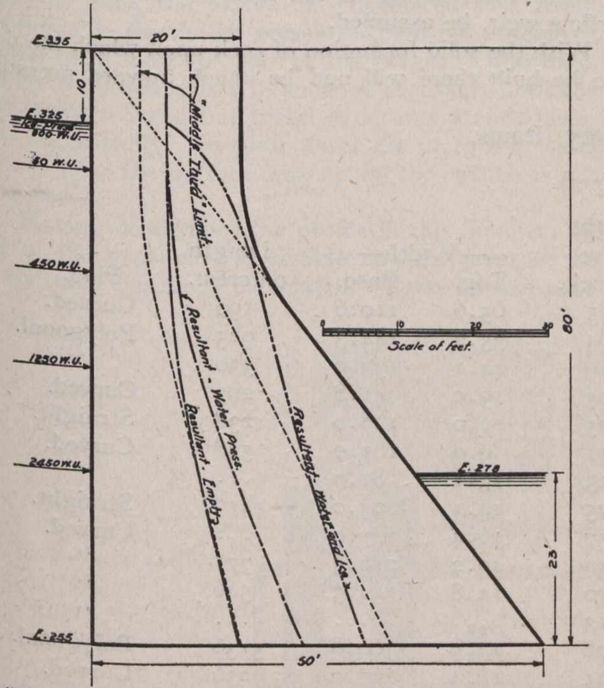


Fig. 5.—Part Longitudinal Section of the Dam.

be provided against each of these possible manners of failure.

A number of high masonry dams have been built in France and Algeria according to the principles proposed by the engineers mentioned above. The greatest of these works is the celebrated Furence dam, built in 1862-66 near St. Etienne, France. It is about 170 feet high, and was for many years the greatest work of its kind.



NOTE: 50 w.u. = 50 Water Units = 50×62.5 lbs.

Fig. 6.—Profile Which Accompanied the Consulting Engineer's Report.

Prior to 1884 there was only one high masonry dam in America, viz., the Boyd's Corner dam, 78 feet high, which was built in 1866-72 to form a storage reservoir for the city of New York. From 1888 to the present time a number of high masonry dams have been built in various parts of the world. The greatest of these works with their principal dimensions are given in Table II.

Up to about twelve years ago, the profiles for all masonry dams, with one exception, were determined by considering the water as acting only on the upstream faces of the dams. The failures of three dams built on poor, porous rock, viz.: the Bouzey dam in France in 1895; the Austin dam in Texas in 1900, and the dam at Austin, Pennsylvania, in 1911, drew the attention of engineers to the fact that water might percolate under the base of a dam and exert a strong upward pressure, which would diminish the strength of the dam materially. This led designers to include such an upward force in determining the profile of a masonry dam. The intensity of the uplift depends evidently on the permeability of the rock. It may vary from practically nothing in good sound rock to almost the full head of the reservoir in porous rock, full of seams. The pressure of the water against the upstream face of a dam is easily calculated, but the amount of a possible upward force under the base or in the masonry itself must be decided, of necessity, by the judgment of the designer.

In addition to the action of the water against the upstream face, and possibly, under the base of a dam, we must consider in northern latitudes the thrust which ice may exert against a dam in forming and in expanding during a rise of temperature. When confined, as between two bridge piers, thick ice exerts a great force in expanding. A small masonry dam at Minneapolis, Minnesota, was partly revolved in 1899 by a sheet of ice, 4 feet thick and 300 feet long, lying between the dam and the retaining wall of a canal. The dam was 18 feet high, 5.25 feet wide at the top, and 12 feet at the base. The top of the wall was forced nearly a foot out of line, but, when the ice was cut, the wall returned nearly to its original position. If the ice is only about 12 to 15 inches thick and forms a long sheet, it will buckle and form "reefs" and possibly may not cause a great pressure against a dam. In the present state of knowledge we cannot determine accurately the pressure which ice may exert against a dam, and the allowance to be made for this force in designing the profile of a dam is a matter of judgment which must be based upon the local conditions. The following reservoir walls have been built for the city of New York without making any allowance for ice pressure or any possible upward pressure under the base, and stand successfully without the slightest indication of any weakness, viz.: The Sodom dam, 98 feet high, built in 1888-93; the Titicus dam, 135 feet high, built in 1890-95; and the new Croton dam, 297 feet high, built in 1892 to 1907.

On the other hand, engineers have deemed it advisable of late, to take ice pressure and possible uplift under the dam into account in designing the profile, as will be seen in the following table:

Recent Masonry Dams.

Dam.	Built.	Height, ft.	Ice pressure, lbs. per lin. foot.	Uplift.
Wachusett, Mass. ..	1900-06	228	47.000	
Cross River, N.Y...	1905-09	170	24.000	
Croton Falls, N.Y...	1906-11	173	30.000	
Olive Bridge, N.Y...	1907-13	252	47.000	
Kensico, N.Y.	In construction.			

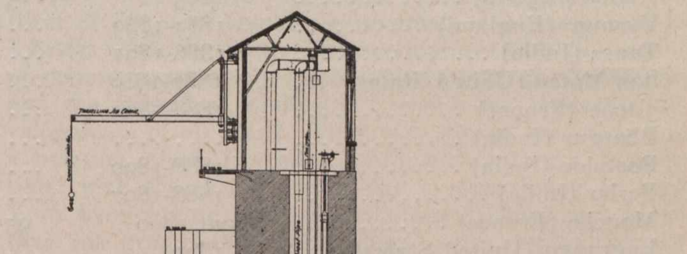


Fig. 7.—Cross-section of Portion of Power House, Showing Turbine Inlet.

In all of the above dams, the upward pressure under the base of the dam was taken as ⅔ of the full head in the reservoir at the upstream side, diminishing to zero at the downstream side.

As to recommendations for the design of the dam across the St. Maurice River, there are two types of construction that might be adopted. The dam might be built as a solid masonry dam, or as a hollow dam of reinforced concrete. It is recommended that it be built as a solid dam of cyclopean masonry, consisting of large blocks of stone laid in and surrounded by Portland cement concrete.

As regards the profile to be adopted, this depends upon the weight of the masonry, about which we have thus far no accurate data. The specific gravity of the stone should be accurately determined, and then the percentage of large stone in the cyclopean masonry must be estimated to find the probable average weight of the masonry. In the part of the New Croton dam which was built of cyclopean masonry, there were 40 per cent. of large stone in the foundation and 20 per cent. near the top, the average being 23 per cent. of large stone for the whole wall. In the St. Maurice River dam, which will be only 80 feet high, the percentage of large stone will be less, probably not over 20 per cent.

It is recommended that an ice pressure of 50,000 lbs. per linear foot, acting at the level of the crest of the overflow weir, be assumed.

With the solid formation of rock upon which the dam is to be built there will not be much upward pressure,

Table II.—High Masonry Dams.

(Dimensions in feet)

Dam and location.	Date of construction.	Depth of water.	Height above bed-rock.	—Width— Top.	Base.	Length on crest.	Plan.
Alicante (Spain)	1579-1594	127	135	65.6	110.6	190	Curved.
Puentes* (Spain)	1785-1791	154	164	35.7	144.3	925	Polygonal.
Val de Infierno (Spain)	1785-1791	...	116	42.1	137.0	330	"
Zola (France)	About 1843	120	123	19.0	41.8	205	Curved.
Lozoya ((Spain)	1852	94	105	22.0	128.0	238	Straight.
Furens (France)	1862-1868	164	171	9.9	161.0	328	Curved.
Terhay (France)	1865-1868	113	125	13.1	81.7	...	"
Habra** (Algiers)	1865-1873	117	125	14.1	95.0	1476	Straight.
Ban (France)	1867-1870	138	157	16.4	127.0	...	Curved.
Gileppe (Belgium)	1869-1875	148	154	49.2	216.5	771	"
Villar (Spain)	1870-1878	162	170	14.8	154.5	546	"
Pas du Riot (France)	1872-1878	...	113	....	.....	...	"
Poona (India)	....	...	108	13.8	60.8	5136	Polygonal.
Hijar (Spain)	1880	...	141	16.4	147.0	236	Curved.
Gorzente (Italy)	1880-1883	121	126	13.1	99.6	492	"
Lagolungo (Italy)	About 1883	...	144	16.4	.....	...	
Gran Cheurfas (Algiers)	1882-1884	...	131	13.1	134.5	509	Straight.
Hamiz (Algiers)	1885	115	135	16.4	91.2	532	"
Vyrnwy (England)	1882-1889	...	146	20.0	117.8	1350	"
Tansa (India)	1886-1891	...	118	12.0	100.0	8800	
San Mateo (United States)	1887-1889	...	170	20.0	176.0	700	Curved.
Tache (France)	1888-1892	...	161	13.1	.....	...	"
Bhatgur (India)	....	...	130	12.0	74.0	4067	
Beetaloo (India)	1888-1890	...	110	14.0	110.0	580	Curved.
Periar (India)	1888-1897	...	180	12.0	136.0	1200	Straight.
Mouche (France)	About 1890	95	101	11.5	.....	1346	"
Lagrange (United States)	1890	...	125	24.0	90.0	320	Curved.
Titicus (United States)	1890-1895	...	135	18.0	75.0	534	Straight.
Hemmet (United States)	1891-1895	...	136	10.0	100.0	...	Curved.
Butte City (United States)	1892	...	120	10.0	83.0	350	"
New Croton (United States)	1892-1907	150	297	22.0	206.0	2168	Straight.
Echapre (France)	1894-1898	116	121	17.0	88.6	541	Curved.
Cotatay (France)	1900-1904	121	144	16.2	.....	509	"
Lake Cheesman (United States)	1900-1904	...	232	18.0	176.0	...	"
Spier Falls (United States)	1900-1905	80	154	....	.....	1369	Straight.
Boonton (United States)	1900-1905	105	114	17.0	77.0	2150	"
Wachusett (United States)	1900-1906	...	228	25.8	187.0	1476	"
Ondenon (France)	1901-1904	107	123	15.4	93.8	420	Curved.
Urft (Germany)	1901-1904	...	190	18.0	165.7	1037	"
Komotau (Austria)	1901-1904	...	139	13.1	98.4	509	"
Cher (France)	About 1907	...	154	15.4	141.1	323	"
Cataract (Australia)	1902-1908	150	192	16.5	158.0	811	Straight.
Roosevelt (United States)	1905-1911	240	280	16.0	170.0	1080	Curved.
Pathfinder (United States)	1905-1910	...	206	10.0	94.0	425	"
Shoshone (United States)	1905-1910	...	324	10.0	108.0	200	"
Cross River (United States)	1905-1909	106	170	23.0	116.3	772	Straight.
Croton Falls (United States)	1906-1911	97	173	23.0	127.7	1100	"
Olive Bridge (United States)	In construction	210	252	26.33	200.0	1000	"
Assuan Dam (Egypt)	Raised, 1907-1911	82	112	36.0	.....	6200	"

* The Puentes Dam was ruptured in April, 30, 1802.

** The Habra Dam failed in December, 1881.

providing, of course, that the masonry is well laid in Portland cement mortar, the concrete being generally mixed in the proportion of 1:2:4.

The design of the profile submitted is based on the dam's being subjected only to the hydrostatic pressure of the water, acting on its upstream face, and also, to the ice pressure mentioned above. With these forces acting upon the dam, the profile is considered safe although, theoretically, the line of pressure would fall outside of the middle third limit for part of the height of the dam. A similar condition exists in some of the dams built for the city of New York, but these structures stand, nevertheless, successfully. In these dams the margin of safety is greater near the bottom than at the top, which is a good condition.

Having determined the profile in this manner, the effect of the greatest conceivable upward pressure acting on the dam has been calculated. Even in this case the

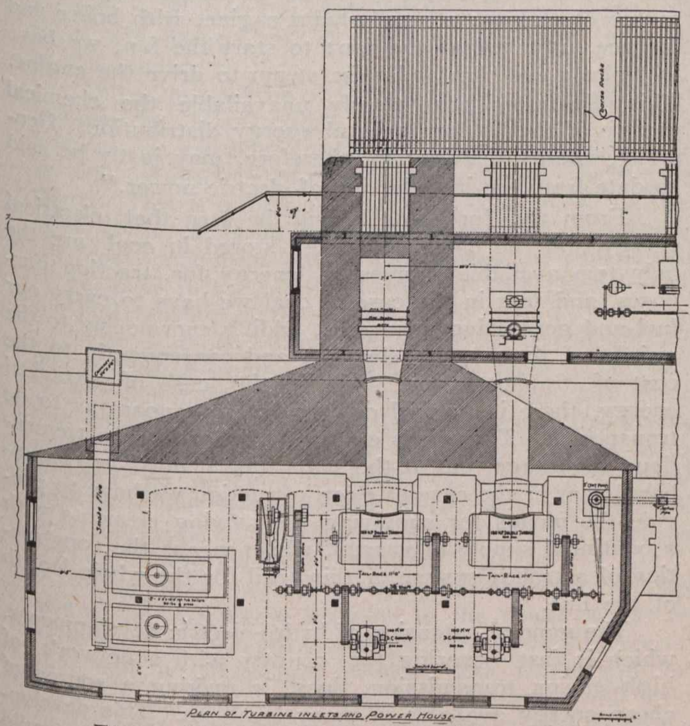


Fig. 8.—Plan of Proposed Power House.

lines of pressure would be kept within the profile of the dam. Some tension would be caused in the masonry, but such an extreme case of upward pressure can never occur and even if it did, the dam would still stand, owing to the cohesion of the masonry.

The width given to the top of a dam must be sufficient to enable the wall to resist shocks from waves and floating bodies and also ice pressure. On account of the thickness of the ice that will form in the proposed reservoir, it is recommended that the dam be made 20 feet wide at the crest. Theoretically this would not be enough to enable the upper part of the dam to resist the combined thrust of the ice and water by its weight alone. The cohesion of the masonry would have to be counted on to insure the stability of the upper part of the dam. From practical examples a width of 20 feet at the crest is felt to be sufficient.

At the top of the overflow weir, however, some reinforcement with steel bars will be required, as this part of the dam has not the weight of masonry, 20 feet wide and 10 feet thick, above the assumed ice line to add to its strength.

THE DEVELOPMENT OF ELECTRIC TRACTION.

By John R. Hewett in "General Electric Review."

THE steam railroad is just about a century old and the electric railway about a quarter as old, and when we think of the astounding developments that have taken place in this comparatively short space of time, we can hardly refrain from asking ourselves why this development has come about. The answer to this question would seem to be that the civilization of the world is absolutely dependent upon rapid communication between man and man—the communication of thoughts and of material matter. The invention of the steam engine and locomotive pointed the way, and then, with the introduction of the electric telegraph and the submarine cable, the different peoples of the world became so much more closely connected in thought that the general extension of a more rapid means of physical communication seemed imperative. The stage coach on land and the sailing ships on the seas had to be replaced by quicker methods of communication. It was about the beginning of the nineteenth century that people began to recognize that the country which developed the best means of rapid communication with other countries would be the leader in the commerce of the world—those that had most ships would control the seas and the markets of the world; and, similarly, that it was only those countries that developed an efficient system of land transportation that could develop their natural resources, and, consequently, become manufacturing countries.

The recognition of these great economic truths came about just at a time when the whole world had been well nigh torn asunder and rent by a series of wasteful and disastrous wars. In looking back at the history of this period, the development seems miraculous. All sections of the civilized world would seem to have taken on a new form of life, and commerce became to be recognized as a better trade than war. The development of better means of communication aided the rapid spread of civilization, and the spread of civilization stimulated industrial developments of all kinds. Thus was started an action and a reaction which has been continued up to the present time, with the result that to-day a man living in New York knows more about the capitals of China and Japan than his grandfather knew about many towns scarcely a hundred miles from his own door, and that each of us individually to-day are virtually in connection with the whole rest of the world. It is easier to make a trip around the entire globe to-day, in comfort and in luxury, than it was to travel from one end of New York State to the other, at the cost of hardships and dangers, a hundred years ago.

These developments have absolutely changed our modes of living, and during the transition stage one thing of vital importance has happened, viz., we have let these means of communication become our masters as well as our servants. When we stop to consider the enormous populations congested into our large cities, and the distances from which their daily food supplies have to be transporated, it is apparent that our means of communication are the masters of the situation. Should they for any reason fail to fulfill their functions in the community for even a brief time, it would spell death by starvation to hundreds and thousands of human beings.

So in this brief period of one century we have built up a set of conditions that has so complicated our modes of living and increased our dependence on the labors of others, living at a great distance from us, that now our transportation facilities have become just as much one of the necessities of life as are food and clothing. The character of our transportation systems has thus become a matter of national importance.

It was long after this civilizing movement had set in and became well established that the electric railway made its appearance. In fact, it is just about twenty-five years ago that Sprague, Van Depoele, Daft and Bentley-Knight, amongst other energetic pioneers in the industry in this country, began to show the possibilities of this new mode of traction. In this short space of time electric traction has not only become well established, but has grown to be one of the most important industries in the country. In the last twenty-five years electric traction has, practically speaking, superseded all modes of transportation for city, suburban and interurban service, including elevated railways and subways. A whole paper could be written with profit to show the advances that have been brought about in our social status by the electric railway. There are few who realize how much the public, and especially those interested in real estate, have benefited by the enterprise of those who have been responsible for the building of our electric railway systems, but we have not time to go into this phase of the subject here.

It seems to-day that the field for electric traction is as broad as the traction field—that is to say, that it has been developed to a stage where there are no longer any technical limitations to its adoption on every railroad in the country. The traffic could be handled electrically and the considerations which govern the choice between steam and electric traction are financial and economic, not technical. Within the last decade we have seen many notable examples of the electrification of steam railroads, and, judging by the general interest that has been awakened in railroad circles and the recognition of the splendid service being performed by those electric installations already made and the economies secured by their adoption, we shall see many more examples of steam railroads adopting electric traction during the next decade.

All modes of traction depend primarily upon energy, and whether steam or electric traction ultimately becomes universal depends upon the relative economic values of the form of energy used. It should be noted here that of all the forms of energy available, only two are generally considered for traction purposes, viz., the chemical energy stored in coal and electric energy. Dr. Steinmetz in a paper before the Franklin Institute has recently pointed out the reason for this, viz., because they are the only two forms of energy that can be economically transported or transmitted over long distances. The two following paragraphs are taken from Dr. Steinmetz's recent paper:—

"Electrical energy can be transported, or, as we usually call it, transmitted—economically over practically any distance. Mechanical energy can be transmitted over a limited distance only, by belt or rope-drive, by compressed air, etc.; heat energy may be carried from a central steam-heating plant for some hundred feet with moderate efficiency, but there are only two forms of energy which can be transmitted over practically any distance, that is, which in the distance of transmission are limited only by the economical consideration of a source of energy nearer at hand—electrical energy, and the chemical energy of fuel. These two forms of energy thus are the only competitors whenever energy is required at a place distant from any of Nature's stores of energy. Thus, when in the study of a problem of electric power transmission we consider whether it is more economical to transmit power electrically from the water power or the coal mine, or generate the power by a steam plant at the place of demand, both really are transmission problems, and the question is whether it is more economical to carry energy electrically over the transmission line, or to carry it chemically, as coal by the railroad train or boat, from the source of energy supply to the place of energy demand, where the energy is converted into the form required, as into mechanical energy by the electric motor or by steam boiler and engine or turbine.

"Electrical energy and chemical energy both share the simplicity and economy of transmission or transportation, but electric energy is vastly superior in the ease, simplicity, and efficiency of conversion into any other form of energy, while the conversion of the chemical energy of fuel into other forms of energy is difficult, requiring complicated plants and skilled attendants, and is so limited in efficiency as to make the chemical energy of fuel unavailable for all but very restricted uses: heating and the big, high-power steam plant. To appreciate the complexity of the conversion of the chemical energy of fuel, compared with the simplicity of electrical energy conversion, imagine the domestic fan motor with coal as source of energy: a small steam engine, with boiler and furnace, attached to the fan: to start the fan, we have to make a coal fire and raise steam to drive the engine. This illustrates how utterly unavailable the chemical energy of fuel is for general energy distribution. Generally, energy distribution, therefore, may justly be said to date from the introduction of electric power."

From the foregoing it will be seen that electrical energy and the chemical energy stored in coal are the only two available sources of energy for traction purposes, and that in the case of coal we have to carry our fuel and generating apparatus, adding enormously to the weight of the moving element, and consequently to the cost of transportation, while in the case of electrical energy, there is no fuel or generating apparatus to be transported. This gives electric transportation a tremendous advantage, but at the same time it must be remembered that in the case of electric traction we have to provide the means for supplying the moving elements with a continual supply of energy, which means the construction of a trolley system or third rail for the whole length of the line.

The general extension of hydro-electric developments, which is fast covering the country with a network of high-tension transmission lines, is making a source of cheap energy available in many localities. This development will prove quite an asset to many roads who would rather buy than manufacture their own power.

In the case of electric traction, the range of energy supply is very flexible—we have the whole resources of the power house available—while steam traction, if we want excessive power for only a short distance we have to transport sufficient generating apparatus and fuel all the time we are working at light loads.

So the question of the electrification of steam railroads resolves itself to a question of whether it is cheaper to build a system for the distribution of energy for the whole length of the line than to carry the fuel and generating apparatus along with our freight and passenger trains.

This is absolutely a question of economies, and will be settled as such in each individual case after a careful analysis has been made of the individual requirements.

If the traffic were sufficiently dense, it would always pay to electrify a railroad, because the economies to be secured by electric operation would more than offset the interest to be paid on the initial expenditure, but where the traffic is scarce and the length of the line is long, that is to say, where the initial cost of electrification and the cost of operating and maintaining permanently an extensive system of energy distribution would be great, in comparison with the cost of hauling the fuel and generating apparatus along with the train, then steam traction is still the most economical.

We have many examples of steam railroads with dense traffic that have made or are contemplating the change from steam to electric traction to secure these economies, and also many special cases where electrification has come into being to secure some special economies or overcome some special conditions, such as the abatement of smoke in terminal stations, etc.

The analysis of operating conditions to determine whether it would be economical to electrify or to continue steam operation is becoming an important branch of the engineering profession. There are to-day many instances where electrification would pay, but where difficulty would be found in financing the undertaking. When some of the roads that are contemplating electrification have done so and have gained the experience from actual practice, it is likely that other roads will follow their example and that the electrification of our steam railroads will become one of the large electrical industries of the country.

When an analysis of the conditions in any particular instance has shown that electrification would be economical, we still have to determine which of the available systems of electrification is best suited to the requirements. This is purely a question of economics, and here again is the necessity for a careful analysis to determine the most economical way of distributing the expenditures to be made in the inital construction, the operation and the maintenance of the system.

For example, when the traffic is very dense, and where cars or trains of moderate size have to be run at very frequent intervals and the total energy used at any one instant is not very greatly in excess of the average load, then standard 600-volt apparatus has no equal. There is no objection to the heavy outlay in substation apparatus and feeder copper when such apparatus will be in operation at an efficient load factor for a good percentage of the twenty-four hours.

It is when the load is such that the cost of copper and of the machinery installed in the power house and substations is excessive, and the percentage of time that they will be working at anything like an efficient load factor is small, that we look about for ways and means of reducing the amount of machinery necessary and of increasing the time that it will be in actual use. As a matter of fact, these conditions are just what exist on most systems where electrification is contemplated, and it is to meet such conditions and make electrification an economic possibility that the high-voltage systems, viz., the three-phase system, the single-phase alternating current system and the 1,200 and 2,400 -volt direct current systems have been evolved; in other words, higher voltage is an economic necessity to avoid excessive expenditure in copper and in machinery which would only be working at part or no load for a great percentage of the working day.

The three-phase system has found but little favor up to the present in this country, while it has been very extensively adopted in Europe; but there is one case, viz., the electrification of the Cascade Division of the Great Northern Railway, where such a system has been in successful operation for some years in this country. It would seem in the light of our present knowledge that such a system, at least for conditions as they exist in this country, is likely to be confined to mountain grade work, where the advantages of regeneration can be secured. On the other hand, as the high potential direct current system has been developed with these same features, there seems little to warrant the additional complication of the three-phase trolley.

During the last decade the relative merits of single-phase alternating current and high potential direct current systems have been freely discussed, and many examples of each system have been installed and have been operated for a sufficiently long period to enable a logical opinion to be formed as to their relative merits. It would be impossible to enter into a detailed discussion of this phase of the subject in a paper of this length, but, judging from the results of operation, as published, and the number of single-phase interurban roads that have been changed from single-phase alternating current to direct current, and from the number of direct current roads now in successful operation, and the fact that no roads adopting higher direct current potential have changed, and the present ratio of alternating and direct current work now under construction and contemplated, it would seem safe to infer that at present, at least, the higher potential direct current road has a decided advantage over all other systems for heavy traction work.

What the future has in store no one can say. The alternating current system or some modification of it may be developed along lines that will enable advantage to be taken of its good features, and its inherent limitations to be overcome. And again, new modes of power transformation may come into use, such as rectifying alternating current to direct current when the advantages of the alternating current secondary distribution could be combined with the excellent characteristics of the direct current railway motor. But if we start speculating on the future, there is no limit to the range of our imagination.

There has recently been said, both in the technical press and elsewhere, a great deal about what pople are pleased to style "The Battle of the Systems." Some people have taken the attitude that electric railway developments have been hindered because all manufacturers of electrical apparatus are not agreed upon the best system for heavy traction purposes. Such people are prone to infer that such a condition of things is hindering development and that the manufacturers are responsible for this condition. As a matter of fact, such differences of engineering judgment, when there are several different methods of attacking a problem, must, in the long run, be beneficial to the railroads rather than harmful, as without such differences of judgment, the possibilities of the art can at best be but imperfectly developed. When any art has been developed to a reasonable state of perfection and the fundamentals have been well considered and thoroughly tried, and after the process of eliminating the less suitable factors and perfecting those which have shown themselves capable of meeting the necessary demands, under actual service conditions, has been carried to the point where our knowledge, based on experience, enables us to retain the good and reject the bad, then and not until then, is the time to talk of standardization. An attempt at standardization when an art is in a more or less embryo state is likely to work a permanent harm, inasmuch as it limits our knowledge of the broader engineering possibilities that might be brought to bear upon the subject. This question is of such importance to-day that it is worthy of consideration from both sides.

This so-called "battle of the systems" to-day is, as we all know, applied to heavy traction between single-phase and high-voltage direct current. Briefly, there are two courses open: to attempt to standardize one, or to try both. First, let us imagine that we are living under such conditions that an imperial edict has been issued that single-phase is par excellence, and that henceforth every railroad in the country that wishes to be electrified must use this system. This is not very far from what has happened in Germany. The first fruits of such a condition might possibly be that a great amount of talent would be focussed upon one subject and that developments along certain limited lines might be stimulated. Also, the customers or railroads would be relieved of any worry concerning the selection of the correct system. There would be no choice in the matter; they must take what was presented or leave it. Under such conditions, the field of research and development would be limited to such an extent that any inherent limitations in this one system of electrification would literally form a stone wall across the paths of progress. If there are inherent limitations in any system and we insist on its adoption, we are hindering rather than helping the permanent sound progress of the art. On the other hand, when there are two or more systems that are recognized as competitors, and there are, as it were, opposing camps, one side championing one system and the other side championing the second system, we are building on broader foundations. As a matter of fact, the battle of the systems is merely a bogg—the selection of the best electrical apparatus to meet the service conditions in any particular case is the settlement of engineering details—not the adoption or rejection of a system.

There are some engineering firms that have thoroughly tried out all the apparatus which has been developed up to the present time, and their judgment in these matters is tempered by experience and costly tests, and the railroad companies are getting the benefit of this experience.

The development of the higher potential direct current railroad is of peculiar interest, as the apparatus used has gone through such a logical sequence of evolution. It is just about a decade ago that we began to recognize that 500 or 550 volts was no longer the standard potential for railway work. The voltage had gradually been raised from these figures to 600 volts, until there were more roads operating on 600 volts than at any other potential. When this condition was recognized, 600 volts was talked of as the standard. The evolution from 500 to 600 volts was largely brought about by a gradual increase of the traffic on existing systems, the raising of the voltage being the simplest and cheapest method of meeting the severe demands. There have been isolated cases of roads operated at 700, 750 and 800 volts, and the step from these potentials to 1,200 volts was a comparatively small one. It should be specially noted that the increase from 500 to 600 volts made no difference whatsoever in the design, construction and operation of the equipments. When the jump to 1,200 volts was taken, it was made for purely economic reasons, and no radical changes were made in the equipment. To retain the good and well-tried features of 600-volt control, a very simple piece of apparatus called the "dynamotor" was devised which enabled the control and auxiliary circuits to be operated at 600 volts and the main motors to use the higher potential. The only change in the motors to suit the higher voltage was that they were insulated for 1,200 volts instead of 600 volts, the common arrangement being to operate two motors in series so that 600-volt windings were still used. The adoption of commutating poles on railway motors greatly facilitated the raising of the trolley potential without the introduction of complications. The marked success that attended the operation of 1,200-volt apparatus under severe service conditions encouraged further steps along the same line with the result that some roads of 1,500 volts were installed. The results were equally satisfactory. Most of the roads at present operating at higher direct current potentials are in the nature of interurban railways but some, however, approximated steam railroad conditions. In all cases the apparatus has proved itself as well suited to the severe conditions as the older 500- and 600-volt apparatus had. Under these circumstances it is not surprising that a still higher direct current potential should have been considered for a heavier class of service. In 1912, just five years after the first 1,200-volt road was put into successful operation in this country, 2,400-volt direct current was adopted as the most suitable system to meet the peculiarly severe conditions existing on the Butte, Anaconda & Pacific Railway—thus direct current apparatus has evolved from a small beginning until it has reached a stage where it meets the demands of the heaviest traction undertakings contemplated.

This is as far as we have gone at present in this direction, in actual practice, but there seem no logical reasons or limiting conditions that we know of at present which would prohibit the use of still higher direct current potentials.

Since the initial adoption of 1,200 volts, the extension of its use has been exceedingly rapid, and it may now be regarded as the standard for all new interurban railways. In some cases where marked economies can be secured 2,400 volts may be used in interurban service. One example of this is already under construction, viz., the Michigan & Chicago Railway.

The first road to adopt 1,200 volts in this country was the Pittsburgh, Harmony, Butler & New Castle Railway. This road started operation in 1907. Since this date, the extension of high potential direct current railways has been exceedingly rapid, as shown in the following table:

Date of installation.	No. of roads.	Total road mileage.
1907	1	41
1908	2	134
1909	0	0
1910	6	424.6
1911	2	201
1912	3	196.5
1913-14	17	1061
Totals	31	2058.1

Most of the roads are in the nature of interurban railways, but it should be noted that as far as we can see the vast majority of the heavy traction work now under construction or contemplation will employ direct current apparatus and this will, in most instances, be operated on "higher potentials."

We are apparently fast coming to recognize that there is such a thing as "a science of development" and that such a science among other factors must include the following fundamentals:

(1) An accurate determination of the actual operating conditions which will enable us to settle definitely what is wanted.

(2) The co-ordination of the work of a large number of differently trained men, so that the finished product may embrace the experience of each worker in his particular line, and thus become in every detail the product of experts.

(3) The confidence and co-operation of the users and makers of apparatus both before and after its manufacture, this co-operation to continue in some form or other during the useful life of the machine.

(4) The standardization of apparatus when such will be profitable to all concerned.

(1) There are, perhaps, many who do not realize the costliness of determining what is wanted to suit a par-

ticular set of service conditions. An accurate determination of the precise requirements will often necessitate months of exhaustive investigation, often including costly tests. This is particularly true in large undertakings. If we compare the work done in this direction to-day with the older haphazard methods of designing machinery first and seeing whether it would do the work afterwards, it is apparent that the art has benefited enormously by the work of the large corporation along these lines. Some phases of the research and development work undertaken to-day are so costly and require such a large staff of expert workers that no small engineering undertaking could shoulder the burden, as assumed by the large corporation.

(2) The proper co-ordination of the work of a host of men who are contributing to the design, manufacture and testing of electric railway apparatus is no small part of the Science of Development. The extent of this work is enormous, including as it does, preliminary proposition, final proposition, designing, drafting, actual manufacture and work incident to following apparatus through the factory, assembling, testing, installing, and preliminary operation. The final cost of the apparatus depends largely upon whether this co-ordination of work is done in a scientific or unscientific manner.

(3) A whole paper might be read with profit on the subject of the confidence and co-operation between the user and the maker. Upon the encouragement and extension of what we might call "the modern business idea," the rapidity with which we are going to develop in the future must largely depend. The successful development of electric apparatus for traction purposes depends on "how it is made" and "how it is used." The manufacturer is dependent upon the user just as the user is dependent upon the manufacturer. An ounce of mutual confidence and co-operation will do more towards the development of the art than a ton of fault finding and mutual distrust. In the broadest sense, the aims and objects of both parties are identical. The user wants the best obtainable for his service and the maker wishes to produce the best and most efficient apparatus, as upon this his reputation and future business depends. The work of all parties concerned is in reality the part of one great plan.

(4) The correct time at which the standardization of electric apparatus should be attempted is a science in itself, e.g., it would undoubtedly be profitable to all concerned if all trolley systems would co-operate with the manufacturers in using standard apparatus, especially standard railway motors and standard control equipment, where such standards will fulfill the requirements. There will, however, always be special conditions arising that will demand special apparatus, and the things that dictate these special requirements are many and varied, e.g.: Who could have foreseen that the fashion of ladies' skirts could affect the design of railway motors? But such has been the case—the hobble skirt gave birth to the low-step car—and the low-step car required a new design of motor.

The standardization of all apparatus that is used in large quantities and has reached a high state of perfection would be a great asset to the industry.

On the other hand, until we have more experience with the different systems of electrification, it would seem unwise to lay down too definite standards for heavy traction work, although it might be profitable to standardize such things as trolley voltages that would vitally affect the future development of the art as much as the present.

In conclusion, it is well to emphasize one point, namely, that modern engineering involves, above all things, the study of economics. Yesterday we were finding out how to do things—to-day we are striving to find out how to do them more cheaply than yesterday. To combat the increased cost of living and of labor, etc., and the generally more complicated social and commercial conditions under which we are living, the work of the scientist and the engineer is to teach the world at large how to do for one dollar that which they could not do for two dollars yesterday.

AN IMPROVED TUNNELING MACHINE.

In Fig. 1 is shown the side view of an improved pneumatic machine designed for driving an 8-ft. tunnel in rock. The machine is the invention of Mr. O. O. App, and is manufactured by the Terry, Tench & Proctor Tunneling Machine Company, New York.

The present design is a modification of a previous machine, the first of its type, introduced in 1908. This was practically operated in a rock tunnel in New York City, where it developed a capacity for cutting at the rate of from 1 ft. 4 in. to 3 ft. 4 in. per hour. While the improved machine is constructed on the same general principles as its predecessor, it embodies important modifications in detail. Through six years of experiments and tests in actual service conducted by the inventor, every detail has been carefully worked out and perfected to the point where it is now ready to be placed on the market.

As every engineer familiar with previous developments of this character knows, failures of tunneling machines in the past have been due chiefly to lack of capacity to stand up in all kinds of rock. One of the main problems has been to find a material for the vulnerable parts that would meet the drastic service requirements.

In the machine here illustrated, the chief difficulties have been to make it take care of itself automatically and to have the cutting tools and tool holders of the proper shape and quality to stand 1,000 rapid-fire blows a minute, each of sufficient power to chip ½ in. or more of rock.

An ingenious design of drill, worked out by the inventor, has successfully overcome the first of the above two troubles; the other has been solved by the use of vanadium steel for the cutting tools and the moving parts and other parts subject to wear of the drills. This has been clearly demonstrated by the results of actual service tests of the machine operating in the hard rock formation along the Harlem Ship Canal, in cutting the channel through which the greatest difficulty was experienced in the construction of the canal.

An unusual combination of hardness and toughness is essential to meet the duty placed upon the steel in this class of service. Probably no severer test could be given these properties of a steel than in this kind of a machine. It is because it combines these characteristics in an exceptional degree that vanadium steel has been used. Formerly, cutting tools 2 in. square and 12 in. long of high-grade carbon steel were used: whereas they now use tools 1⅜ in. square and 4½ in. long. Breakages have been practically eliminated and wear on the tools reduced. The inventor, to whom credit for the development of the device in all its details is due, claims that the type of steel used has made possible the achievement of a practical, efficient machine that will cut rock tunnel commercially.

The general construction of the machine is shown in the accompanying illustrations.

Sixteen 3-in. hammer drills are mounted on a massive cast steel revolving head with four arms or shafts. Each drill cylinder passes through an arm of the head and is firmly held in a swivel holder, thus permitting changing the hammers to the proper angle with the face of the rock.

Compressed air is supplied to the drills at 80 to 100 pounds pressure through the main horizontal shaft on which the head is mounted. This shaft is rotated by a worm wheel 3 ft. 4 in. in diameter, operated by a 25-h.p. air engine geared 200 to 1.

each complete revolution of the head. This action thus permits each cutting tool to carry positively a ½ in. chip of rock; and the machine thus removes a ½ in. layer of rock from the entire face of the tunnel for each revolution of the head.

The muck is removed by a belt conveyer, suspended from the forward diaphragm and carried by a pair of rear

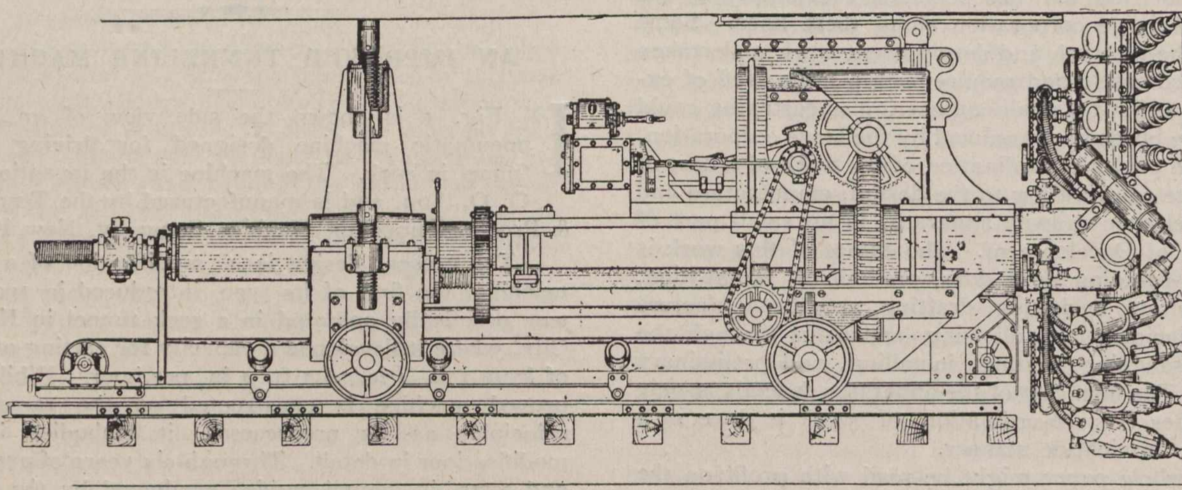


Fig. 1.—Side View of 8-ft. Tunneling Machine.

wheels. This is operated by a 2-h.p. electric motor, and delivers into dump cars on a track following the machine.

The shaft and engine are carried in a main horizontal frame with front and rear vertical transverse diaphragms, mounted on wheels.

In the upper part of each diaphragm are screw jacks which are operated to engage the roof of the tunnel and hold the machine firmly in position.

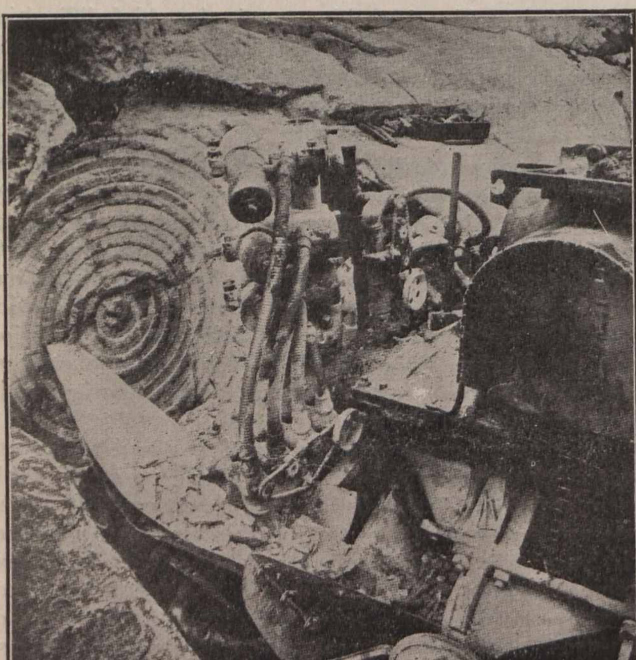


Fig. 2.—Showing Face of Bore Made by Tunneling Machine.

The machine is advanced by a pair of horizontal, longitudinal screw jacks 4 in. in diameter and of 36-in. feed. These connect the front and rear diaphragms and move them back and forth relative to each other, being operated by the central shaft by means of spur gears.

When the machine is in operation, the screw jacks move the front portion of the machine forward ½ in. for

One of the most interesting details is the improved type of drills, which are so designed that they are automatically governed by the character of the rock. The cutting tools have a slight longitudinal movement in the drill cylinders and are provided with ports which control the exhaust. They do not reciprocate; but are held in one position or another and receive the impact from the hammer, which weighs 25 pounds and strikes from 1,000

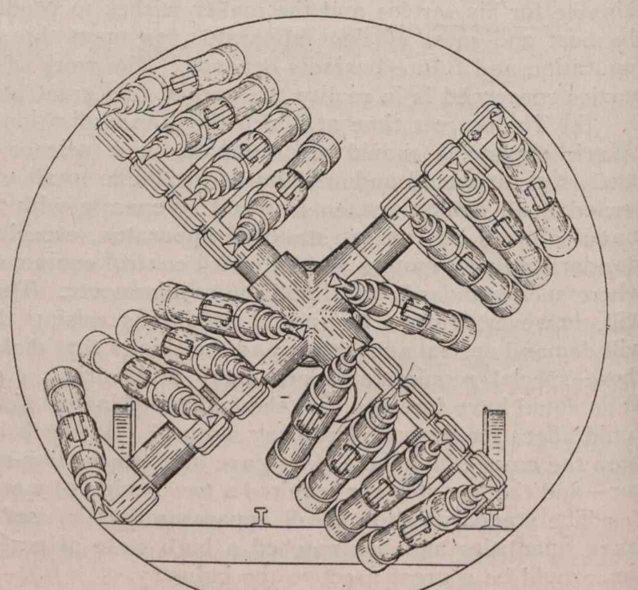


Fig. 3.—Front View of 8-ft. Machine.

to 1,200 blows per minute. When the pressure against the cutting steel is sufficient to overcome the constant pressure in the rock drill, it moves slightly backwards and opens the exhaust port, putting the hammer in operation against the head of the cutting steel. This action continues as long as the machine is in operation, and the cutting steel is forced against the rock with a pressure of about 100 pounds. If the resistance against the point of the cutting steel becomes less than 100 pounds, through soft rock, open fissures or other reasons, the interior pressure forces it forward, closing the exhaust port and stopping the action of the hammer piston. If the machine is still continued in operation, the cutting steel acts as a gouge, milling off the tunnel face until the resistance is great enough to force it slightly back in its seat, when the hammer action is resumed, thus maintaining uniform regular action and automatically stopping the hammers when they are not needed.

The tool holders are so designed that the entire set of sixteen drills can be changed in 15 minutes. The cutters are so arranged as to remove all of the rock in the face of the heading and provide clearance for the machine.

The muck is removed by the conveyer before any accumulation can interfere with the operation of the cutters in the lower part of the tunnel.

All parts of the machine are accessible while it is in operation in the tunnel.

This machine can be controlled and operated by one man and is expected in ordinary rock to have a capacity of from 25 to 50 lineal feet of 8-ft. tunnel in 24 hours.

The advantages of an efficient tunneling machine are readily appreciated. Such a machine offers possibilities for large economies in the cost of construction work. The present demand for a device of this kind to drive subway, aqueduct, hydro-electric, irrigation and pneumatic tube tunnels furnishes a wide field of usefulness.

KOOTENAY CENTRAL RAILWAY NEARING COMPLETION.

While on a tour of inspection through British Columbia last week, Mr. J. G. Sullivan, chief engineer of the western lines of the Canadian Pacific Railway, stated that about 20 miles of track beyond Spillimacheen was completed on the Kootenay central line south from Golden. It is expected that the entire line, from Golden to the junction point with the Crow's Nest line near Ft. Steel, will be open for traffic this season.

The new line, which will afford direct railway communication from the Crow's Nest to the main line of the C.P.R. through the Columbia valley is 160 miles in length. Sections from both ends have been finished for some time, the service being placed in operation from Golden to Spillimacheen, a distance of about 40 miles, several months ago. The Kootenay Central opens up a large tract of fertile land through the Columbia valley.

Discussing the work being carried on by the C.P.R., Mr. Sullivan said that the company was laying 600 miles of new track in the west this year. Another 80 miles of double-track line would be ready for operation in British Columbia by October next.

Ballasting is now proceeding on the 34-mile stretch of double track east of Kamloops, and on a nine-mile section west of Kamloops. Tracklaying is now proceeding on the 28-mile portion between Revelstoke and Taft.

The attitude of unconcern and doubt at first prevalent in connection with the Beaver Lake gold fields near Saskatoon, Sask., is rapidly changing into one of interest and importance as the result of the discovery of much definite and encouraging detail. Over 1,000 miners and prospectors are said to be already on the ground, and the mineralized area is stated to be quite extensive and very rich.

COST OF SUBWAY CONSTRUCTION.

Diagrams for facilitating preliminary estimates of cost of subway construction have been prepared by Mr. Frank H. Carter, Designing Engineer, Boston, and have appeared in "Engineering and Contracting," to whom we are indebted for the following concerning them and their use:

The art of subway construction has advanced so rapidly towards certain standards since its inception by the city of Boston about 20 years ago as to warrant a survey of present types and their costs.

The practice to-day may be said to have narrowed to two standard sections for two track subways, the single tube with arch roof or with flat roof. The former has certain advantages in the matter of ventilation over the flat roof and at the outset was supposed to be cheaper per lineal foot.

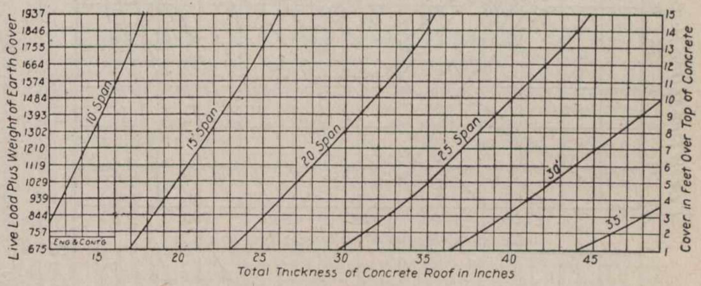


Fig. 1.

Both cross-sections are now generally designed to safely withstand the stresses consequent upon the removal of part of the earth backing on one side of the structure arising from the construction of cellars for adjacent buildings or the construction of sewers. Were it not for this provision, the arch section would undoubtedly be cheaper than the flat roof.

The flat or nearly flat invert has been developed with due consideration of the opinions of the engineers of Maintenance of Way with respect to depth of ballast.

Clearance lines have been adopted from a study of the possible use of the subways for the transfer freight cars, with a centre to centre distance between tracks of 12 ft.

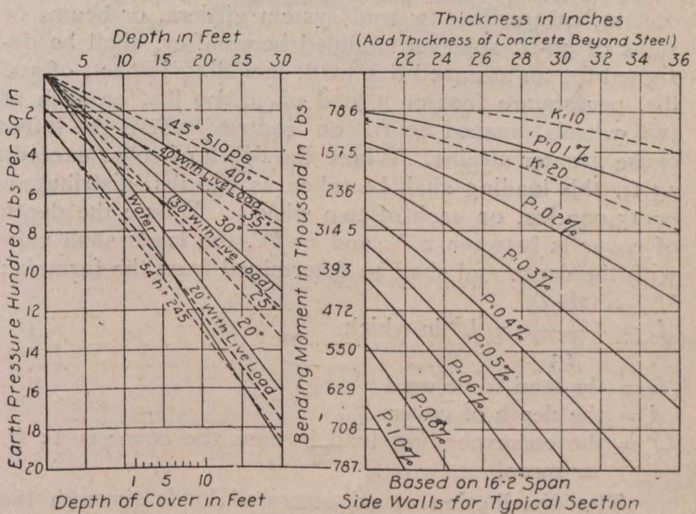


Fig. 2.

The allowable unit of stress in concrete and steel for parts of structure, subject to loads with impact, has been 600 lbs. per square inch for concrete in compression and 12,000 lbs. per square inch for steel in tension; for sides and invert of the structure, subject to quiescent earth pressure, unit stress of 800 lbs. per square inch for concrete in compression and 16,000 lbs. per square inch for steel in tension.

Live and dead loads somewhat as follows were specified for the Cambridge Main Street Subway, being varied slightly from time to time to suit the situation.

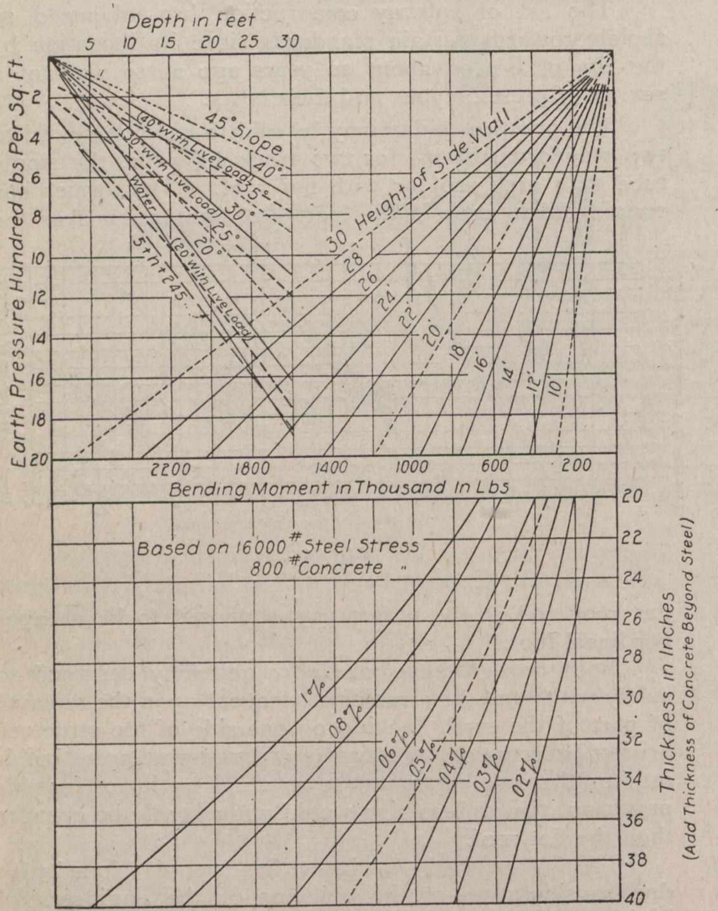


Fig. 3.

All parts of the structure under streets where the depth of cover from street surface to top of roof is 2 ft. or less, except floor or roof system girders, or beams or slabs of 30-ft. span as modified hereinafter, shall be designed for an assumed live load, including impact, of 500 lbs. per square foot or a load of 30,000 lbs. on each of two wheels, spaced 10 ft. on centres, where the latter cause greater strains. Where the depth of cover exceeds 15 ft. this loading shall be taken as 250 lbs. distributed, or 15,000 lbs. on each of two wheels. Where the depth of cover is between 2 ft. and 15 ft., the loads shall vary with the depth and shall be determined from the formula:

$$L = \frac{(28-d)}{13} \times L^{\circ} \text{ in which}$$

L = the load to be used.

d = the depth of cover.

L° = the corresponding load in case the cover is 15 ft. or more.

The distribution of concentrated loads through the earth (and concrete in the case of a reinforced concrete roof) in addition to the reduction for depth of cover, shall be assumed a trapezoid in a vertical plane at right angles to the direction of the span, 2 ft. wide on top and sides sloping outwards ½ to 1. Live loads for floor or roof system girders carrying over 100 and less than 200 sq. ft. of roof may be reduced 10 per cent. before applying other corrections; over 200 and less than 300 sq. ft., 20 per cent.; over 300 and less than 400 sq. ft., 30 per cent.; over 400 and less than 500 sq. ft., 40 per cent.; over 500 sq. ft., 50 per cent. Where the span of a beam or slab is over 30 feet, excepting as provided for the floor or roof system girders as above, uniform live loads may be reduced before applying other corrections 10 lbs. per square foot for each foot of span more than 30.

In general, two-track subway construction to-day will cost from $250 to $300 per lineal foot, depending upon the character of the material through which it is built as well as the depth of rail below the surface of the ground. Earth excavation for subway construction including the removal or support of street railway tracks during construction and street surfacing and the complete restoration of both, also the sheeting and bracing of trenches and underground water pumping will cost from $2.50 to $5 per cubic yard with an average perhaps of $4 per cubic yard. Concrete will cost from $8 to $12, including labor and materials but exclusive of the cost of steel reinforcement or its placing. Steel reinforcement will, of course, vary with the market but may be estimated at 2 cents per pound with an allowance of ¾ cent per pound for cutting, bending and placing, or at the rate of $15 per ton of 2,000 lbs. The item of cutting, bending and placing steel may be reduced to $8 per ton under proper management.

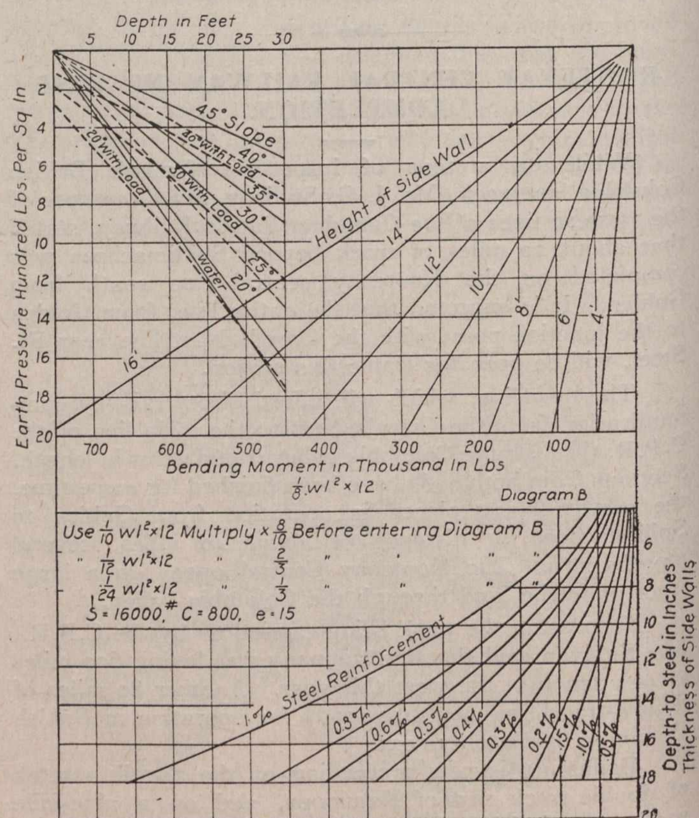


Fig. 4.

Thickness of Concrete.—The thickness of the side walls of the arch section should be decided only after study of the stresses in the arch proper and the consequent economical thickness of the arch ring. This observation applies as well to the invert of the arch section because of the racking stresses at the lower corners of the section due to the assumptions in regard to deep trench excavations on one side of the structure. In other words, the thickness of side walls and invert depends upon the arch thickness to a certain extent. This does not apply in the case of the flat section, the thickness of whose side walls is not closely related to the thickness of the roof. It is in this case, however, desirable to maintain the thickness of side walls and invert at the corner very nearly the same because of the racking stresses due to the assumption of a deep trench on one side of the structure.

Fig. 1 gves the allowable total thickness of roof for the specified loads and allowable unit stresses of 12,000 lbs. per square inch on the steel in tension and 600 lbs. per inch on the concrete in tension.

Fig. 2 gives the thickness of side wall for the typical section under the earth pressures specified and for the unit stresses of 16,000 lbs. per square inch tension in the steel and 800 lbs. per square inch compression in the concrete.

Fig. 3 gives the thickness of side walls for section greater than the standard in height.

Fig. 4 gives the thickness of side walls of sections less than the standard height.

Fig. 5 gives the thickness of side walls for section composed of steel beams placed vertically.

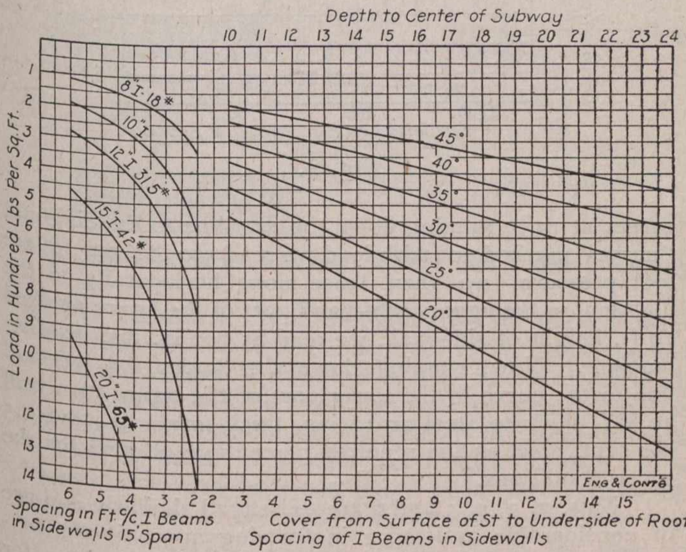


Fig. 5.

Fig. 6 gives the allowable thickness of side walls of typical sections of subway with no steel reinforcement assuming a tension of 60 and 120 lbs. per square inch in the concrete for K of 10 and 20 respectively.

The costs of subways per lineal foot given below in the table are from actual designs of sections, as shown in Figs. 7 and 8, for the arch and flat roof respectively. The cost of arch or flat section is practically the same per lineal foot of subway for a depth of rail of 26.5 ft. below the surface. It is probable that the arch section is the more stable, better ventilated and perhaps more attractive in appearance, though obviously the latter feature is scarcely worthy of consideration.

For other widths of subway, the cost is almost directly proportional to the width of section, for instance, for a 25-ft. section our diagram reads $285 as the cost per lineal foot of structure. For a one-track subway, therefore, we should have (13 ft. span) $150 as the cost per lineal foot and for a six-track structure $900 per lineal foot of structure.

It is observed that this cost is about $11.40 per square foot and a variation of roughly 27 cents for each foot in depth. Indeed, Mr. Howard A. Carson states that subway stations of simple construction may be roughly estimated at $12 per square foot for a depth of rail below the surface of 20 ft., allowing 20 cents per square foot for each additional foot of depth below 20.

The removal and care of underground structures, such as sewer, gas and water pipes, must of course vary considerably from the very expensive work required, for instance, along the lower reach of Market Street, Philadelphia, down to some of the simplest work costing little or nothing.

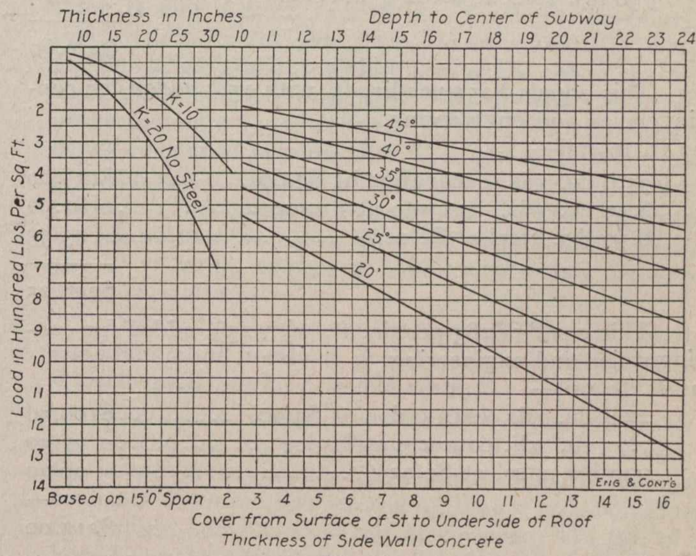


Fig. 6.

As an average at least $12 to $15 per lineal foot should be added to the cost given in the diagram as the cost for caring for underground structures.

With regard to underpinning of buildings along the line of construction, it is extremely difficult to give reliable or satisfactory figures. As a guide, however, the following three instances are cited, the authority of which is unknown. It costs to underpin along subway construction a building four stories in height 21 feet deep $122 per lineal foot of frontage. Another building of four

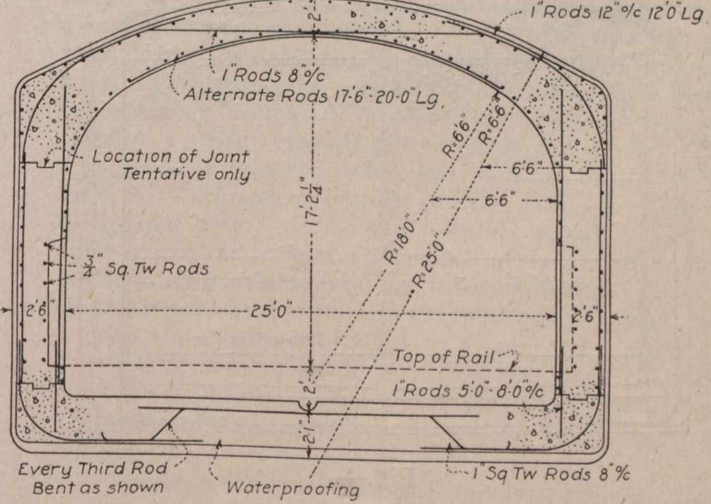


Fig. 7.

stories 11.6 ft. deep cost $120 per lineal foot of building frontage. Still another building of seven stories 20 ft. depth of underpinning cost $153 per lineal foot of building frontage. It is reputed that the foregoing costs are from work done by the city of Boston. It is estimated that underpinning for a six-story brick building might cost $150 per lineal foot of building, while that for a two-story brick building might cost $90 per lineal foot of building with a graduated scale of prices for buildings of different heights.

Standard Arch Section.

21 ft. to rail—

28.8 cu. yds. excavation at $4.00	$116.00
8.19 cu. yds. concrete at $10.00	81.90
790 lbs. steel at $0.02¾	21.70
	$219.60

This equals $252 per lin. ft. with 15% added for contingencies and engineering.

27 ft. to rail—

35.6 cu. yds. excavation at $4.00	$143.00
8.19 cu. yds. concrete at $10.00	81.90
8.50 lbs. steel at $0.02¾	23.35
	$248.25

This equals $285 per lin. ft. with 15% added for contingencies and engineering.

21 ft. to rail—

27.4 cu. yds. excavation at $4.00	$109.50
7.73 cu. yds. concrete at $10.00	77.30
990 lbs. steel at $0.02¾	27.20
	$214.00

This equals $246 per lin. ft. with 15% added for contingencies and engineering.

Flat Roof Section.

27 ft. to rail—

34.0 cu. yds. excavation at $4.00	$136.00
8.36 cu. yds. concrete at $10.00	83.60
1,075 lbs. steel at $0.02¾	29.60
	$249.20

This equals $287 per lin. ft. with 15% added for contingencies and engineering.

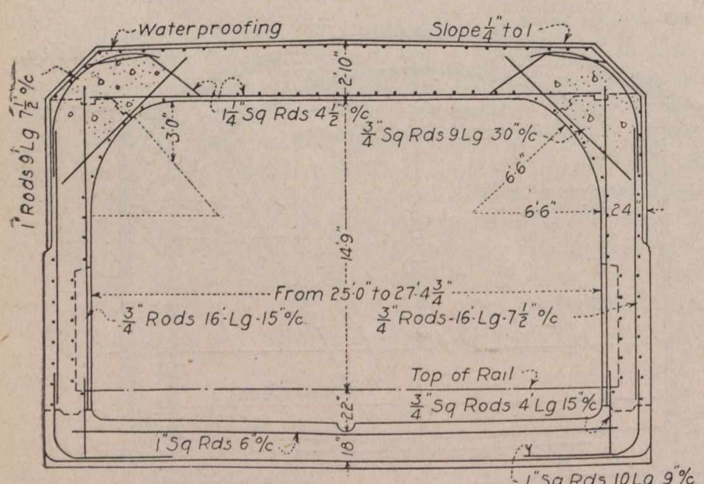


Fig. 8.

For underground structure add $12 to $15 per lineal foot and for waterproofing the outside with concrete protection to the waterproofing add $19 per lineal foot.

An example will illustrate the use of the curves for approximating the preliminary design of a sewer closely enough for the estimation of its cost.

It is required to design the roof and side walls for a rectangular sewer with a cover of 6 ft., span of 15 ft. and height of side walls of 10 ft.

First, from Fig. 1 we find for a cover of 6 ft. and a span of 15 ft. that the roof should be 20.6 ins. in thickness for 1.07 per cent. steel stressed 12,000 lbs. per square inch and concrete stressed 600 lbs. per square inch. Then, from Fig. 4 for a slope of material of 30° with super load, and for a distance below the surface of "*centre of depth*" of side wall, which consists of the sum of the following: Six feet cover plus 20.6 ins., the thickness of the roof plus 5 ft., which is one-half the height of the sewer walls or a total depth of centre of the side wall of 6 + 1.7 + 5 = 12.7 ft., we enter the diagram at the upper left-hand

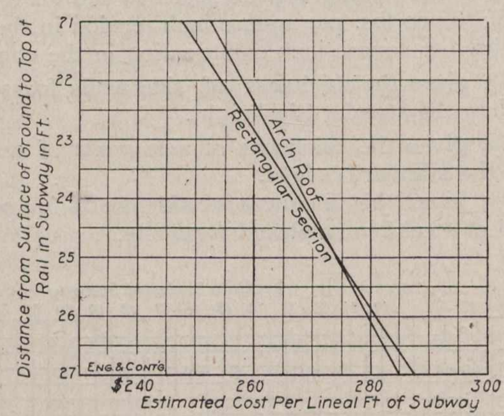


Fig. 9.

corner at 12.7, running down the 12.7 line to the diagonal "curve" marked 30° with load we read 570 lbs. per square foot pressure, we then trace along horizontally to the diagonal in the upper right-hand part of the figure marked 10 ft. height of side wall, we read 85,000 in. lbs. bending moment. Now, running down the 85,000 lbs. vertical line to the curve in the lower part of the figure to a wall 10 ins. thick to steel or 12 ins. thick total, we read 0.5 per cent. steel as the required percentage of steel for the given conditions.

Figs. 2, 3, 4, 5 and 6 are to be read similarly and are of considerable assistance in forming approximate estimates of cost or in checking designs of sections for construction.

THE ST. PAUL ELECTRIFICATION.

The St. Paul railway across Montana is the biggest thing of this kind that has yet been undertaken. The "Boston News Bureau" gives the following data. The electrification will comprise 440 miles of line. With normal traffic about 60 electric locomotives will be needed as against 82 steam locomotives. Electric power will be supplied by the Montana Power Company at 0.536c. per kw. It is estimated that 5,000 to 6,000 tons of copper will be required, or at the rate of 11½ to 13½ tons per mile. The work has already been commenced. The entire job should be finished by January 1st, 1918. It will cost about $8,000,000.

The engineering faculty of the University of Western Australia was established in 1913, and is conducting degree courses in civil, mining and electrical and mechanical engineering.

A recent report made to the Edmonton industrial association is to the effect that a virgin gold field has been discovered in the unexplored Liard River district of northern British Columbia, about 1.500 miles northwest of Edmonton, in a district which is declared to be extremely difficult of access, owing to the unfriendly attitude of the Indians inhabiting it.

SOME TRACK CONSTRUCTION STANDARDS FOR 1914.

THAT there is apparently no standard practice in track construction for street and radial railways is plainly evident from the widely differing standards of different public utility corporations. Transit companies go ahead, from year to year, improving their own standards by every possible means, but the indications of general standardization are not many. Examples of track construction standards for a number of cities are given below. For them we are indebted to "Electric Traction," and have selected those which will be of particular interest to electric railway men.

Columbus, Ohio.—Fig. 1 shows longitudinal and cross-sections of the track construction being used by the Columbus Railway, Power and Light Company, of Columbus, Ohio, at the present time. This is laid with Lorain section No. 434, 7-in. girder groove rails, 116 lb. to the yard, which are carried on Carnegie steel ties, section M-25, with the broad face turned up and spaced at 4-ft. 6-in. centres. The concrete base is carried up over the base of the rails to form the foundation for the pavement. The concrete is carried to a depth of 12 in. below the base of the rail to form a girder 18-in. wide and is also brought down low enough between the rails to protect the ties. On top of the concrete a comparatively dry cement mortar is used in which to set the wood block paving. This variety of paving has been found to be very satisfactory and will be made use of by the company in its new work wherever possible. When 3½-in. blocks are used the steel tie rods are laid flat underneath the blocks. When 4-in. blocks are used, however, the tie rods are placed edgewise and the bottom corners of the adjacent blocks are chipped off in order to make the blocks come together.

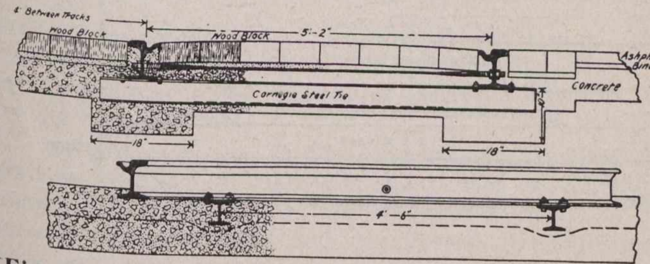


Fig. 1.—Columbus Railway, Power and Light Company.

The joint construction in Columbus has had a very interesting development. On one of the old types of track with 9-in. 94-lb. grooved-rail Lorain section No. 313 the joint was constructed by placing a piece of old rail having the same width base underneath the joint and buried in the concrete. Continuous rail joints were open up to include the base of the under rail which was turned bottom side up and the whole structure was bolted and bonded together and anchored in concrete.

The next joint development was used in connection with track employing the same weight and section of rail and was made by using a section of Carnegie steel tie of sufficient width to allow the fastening of the rail with Carnegie clips placing three clips on each side of the rail at each joint. This joint was bonded with compressed terminal bonds.

The present joint construction is the well-known Clark joint with some slight variation. In place of rivets eight drive-fit bolts are used with plates 30 in. long. A section of the Carnegie tie used as cross ties is cut off 36 in. long and placed underneath the joint parallel to the rail. These bottom bars are then welded to the rail, taking the place of the bottom thermit weld of the Clark joint and forming the bond.

Cincinnati, Ohio.—The standard track construction of the Cincinnati Traction Company is especially interesting for the thorough manner in which the sub-grade is drained and for the substitution of knee braces for the usual tie-rods.

As the gauge in Cincinnati is 5 ft. 2½ in., it is necessary to excavate for the sub-grade to a width of 9 ft. 2½ in., the depth being 21 in. Along the centre line of the track is dug a ditch 12 x 12 in. In about the centre of this is run a line of 4-in. farm tile surrounded by washed pebbles which come to within 2 in. of the top of the ditch. This space is filled with loam. In the track excavation proper is laid a 1:3:7 concrete mixture, standard oak ties being embedded in same with 6 in. underneath and about 2 in. on top. On top of this is a sand cushion for the paving. The company uses a 9-in., 140-lb. Trilby rail, Lorain section No. 402, with cast weld joints. Ties are spaced on 24-in. centres at joints where they are spaced on 28-in. centres.

Cast weld joints are used in tangents, with continuous joints at all breaks in grade and also in all curve work whether plain work or special work.

The company has found the knee brace preferable to the tie rod, as the great trouble with the tie rod was in the laying of the paving, and it was frequently found that a certain vibration was caused by the tie rod, resulting in the paving being pushed out of surface. The use of the knee brace has eliminated this trouble.

This type of construction has been in use in Cincinnati for practically seven years. The only change which has been made in the company's practice has been in the rail section itself, the rest of the work being substantially as adopted at that time. The results obtained from this construction have been very satisfactory as not a dollar has been spent on the foundation or drainage; the only expense the company has been subjected to has been an occasional slip of a joint, which has been, up to the first of this year, about ¾ of 1% of the total number of joints poured.

Lexington, Ky.—The standard construction of the Kentucky Traction and Terminal Company is to excavate a sufficient depth to allow 6 in. of crusted stone under the ties. After first thoroughly rolling the sub-grade and boarding, if necessary, any soft spots, should such be encountered, a course of crushed rock, broken to pass through a 2½-in. ring, is placed on the sub-grade. This is rolled with a 10-ton roller, and then the ties, 6 in. x 8 in. x 8 ft. and spaced on 2-ft. centres, are laid. Ties are all treated with Carbolineum. Eighty-pound A. S. C. E. open-hearth rail is used. The track is then tamped under traffic to a true surface and line. This tamping is repeated until it is evident that the ties are thoroughly bedded. The broken stone is then brought to a point 2 in. above the base of the ties, and the space between that point and the base of the rail is filled with a 1:3:5 concrete mixture. Over this a sand cushion is spread, on which to lay the paving.

A special cut granite block is laid longitudinally along the gauge side of the rail. This granite block is laid in a bed of a dry mixture of one of cement and two of sand. The brick on the outside of the rail and in the devil's strip are laid ¼ in. below the top of the rail so as to prevent breaking the skin of the brick with worn treads. All paving is laid level as this company's experience has been that it gives better riding conditions for vehicular traffic.

After the brick paving has been thoroughly rolled with a 5-ton roller, it is grouted with a mixture of one of Portland cement and two of sand. This grout is allowed to set for three days before vehicular traffic is allowed on the paving. The grout is applied in two applications, the first one being very thin so as to run into all crevices and voids. The second application, about the consistency of a rich cream, is carefully swept into all crevices, and is made before the first has had a chance to take an initial set.

The practice of this company is not to plaster the outside of the rail between the head and the base but to lay the brick snugly against the rail and allow the grout to fill this space.

An electrically welded joint, purchased from and applied with an Indianapolis Frog and Switch Company's outfit, is being used this year. Before allowing traffic on the track all joints are dressed off with a reciprocating rail grinder, so as to make the riding service absolutely true at the joints.

work trains, smaller material is delivered by a 3-ton Packard auto truck. For drilling holes for bonding, tie rods, etc., four Duntley electric track drills are used, and two Duntley electric grinders are employed for polishing rails in connection with bonding work.

Brooklyn, N.Y.—The chief feature of the standard type of surface track to be used in reconstruction of various sections of the Brooklyn Rapid Transit system during the present season, is that the ties are laid directly on the natural soil, which is a loamy sand, with good natural drainage. This company's experience has been that a ballast or concrete foundation is not necessary.

The natural soil is well compacted at the level of the sub-grade, which is 13 in. below the top of the rail. Long leaf yellow pine, 6-in. x 8-in. x 8-ft. ties, of prime inspection, are laid on this sub-grade on 2-ft. centres. A 1 :3 :6 gravel concrete (1½-in. washed gravel, graded) is poured between the ties and to 1 in. above them. On top of this is a 1-in. sand cushion for the 5-in. granite blocks. The rails, which are 7-in., 105-lb., grooved girder, in 60-ft. lengths, are fastened to the ties by 9/16-in. x 5½-in. spikes, four per tie, with 2-in. by ⅜-in. tie rods having ⅞-in. ends and spaced 6 ft. centre to centre. Thack joints are of the Falk cast welded type, weighing 190 lb. per joint and being placed opposite to each other. The space between the rail and the granite blocks is filled with a 1 :4 cement grout while the interstices between the paving blocks are filled with a 1 :1½ cement grout.

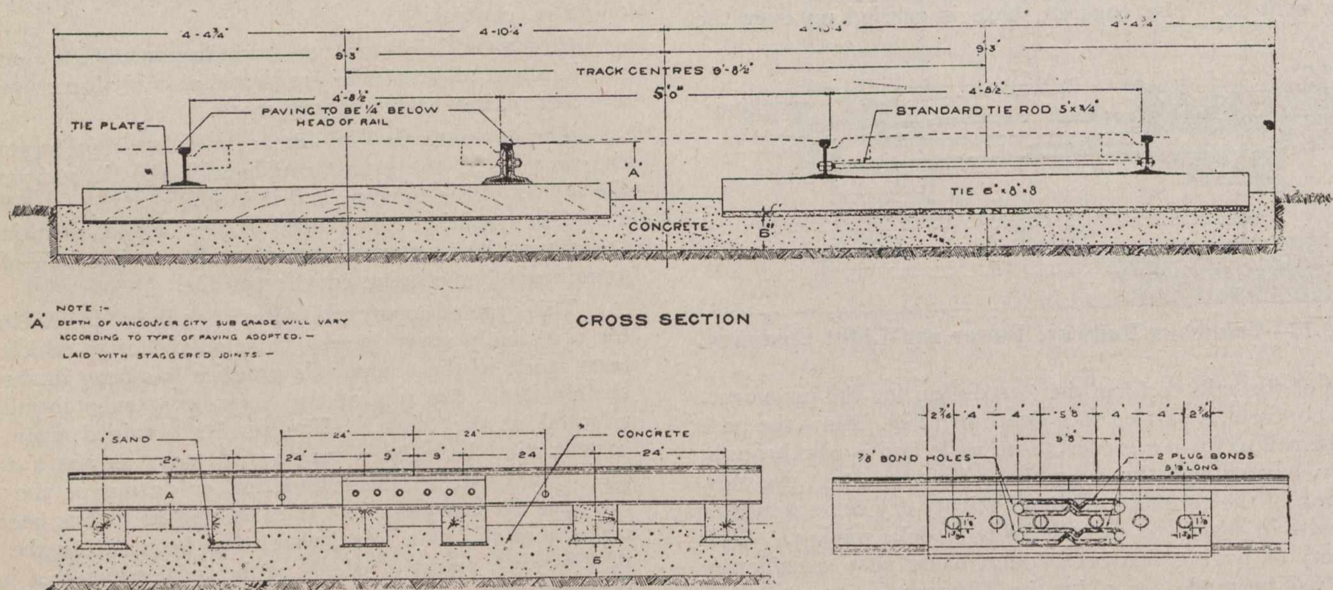


Fig. 2.—British Columbia Electric Railway Company Standard, Showing Sections and Detail of Drilling and Bonding.

Vancouver, B.C.—In its standard construction in Vancouver, B.C., the British Columbia Electric Railway Company uses 91-lb. high T-rail on its main lines and 70-lb. high T-rail on branch lines. For double track, the concrete slab foundation is made 18 ft. 6 in. in width and 6 in. in depth, partially embedding the ties. There is, however, a sand cushion under the ties varying in thickness from 1 to 2 in. The ties are rough fir (sawn) of standard size. Tie plates are used, being Australian gum ⅜ x 8 x 10 in. Other interesting details of construction are as follows: Spikes, railroad, 9/16 x 5½ in.; joint bonding, two 10-in. plug bonds, brazed with thermit; cross-bonding, two 300,000-cm. cables every 200 ft. of track; joint plates, continuous, suspended; bolts, 1 x 4½ in., oval neck, rolled thread; tie rods, ⅜ x 2 in. with ¾-in. terminals.

All track construction and reconstruction is carried out by the company's forces. Excavation is taken out with a No. A-1 Thew steam shovel to a depth of 20⅜ in. For doing the necessary concrete work before and after the track is laid five Koehring special street paving mixers, No. 14, are employed. Rails and ties are delivered on the job with a steam and an electric Brownhoist derrick and

Davenport, Iowa.—The Tri-City Railway Company uses both the concrete base and ballast construction in its track work. Except in cases of badly drained or a settling sub-grade, the ballast construction is preferred, and as a general thing a concrete paving base is employed only when required. In all cases the company favors the concrete paving base, as shown in the accompanying drawing.

In the ballast type of construction, a trench, 8 ft. 6 in. wide by 29 in. deep, is excavated. After rolling, 6 in. of crushed rock, broken to pass through a 2-in. ring, is laid as the first course. On this are laid 6-in. x 8-in. x 8-ft. ties, and crushed rock is placed around them 2⅞ in. above their base. On top of this is placed a 1 :3 :5 concrete, 5 in. in depth; then a ½-in. sand cushion on which to lay the paving brick. The ties are, for the most part, No. 1 6-in. x 8-in. x 8-ft. red oak, zinc chloride treated, and are spaced from 24 in. to 30 in., according to the prospective duty of the track. Standard spikes are used, without plates.

In the concrete base type the trench is made 9 ft. wide and 17 in. deep, from the top of rail. The concrete, a 1:3:5 mixture, entirely covers the ties, with 4 in. underneath and 6 in. at the ends. At the centre line of track

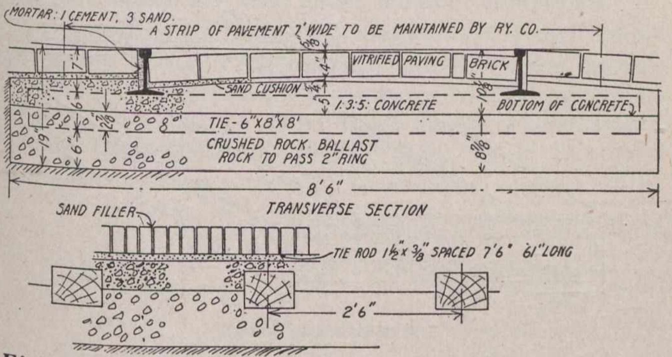


Fig. 3.—Tri-City Railway Company, Davenport, Iowa.

the concrete comes 11⅞ in. above the trench bottom. The concrete runs about 29.4 cu. yd. per 100 ft. There is ¾-in. sand cushion on top of the concrete, on which the paving brick are laid.

Of late years the Tri-City company has favored the six-hole continuous suspended joint with a concealed bond. There has been no one standard of bond, as the soldered, pin expanded and compressed terminal types have been used, each in considerable numbers.

While T-rail is generally preferred and used, when required by ordinance or possibly in case of very heavy street traffic, a 7-in. girder, Pennsylvania section 80-238, is used. Also, where required with the Shanghai rail, a special nose brick may be used, but the company's preference is the plain brick, as shown.

In general, it is the plan to secure permanence of construction by careful workmanship along the line of accepted standards rather than through attempting radical departures.

The rails used are the British standard section, girder type, 60 ft. in length. The straight track section weighs 110 lb. per yd., and the curving section weighs 116 lb. per yd., the extra weight on the latter section being due to the thicker lip or guard. The fishplates are 2 ft. in length, and are secured with six 1-in. bolts.

The Glasgow Tramways have recently decided to weld all joints on renewals and on new track. The welding may be either electric or by the thermit process. In the former case the fishplates are put on in the usual way, then welded in position; in the latter case, no fishplates are used.

About three years ago, a portion of track in the centre of Glasgow, where the traffic amounts to about four cars per minute, was welded by the former process, and up to recently there had been little or no expense for repairs.

Crown bonds are used at each joint whether the joints are welded or fishplated, in addition to cross-bonds at frequent intervals. The tie-rods, of mild steel, are 2½ x ½ in. in section and are spaced on 5-ft. centres. These are screwed at both ends with thick plate washers on each side of the rail web.

In new work, the class of paving will be the ordinary dressed granite sets, measuring 6½ in. deep, 3½ in. thick and varying from 6½ to 9½ in. in length. The tendency, however, in the city is to put down what is termed nidged granite blocks, the dimensions of which are 6 in. in depth, 6 in. in width and from 7 to 10 in. in length. These sets are hammer-dressed on five sides, ends, sides and top. Particular attention is paid to the top surface to have it perfectly flat. They are very closely jointed together in a bed of cement mortar, the proportions of the mortar being four parts of sand and one part of cement. They can either be grouted with cement or pitch, according to the time the traffic can be kept off. When sets of this kind are laid the street has a perfectly smooth surface. They are, however, very expensive, costing more than double the ordinary sets.

Some years ago, the Glasgow Tramways laid several miles of track on cross-timber ties. These extensions were several miles from the centre of the city, consequently the traffic is not so great. The track, however, has needed little or no repair all these years, but there is now considerable difficulty in obtaining the necessary ties, and on new extensions it is planned to use only concrete base, as already described.

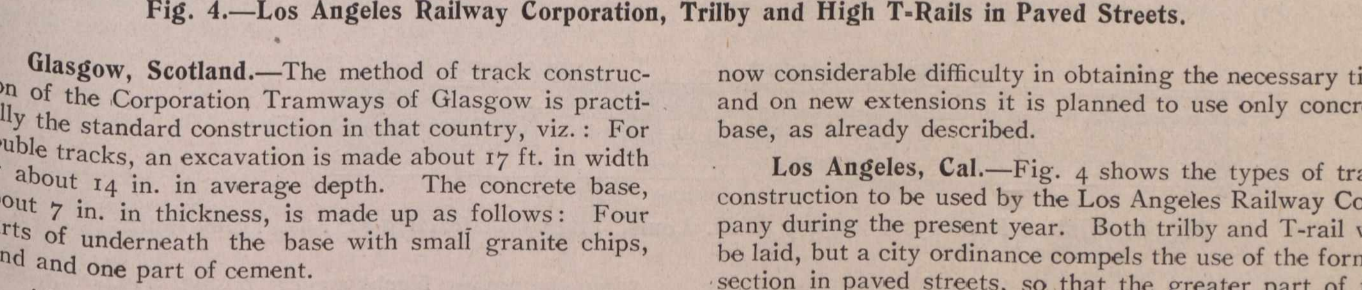


Fig. 4.—Los Angeles Railway Corporation, Trilby and High T-Rails in Paved Streets.

Glasgow, Scotland.—The method of track construction of the Corporation Tramways of Glasgow is practically the standard construction in that country, viz.: For double tracks, an excavation is made about 17 ft. in width by about 14 in. in average depth. The concrete base, about 7 in. in thickness, is made up as follows: Four parts of underneath the base with small granite chips, sand and one part of cement.

After the concrete has set hard, rails are laid in position to line and level, after which they are packed underneath the base with small granite chips, sand and cement, mixed in the proportion of 4:2:1.

Los Angeles, Cal.—Fig. 4 shows the types of track construction to be used by the Los Angeles Railway Company during the present year. Both trilby and T-rail will be laid, but a city ordinance compels the use of the former section in paved streets, so that the greater part of the track to be laid this season will be of that type of construction. The trilby rail used is a 7-in. 116-lb. section, while the T-rail is a 7¼-in. 87-lb. section. With the trilby rail a six-hole continuous joint and brace tie plates, spaced every third tie, are used; the T-rails are thermit welded.

For ballast the company uses crushed rock, crushed rock grouted, or concrete, to a depth of 6½ in. below the ties. In the two types of construction shown in the accompanying drawing, crushed rock is used under, around and between the ties to within 1 in. of their top. On top of this is poured concrete which embeds the base of the rails and forms the immediate foundation for the paving.

streets are shown in Fig. 5. In paved streets the earth is excavated to a depth of 20¼ in. below the top of the rail. In this trench is placed 9 in. of gravel ballast, which extends around the ties 1 in. above their base, while pit run gravel concrete, with proportions of 9:1, is used level with the top of the ties. The ties are long leaf Texas pine, 6 in. by 8 in. by 6½ ft., the track gauge being 3 ft. 6 in. They are treated in an open tank with hot carbolineum. The rails are 73-lb. T, with the ends sawed to

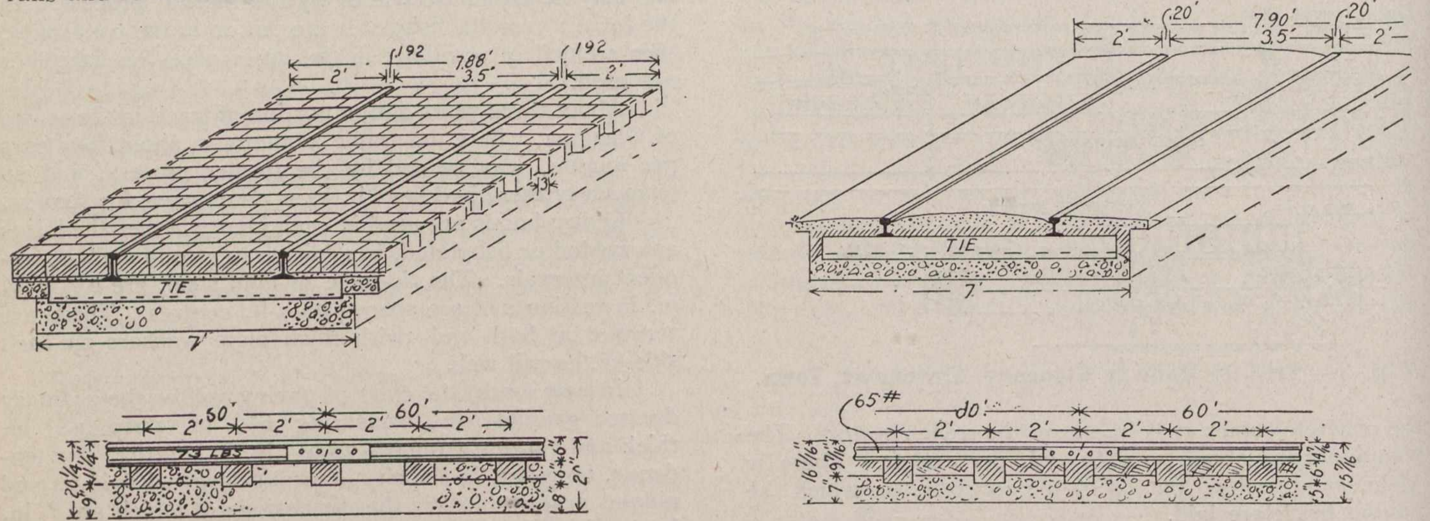


Fig. 5.—Denver City Tramway Company—Track Construction for Paved and Surfaced Streets.

Redwood ties, 6 x 8 in., are used; they are spaced at 20-in. centres.

The company paves its track to a point 2 ft. beyond the outside head of the rail, in accordance with city specifications. Where it paves in the trilby rail granite

a 10-deg. bevel, to provide for the bevel joint which is peculiar to the Denver construction. A 22-in. angle bar, weighing 11 lb. per ft., is used, together with 1-in. bolts. Under the splice plates 4/0 electric brazed bonds are used. The paving is crowned in the centre ¼ in. above the rail,

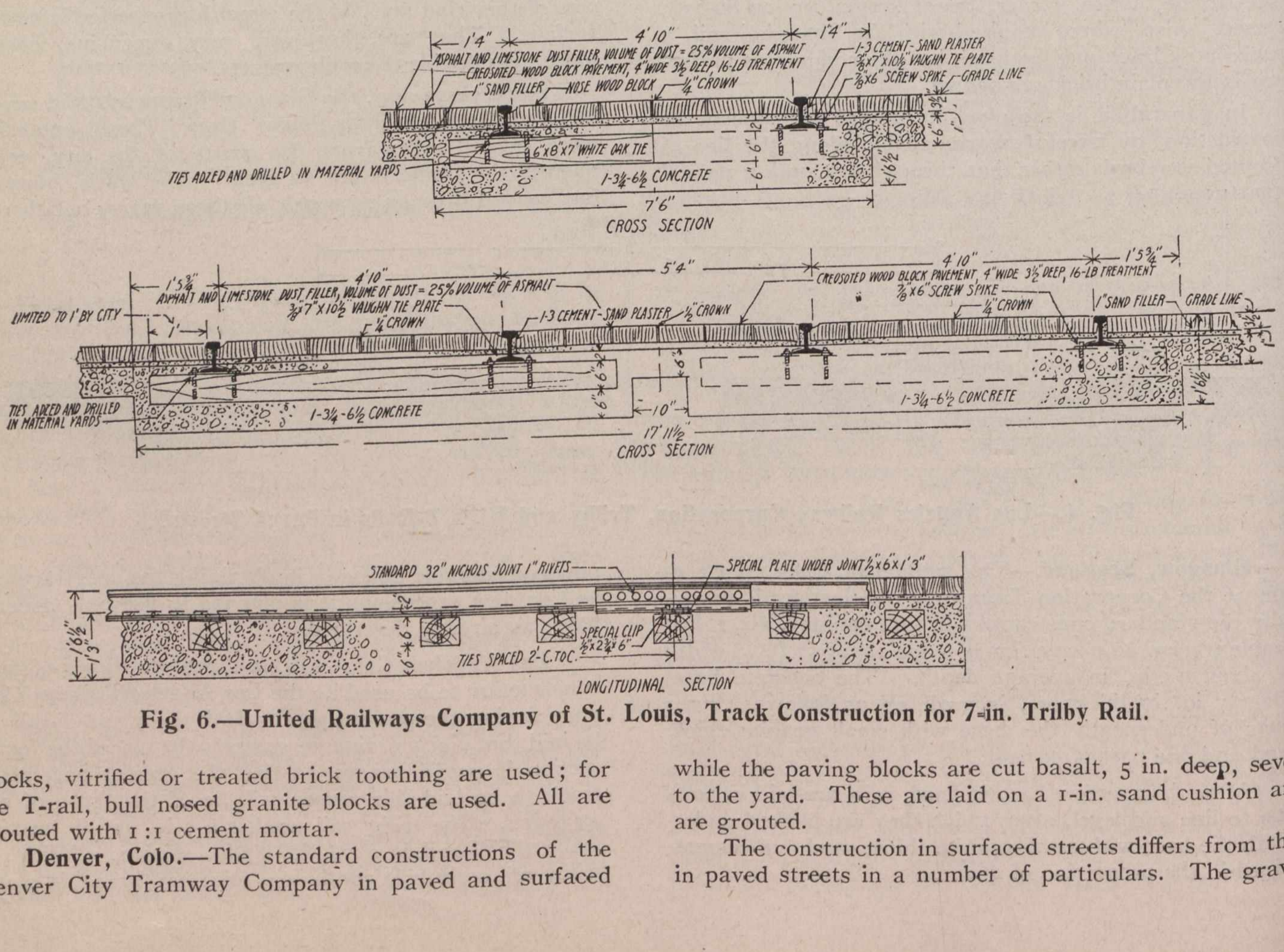


Fig. 6.—United Railways Company of St. Louis, Track Construction for 7-in. Trilby Rail.

blocks, vitrified or treated brick toothing are used; for the T-rail, bull nosed granite blocks are used. All are grouted with 1:1 cement mortar.

Denver, Colo.—The standard constructions of the Denver City Tramway Company in paved and surfaced

while the paving blocks are cut basalt, 5 in. deep, seven to the yard. These are laid on a 1-in. sand cushion and are grouted.

The construction in surfaced streets differs from that in paved streets in a number of particulars. The gravel ballast under and around the base of the ties is 7 in. deep. In place of the concrete on top of this, as in the other type, earth is used, with 3 in. of screened gravel on top. This is crowned in the centre ½ in. above the rail. A 19-in. angle bar, 9.2 lb. per ft., is used, together with ⅞-in. bolts. The rail is a 65-lb. T-section.

A number of variations in the type of paving aside from that shown are used under different conditions.

The company's franchise provides that it shall maintain paving between the tracks and 2 ft. on the outside of each rail. Sometimes the company lays the paving to this 2-ft. line, and at other times makes arrangements with the city's contractor to pave a portion of this strip in. deep, with 6 in. under the ties and 5 in. above them.

The pavement of the tracks consists of brick, granite blocks or creosoted wood blocks, depending upon the pavement of the street outside of the tracks. The creosote wooden flange, shown in the drawing of the T-rail construction, will not be used on the work planned for this year as the city authorities have agreed to the trying out of granite flange blocks along the rail with wood blocks, brick or granite blocks in the centre of the track between the rows of flange blocks.

The main features of the various types of construction for girder tracks are the use of the solid concrete type of foundation; untreated white oak ties, of standard dimensions, laid 2 ft. centre to centre, the ties being

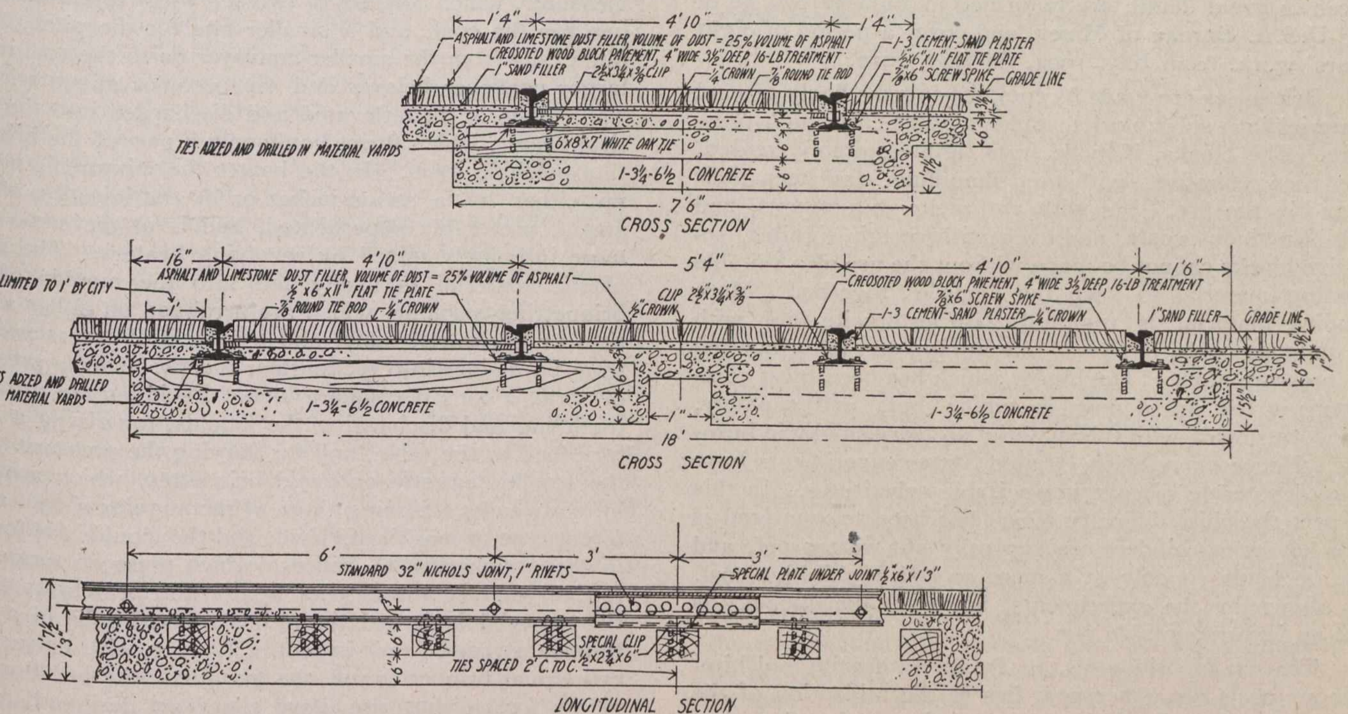


Fig. 7.—United Railways Company of St. Louis, Track Construction for 6-in. T-Rail.

with asphalt or whatever material is being used on the balance of the streets.

St. Louis, Mo.—During the past two years three types of track construction, for 9-in. trilby rail (Lorain section 132-440), 7-in. trilby rail (Lorain section 103-426) and 6-in. 100-lb. A. R. A. T-rail, have been used by the United States Railways Company of St. Louis, and these types of construction will be used on the work planned for the present year. Drawings of the 7-in. trilby and 6-in. T-rail types are shown in Figs. 6 and 7. The 7-in. and 9-in. trilby rail types differ only in the depth of the concrete foundation, the former being 15 in. deep, with 6 in. under the ties and 3 in. above them; the latter type is 17 adzed for tie plates by a machine in the material yard; ⅞ x 6-in. screw spikes; ½ x 6 x 11-in. flat tie plates on all ties; ⅜ x 2 x ¼ x 3¼-in. steel screw clips; 32-in. Nichols joint plates and ⅞-in. round tie rods.

The main features of the T-rail track construction are the same as those for the girder rail type, except that no tie rods are used, and instead of the ½ x 6 x 11-in. flat tie plates and the screw spike clips, a special patented tie plate is used. This tie plate consists of a ⅜ x 7 x 10½-in. flat soft steel plate sheared at the ends so that four ⅜ x 1⅛ x 2½-in. strips can be bent down over the rail base. The screw spike holes in the tie plates are located 1½ in. outside of the rail base.

INVESTIGATION FOR COAL IN NORTHERN CANADA.

A report from St. John's, Nfld., states that a schooner is now being equipped for a prospecting expedition to Hudson Bay, the main object of which is to investigate coal deposits in that area which can be utilized in connection with the operation of the Hudson Bay Railway, now under construction. A supply will also be required for the steamers. At present all the coal that is required in connection with steamer traffic to the Bay has to be conveyed there by Newfoundland sealing steamers that are used for freighting purposes in the summer months. They are the only vessels available that can withstand the wear and tear of navigation in these northern ice-laden waters.

Coal for the needs of the railway construction forces is conveyed by train from Winnipeg and Le Pas as the railroad progresses. When the line is opened to Port Nelson and terminals constructed there provision for a large storage for coal will be made. Its cost, however, in view of the lengthy transportation from Cape Breton by water and from Western Canada by rail will be a considerable item. Hence the present efforts to locate coal deposits near Port Nelson.

FUEL-BRIQUETTING INVESTIGATIONS.

THE manufacture of fuel-briquettes is now well established as a commercial process on the Continent of Europe, and, so far as the demand permits, in Great Britain, according to "Engineering," London. But in the United States, in spite of the vast fields of lignite, or brown coal, which are available, the industry cannot be said to have attained a proper foothold. Up to 1912, in fact, there were only twenty-four American plants in operation. For this reason the government arranged an exhaustive series of experiments on the briquetting of American fuels, and a mass of useful information has been collected. The results, which are given in great detail, are published in Bulletin No. 58 of the U.S.A. Bureau of Mines, and cover a period of eight years' work, from July, 1904, till July, 1912.

Briquettes are made by compressing the finely ground material into solid blocks, under a sufficiently high pressure. The blocks, if made from lignite suitably treated, are then cohesive, withstand handling, and keep their shape in the fire. But with anthracite, bituminous, and sub-bituminous coals, and even with certain lignites, sohesive blocks cannot be made without the use of a suitable binding material to keep the particles together. More binding material is required with anthracite than with bituminous coals, but peat, like lignite, can be briquetted by pressure alone. The binder which has been most commonly in use up to now is pitch; but, unfortunately, briquettes made with this material are very smoky in burning. Hence many of the United States experiments have been devoted to discovering suitable substitutes. In this respect the chief difficulty which has been encountered is that smokeless binders are generally not waterproof, and can be made so only at a more or less prohibitive cost. As shown by the experiments, however, the difficulty is not an insurmountable one.

The use of briquettes, so far as anthracite and bituminous coals are concerned, lies in the utilization of the fine or small coal. Although some fine coals coke when burning, most of them remain in their natural state, with the result that the dust clogs the draught, or falls through the bars with the ashes. Well-made briquettes, on the other hand, retain their form in the fire, and allow of a good air circulation being established. It follows that, where the difference in price between lump and fine coal is sufficient, they can be manufactured and sold at a profit. Other advantages which briquettes possess over ordinary coal are that they burn to a fine ash without clinker; the stoker's work is easier; the evaporative power, owing to the higher calorific value of the binder and the loss of moisture, is increased; more resistance is offered to weather; and the risk of spontaneous combustion is eliminated.

In the case of lignite, which requires no binder, and in its natural state contains a high percentage of moisture, the advantage of briquetting requires no demonstration. A series of tests reported in the United States bulletin shows that, where the moisture content of the samples varied from 33 per cent. to 42 per cent., from 24 per cent. to 32 per cent. was removed in briquetting, and the heating value of the fuel was increased by from 36.5 per cent. to 52.4 per cent.

These experiments are of the highest importance to Americans, but, in view of the smallness of our lignite supplies, do not possess the same interest for us. The principal European lignite fields are located in Germany and Austria-Hungary. In this country, where chiefly bituminous and anthracite coals are produced, it is with the working up of the "smalls" of these coals that we are concerned. Our output is smaller in proportion than that of other European countries, for the reason that briquettes have not been adopted to any great extent in our locomotives and steamships.

The plant required for making briquettes from anthracite or sub-bituminous coals includes a coal-elevator, pitch-cracker, pitch-elevator, measurer, mixer, disintegrator, compo-elevator, vertical heater, briquetting-machine, and briquette-conveyer. The coal is fed into the elevator direct from the wagons, and the pitch, after going through the cracker, falls into the boot of the pitch-elevator. Both are then discharged into the mixer and measurer, which consists of two screw-conveyers—a large one for the coal, and a smaller one for the pitch. The pitch falls from the smaller conveyer on to the coal in the larger conveyer below, and so becomes mixed with it. The compo is then elevated and discharged into the vertical heater, which forms commonly a part of the briquetting-machine itself. In the heater the mixture is heated up, either by a steam-jacket or by the injection of live steam, preferably superheated, and is at the same time more intimately mixed by revolving beaters. The semi-plastic material is finally fed into the moulds of the briquetting-machine, which are arranged on either a vertical or horizontal table, and a system of levers press it from both sides into rectangular blocks, under a pressure of about 2 tons per square inch. Facilities are provided for filling and discharging the moulds, for giving a rotatory feed to the table, and for varying the pressure. For the smaller eggette or ovoid briquettes, which are now in many cases replacing those of rectangular shape, a different type of machine is used, and the moulds are formed in the peripheries of rollers, which press on tangential feed-slides. In the case of lignite and peat briquetting, the material is forced through a tapered tube in a continuous stream, and is cut off by a wire cutter into cylindrical briquettes of the required length. Portable plants for railway use have also been designed, and a typical example was described in "Engineering" for April 3, 1914.

The English plant, by Messrs. William Johnson and Sons (Leeds), Limited, used in the American experiments, was substantially as above described, except that it was modified in several respects to meet the needs of the experimenters. The principal alteration made was in the measurement of the coal and binder. To ensure absolute accuracy, this was effected by the use of separate scales, instead of by differential conveyers. In the first American plant, by the Renfrow Briquet Machine Company, St. Louis, horizontal heating cylinders were used, fitted with worm-conveyers, instead of beaters. Otherwise the arrangement closely resembled that of the Johnson plant. But in the case of the second American machine, by the American Compressed Fuel Company, Chicago, a different design was adopted. After being measured, the coal was dumped into a steam-jacketed mixer, where the pitch, which had previously been melted and measured, was mixed with it. The mixture was then fed into a roller-press, and formed into briquettes of the eggette type.

For lignite, a German plant by the Maschinenfabrik Buckau Actien-Gesellschaft, of Madgeburg, was used. The lignite, before entering the tube-press, which created a pressure of 14,000 lb. to 28,000 lb. per square inch, was treated in a set of crushing rolls, a rotary drier, sieve, auxiliary crushing-rolls, and cooling-plates with scrapers. The equipment also comprised a small hydraulic hand-press for making preliminary experiments.

The experiments were divided into three periods. From 1904 to 1907 the work was carried on at St. Louis, and the Johnson, American Compressed Fuel Company, and Renfrow machines were used. From 1907 to 1910 at Norfolk, the Johnson and Renfrow (improved) plants were employed, together with a German Schlickeysen peat-machine. And at Pittsburgh, from 1910 onwards, the experiments were confined to the German lignite plant and to the small hand-press, although the English machine has been placed on its foundation.

The physical tests to which the briquettes were subjected were called the "drop" and the "tumbler," the absorption, density, weathering and compression tests. In the first, the briquettes were dropped on the floor, and the pieces, which were held by a screen with 1-in. square holes, were dropped again. This procedure was repeated five times, and the weight of the pieces, which, after the fifth drop, would not pass through the screen, was determined. In the tumbler test a weighed quantity of the briquettes (about 50 lb.) was rotated for two minutes at 28 revolutions per minute in a sheet-steel cylinder. The parts which were held by a 1-in. screen and a 10-mesh sieve were then weighed. The absorptive qualities of the briquette were tested by weighing, and the rate of absorption each day, and the time required for the absorption to become complete, or for the briquette to disintegrate, were determined. The density was taken by means of a Nicholson hydrometer, and the weather-resisting qualities were assessed by observation extending sometimes for as long as 286 days. For measuring the crushing strength a 200,000-lb. Olsen testing-machine was employed, although it is stated that the amount of handling which the briquettes will stand is given more accurately by the tumbler and drop tests.

The chemical tests included analyses and moisture tests, and extraction tests, using carbon bisulphide as a reagent, were made to determine the percentage of bitumen in the raw and the briquetted fuel. To determine the evaporative and burning qualities, the briquettes were burned under a stationary boiler. Special tests were also made on locomotives and on a torpedo-boat, and in domestic furnaces and foundry cupolas. The locomotive tests show that the evaporative efficiency of briquetted as compared with raw fuel is greater; that firing is easier; and that both the clinker and smoke produced are less. On the torpedo-boat it was found that there was no gain in smoke production, or in efficiency, but that the work of the stokers was lightened, and the boiler capacity increased. The domestic furnace tests proved that, for the low temperatures common in house-heating boilers, pitch is an unsuitable binder, as it volatilized and escaped unburned, or became deposited as tar. It also gave rise to too much smoke.

In the experiments the question of what binder can be used has naturally been investigated in great detail. The coal-tar pitch binders at present employed give briquettes which are waterproof, do not crumble during transport, leave little ash, and can be manufactured at a reasonable cost. Other binders, notably cereals and "sulphite pitch" (selpech) have an advantage over pitch, inasmuch as they are smokeless in burning, but they are unfortunately not waterproof, so that the briquettes crumble after exposure to the weather. Such briquettes can easily be rendered waterproof, but the cost has hitherto been considered prohibitive. The American experimenters, however, state that their investigations on this head show that the discovery of a cheap waterproofing process is not an impossible achievement. And the patentee of Middleton's starch binder declares that he has already solved the problem, using 2 per cent. of cereal and ½ per cent. of tar, against, in the ordinary process, 8 per cent. of pitch. The cost of manufacture, he claims, is cheaper than in the pitch process so long as the price of pitch is above 42s. 6d. per ton. He states that the fuel, after exposure to the weather for several weeks, shows practically no deterioration.

In addition to detailed experiments with various kinds and percentages of pitch, the bulletin reports the testing of a large number of other binders. These include creosote, asphalt, petroleum (both of paraffin and asphalt bases), lime, clay, wax tailings, and sludge; various wood products, such as resin, tars, wood pulps, and sulphite liquor; various sugar-factory residues, such as beet pulp, lime cake, and the different molasses; starches, slaughter-house refuse, and petroleum products.

In the tests of pitches it was found that the pitch obtained from the distillation of petroleum gas-tar gave the best results, although other pitches distilled from by-product coke-oven tar, illuminating-gas tar, and producer-gas tar proved quite satisfactory. Water-gas pitch, another binder tested, has an advantage over ordinary coal-tar pitch in that the production of free carbon present is only 10 per cent., as against as much as 30 to 40 per cent. with the ordinary material. The free carbon is useless as a binder, and acts merely as a diluent of the bituminous matter. In all pitches it is important to select a material that is not too hard. The actual hardness required varies with the time of year and the climate; but, generally speaking, it was found that pitch which becomes brittle when dropped into water at 55 deg. Fahr. is of the correct texture. The harder pitches have been robbed of the creosote and lighter oils during distillation, so that pitches from which these oils have been distilled off should be avoided. It is also better for briquetting purposes that the pitch should be prepared in this way rather than by distilling all the oil, and then reducing the pitch with the naphthaline and creosote oils, as is sometimes done. As an example of the disadvantage of using the harder pitches, it may be said that in one experiment with a pitch of this kind, 13 to 18 per cent. was found necessary to make good briquettes, while, when a pitch with the proper amount of light oils was tried, 6 to 9 per cent. proved sufficient. Other experiments show that from 7½ to 14 per cent. of volatile oils is the correct proportion to give the proper binding qualities, and that from 6 to 9 per cent. of pitch of this kind will make good briquettes from most bituminous and anthracite coals. To mix with a non-coking coal 10 to 20 per cent. of a coking coal is better than increasing the percentage of pitch.

Of the other binders tried, it was found that clay, lime, cement, magnesium oxide, plaster-of-paris, acid sludge, sugar-factory residues, slaughter-house refuse, and wood products are all unsatisfactory, although some of the last-named give good results in combination with other binders, and seem for that reason to deserve further investigation. Wax-tailings give fair results, but are not considered altogether satisfactory, while crude petroleum, although answering well, is deemed unsuitable for working on a commercial scale. Resin, used in conjunction with pitch or petroleum, and a percentage of lime to prevent smoking, makes a good binder; but here, again, the cost makes commercial application impossible. Asphalts are also rather too expensive in most places, and give only fair briquettes, but asphaltic tar was found useful as a waterproofing material in briquettes made with starch.

In fact, the only really good binders besides pitch were found to be starch or flour, and sulphite pitch. None of these is waterproof, but a careful study was made of waterproofing processes, and, as stated above, it is believed that a successful and inexpensive process can be discovered. When using corn starch only 2 to 4 per cent. is required with ordinary coals. The briquettes made with this binder were found to be smokeless. They held their shape well in the fire until completely consumed, and, although the heat value of the binder is small, it leaves no ash. Messrs. Yeadon, Son and Co., of Leeds, are, we understand, constructing a plant for Russia to briquette lignite, with a binder made of finely ground meal and mazut, and a small proportion of pitch.

Sulphite pitch, also known as cell pitch, is made from the waste liquors which are produced in the sulphite process of manufacturing paper pulp from wood. Until recently these liquors had no commercial value, and their proper disposal was a serious matter, since, if discharged into rivers, they polluted the water and killed such fish as were contained in it. In making the pitch, the liquor is concentrated to a syrup in a sextuple-effect evaporator, and solidified into pitch as a thin film on two rotating steam-heated drums. With some coals, less than half the quantity of cell pitch is required as compared with ordinary pitch; but with others, in the American experiments, the percentage necessary was the same for each material. German experiments, on the other hand, incline to the smaller value. Briquettes made with this binder are smokeless and odorless, and the price of the material, if there are cellulose mills at hand, is low. In the Pollacsek process, used by the Hungarian government for its collieries, sulphite liquor is employed, and from 3 to 5 per cent. is found to give good briquettes. The briquettes made with sulphite pitch can be rendered waterproof by drying at a temperature of 300 deg. Cent., or by the addition of certain chemicals, the nature of which at present is not divulged. With the latter process, the cost of waterproofing is estimated at 1s. 6d. per ton of briquettes. It is thought at present that the sulphite process will be more useful for anthracite than for bituminous coals, but that it also will be widely employed in preference to pitch in briquetting ores for smelting.

The cost of manufacturing briquettes in England, exclusive of materials, is estimated at about 1s. 6d. per ton of briquettes, and, using 8 per cent. of pitch, the cost of the binder will be about 3s. per ton of briquettes. The cost of the binder, using 2 per cent. of cereal and ½ per cent. of tar, will be about the same, on Middleton's process, when the cereal costs 7*l*. 10s. per ton. In Germany the cost of making lignite briquettes, including all materials, works out at 7s. 6d. per ton, the lignite being taken at ½d. per bushel.

There is evidently a large field for the development of this industry, and the briquetting of ores for smelting, which has not been investigated in the American experiments, is likely to be even more important than the briquetting of coals. Not only iron, but copper, nickel, and other ores can be made into briquettes with advantage.

EXPERIMENTS ON PAINT PROTECTION.

Some experiments recently carried out in Europe indicate that a single coat of paint gives iron greater protection from rusting than several coats. Different samples of iron were painted with one, two, three and four coats, respectively, and after a certain time it appeared that the iron under four coats was completely covered with rust, that under three coats was less affected, that under two coats was partly rusted, but the iron under one coat was free from rust. The theory suggested is that increase in the number of coats gives more corroding electric currents at the surface of the metal.

COST OF GOOD ROADS IN UNITED STATES.

Approximately $206,000,000 was spent last year on public roads in the United States, according to statistics prepared by the U.S. Department of Agriculture. In 1904 the total was only $79,000,000 In nine years the increase has been over 250 per cent.

This awakening on the part of the country to the importance of good roads has, experts say, been due in great measure to the principle of state aid to counties and other local communities. New Jersey began the movement in 1891, when it passed its State Highway Law. Massachusetts and Vermont followed a year later, but for the most part the other states were slow to move. In 1904, only fifteen had state highway departments; to-day there are only six that have not. In 1913, the individual states appropriated a total of $38,755,088, to supplement local expenditures.

The value of this state aid is, however, not to be measured by the figures alone, for the bulk of the money comes, and always must come, from the counties and townships. Thus, in 1912, the cash outlay by counties, districts and townships, was $137,493,985. Complete figures for 1913 are not yet available, but it is safe to estimate the sum at approximately $151,000,000. To this must be added some $15,000,000 to represent the value of the labor contributed instead of cash in districts where this practice prevails. Last year, therefore, local communities contributed, in round numbers, one hundred and sixty-six millions of dollars, as against appropriations from state treasuries of $38,755,088. The true importance of this thirty-eight millions lies in the fact that it means expert supervision of the expenditure of a considerable portion of the vast sum of two hundred millions. When each county built as it chose and when it chose, the services of trained engineers were usually out of the question. There was little opportunity to test innovations, little advance in the science of road-building, and there was also difficulty in arousing each county individually to do its best to improve conditions within its own limits. State aid has changed all this. The best engineering skill is available for all works of importance, there is co-operation and a constant stimulus to further improvements. The money contributed by the state not only builds more roads, but it makes better those that other money builds.

At the present time there are in the United States 20,741 miles of roads improved either wholly or in part by state aid. This is nearly the mileage of the French routes nationales, the system of great national highways which is the envy of every civilized nation. The routes nationales are, of course, only a small part of the total mileage of France, where practically every road of any importance is an improved road. Of the 2,226,842 miles of roads in the United States, 233,774 miles, or approximately 10 per cent., are classed as improved.

ONTARIO MUNICIPAL ASSOCIATION.

An interesting meeting, to be held in the first week of September, will be the annual convention of the Ontario Municipal Association. This association is made up of members of county, city, town, township and incorporated village councils and municipal officials. At its meetings addresses are delivered by specialists in various features of local government and administration, and the discussion of these addresses is always practical and generally very interesting and instructive. The association is also an important agency in the promoting of improvements in municipal legislation. The coming convention, which will be held on September 2nd and 3rd, at Toronto, promises to be unusually large and attractive.

A NEW DEFLECTION FORMULA FOR CONCRETE BEAMS.

In a paper read by Mr. G. A. Maney at the 17th annual convention of the American Society for Testing Materials a new formula was given whereby deflection can be calculated from the known loading and beam dimensions. The deflection, according to it, equals the product of the sum of the deformations at the two extreme fibers of the concrete, into a constant. It is based upon the property of the M/EI curve for any beam, that the deflection of the beam is proportional to the statical moment of the area under the M/EI curve. This curve is obtained by dividing each ordinate of the bending-moment curve by the product of the corresponding values of E and I, which are the modulus of elasticity of the material and the moment of inertia of the sectional area of the beam, respectively. The statical moment of the area under the M/EI curve between any two points on the elastic curve, taken about one of these points, is equal to the vertical deflection of this point from a tangent to the elastic curve at the other point, the beam being assumed to be horizontal.

The unit stress on the extreme fiber is equal to Mc/I. The unit deformation, e, of that fiber is therefore equal to Mc/EI and the total deformation in the distance dS along the elastic curve equals $McdS/EI$. Referring to Fig. 1, it is seen that this total deformation of the extreme fiber, divided by the distance c from that fiber to the neutral axis, is equal to the change of slope, $d\theta$, in the distance dS. Or

$$d\theta = \frac{Mc\,dS}{EI} \div c = \frac{M\,dS}{EI}$$

It will be seen that the term $M\,dS/EI$ is equal to the area under the M/EI curve for the distance dS along it; that is, $d\theta$ is equal to a differential element of the area under that curve.

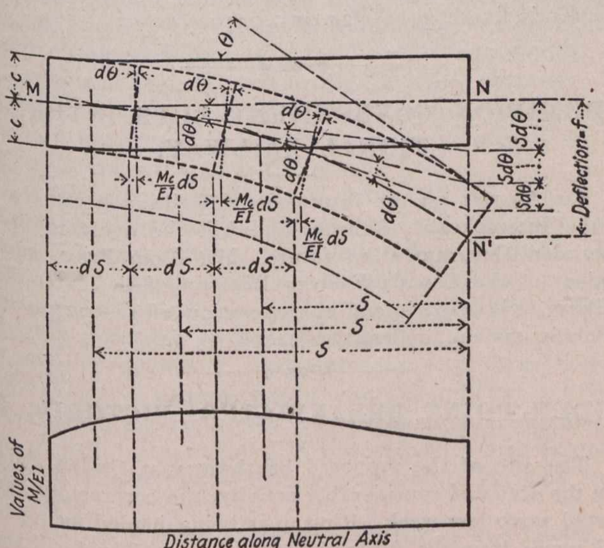


Fig. 1.—The M/EI Curve for Beam.

Now, let S equal the distance from any differential element dS to the point at which the deflection is desired. Then, referring to Fig. 1, it is clear that the deflection of N' from the tangent MN at M is equal to the sum of the products of each $Sd\theta$ along the elastic curve from M to N, S being measured from N'. Or

$$f = \Sigma S\,d\theta$$

But $S\,d\theta$ is equal to the statical moment of the differential element of the area under the M/EI curve about N', by the definition of statical moment. Therefore, the deflection of any point from the tangent to the elastic curve at any other point is equal to the statical moment of the area under the M/EI curve about the first point. (In this proof, as in all treatments of the elastic theory, it is assumed that the projection of the neutral axis after bending, upon its original position, is the same as its length before bending.)

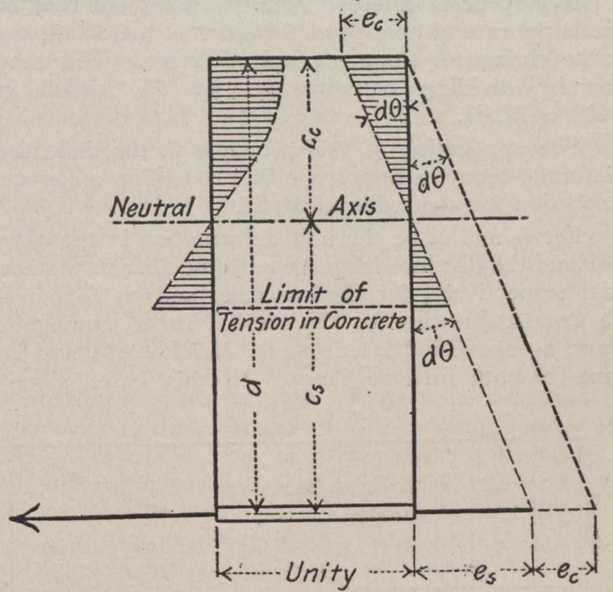


Fig. 2.—Showing Variation of Deformation and Stress.

This property for homogeneous beams may be expressed:

$$f = kl^2\,(M/EI)$$

The value for M/EI in equation (3) will be taken for the point in the beam at which the bending moment is maximum. Then the value of k is such that the statical moment of the M/EI area between any two points, which is equal to the deflection of one point with respect to the tangent to the elastic curve at the other, is expressed in terms of this maximum value of M/EI and the span of the beam, l.

It is evident that the value of k for any case is equal to the coefficient of deflection for homogeneous beams in the well-known equation $f = k_1\,W\,l^3/EI$, divided by the coefficient for the maximum bending moment, which in general may be expressed as $M = k_2Wl$, from which $W = M/k_2l$. Substituting this in the last equation for deflection,

$$f = k_1 \cdot \frac{M}{k_2l} \cdot \frac{l^3}{EI} = \frac{k_1}{k_2}\,l^2\left(\frac{M}{EI}\right)$$

Comparing equations (4) and (3), it is seen that $k = k_1/k_2$. To illustrate, consider the deflection at the centre of a freely supported beam with a single concentrated load at the centre; that is, the deflection of the support with respect to the tangent to the elastic curve at the centre. The coefficient k_1 is 1/48, and k_2 is 1/4. Therefore the coefficient k in equation (3) will become 1/12 = 0.0833 (see Fig. 3b).

The maximum deflection of a simple beam is equal to the deflection of the support from the horizontal tangent to the elastic curve. Usually the maximum deflection occurs at the centre of the beam, as in all cases of symmetrical loading. With irregular loading, it usually occurs near the centre of the beam. Then, by the property of the M/EI curve above referred to, we may express this deflection as the statical moment about the support of the area under the M/EI curve between the point at or near the centre of the span, where the slope is zero, and the support. If this statical moment is expressed in terms of the maximum ordinate of the *M/EI* curve and the whole span, an expression is obtained of the form of equation (3), in which the coefficient *k* will equal k_1/k_2.

It may be of interest here to point out that *M/EI* equals the rate of change of the slope of the elastic curve, or the change of slope per unit distance. This may be seen by dividing equation (1) by *dS*, which gives $d\theta/dS = M/EI$.

The application of this principle to the deflection of reinforced-concrete beams consists in finding a convenient expression for the value of *M/EI*.

Let e_c and c_c be the unit deformation in the extreme fiber and the distance from the extreme fiber to the neutral axis, respectively, for the concrete, and let e_s and c_s be the same quantities for the steel. In a homogeneous beam, as above indicated, $e/c = M/EI = d\theta$, and is the same for both extreme fibers. In this case, since the

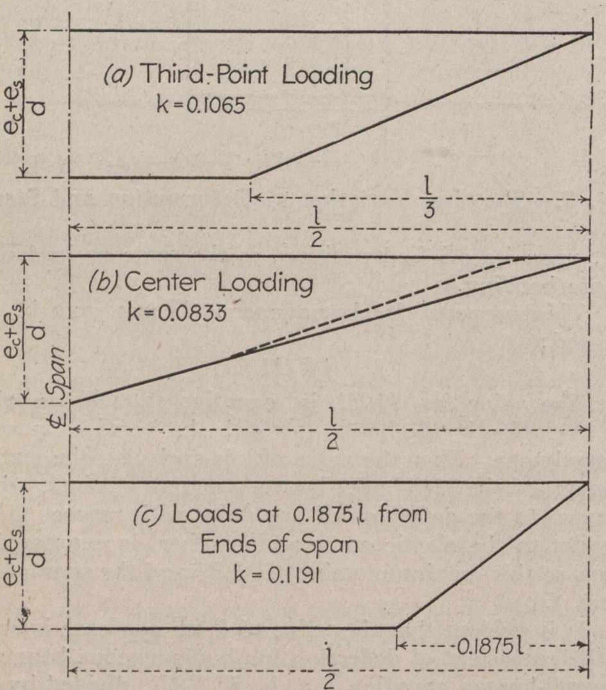


Fig. 3.—Showing Variation in Values of (Ec + Es)/D.

values of *EI* are constant throughout the length of the beam, *e/c* varies directly as *M* throughout the span.

In a reinforced-concrete beam (see Fig. 2),

$$\frac{M}{EI} = d\theta = \frac{e_c}{c_c} = \frac{e_s}{c_s} = \frac{e_c + e_s}{d}$$

Substituting this value of *M/EI* in equation (3), the following expression for the deflection of a reinforced-concrete beam is obtained:

$$f = k \frac{l^2}{d} (e_c + e_s)$$

This is based on the usual assumption that a plane before bending remains a plane after bending, which seems justifiable from the evidence of reliable tests herein referred to.

From the preceding analysis it is evident that the deformations of the extreme fibers are the only determining factors in the deflection, except the span, depth of beam, and load-distribution. It is also evident that the distribution of the stresses in the steel and concrete over the section has no influence on the deflection, except in so far as the stresses influence the deformations of the extreme fibers.

The influence of tension in the concrete might well be discussed here. From the principles of equilibrium it is known (see Fig. 2) that the effect of the tension in the concrete at low stresses is to reduce to some extent the compressive stresses in the concrete and the tensile stresses in the steel. This means that a stiffer beam might be expected in the earlier stages of the loading, as the steeper slope of deflection and deformation curves show.

For the reason, therefore, that tension exists in the concrete and that usually near the end of the beam the roads are bent up, the value of the $(e_c + e_s)/d$ curve, from which the deflection is obtained, will not have the same variation as the values of *M*.

Near the supports of a simple beam and at all points where the bending moment is small, we would expect considerably smaller values of $(e_c + e_s)/d$ than the value of *M* at such a point, relative to the value of *M* at the point of maximum moment would indicate. The values of $(e_c + e_s)/d$ would probably follow the dotted lines indicated in Fig. 3b, because of the tension in the concrete. A glance at Fig. 3b will show, and computations will prove that a small decrease in values of $(e_c + e_s)/d$ ($= d\theta$) near the point about which moments are taken (the support, in this case), changes the value of this moment only slightly.

Values of *k* for maximum deflections under several conditions of loading are here given:

Beam with uniform load:

Ends freely supported, $k = 5/48$ or 0.1041;

Ends fixed, $k = 1/32$ or 0.0313.

Beam loaded at the third points:

Ends freely supported, $k = 23/216$ or 0.1065;

Ends fixed, $k = 5/144$ or 0.0347.

Beam loaded at the middle:

Ends freely supported, $k = 1/12$ or 0.0833;

Ends fixed, $k = 1/24$ or 0.0416.

DOMINION GOVERNMENT BUYS INTERNATIONAL RAILWAY.

On August 1st the International Railway became a part of the Intercolonial Railway and will be operated by the Dominion Government in future. Mr. Evan Price, superintendent of the Canada Eastern Division of the Intercolonial Railway, will superintend the operation of the new portion, which is 112 mi. in length.

OGDEN POINT BREAKWATER, VICTORIA, B.C.

The site of the proposed breakwater at Ogden Point is now the scene of considerable activity, the contractors having started work last week. Rip-rap is being hauled by towboats and scows from the Albert Head Quarries. The facilities for the transportation of this material are adequate for conveying 50,000 tons per month. Pile-driving to indicate the line of the breakwater has been completed, the extreme point being about 1,750 ft. from shore. The shore work in connection with the breakwater is almost complete, the site having been levelled off and the fillings completed. These fillings have greatly enlarged the land surface at the disposal of the government for the piers in connection with the breakwater.

It is expected that the work will be nearing completion in about eighteen months. The breakwater is of concrete construction, faced with large granite blocks.

Editorial

ENGINEERING AT HOME AND WAR ABROAD.

What will be the effect of the great international struggle in Europe upon engineering undertakings proposed and in course of construction in Canada? It is difficult to predict with any guarantee of accuracy, because the present situation is unparalleled, not only in the history of Canada but also in that of the whole world. We can but analyze the situation so far as available data will allow. In the matter of works of construction the natural division seems to be as follows:

(1) Work in progress and possible of postponement.
(2) Work in progress and necessary to continue.
(3) Proposed works, capable of postponement.
(4) Proposed works, necessary to continue.
(5) New work undertaken, due to war.

Obviously, all these divisions are dependent upon successful financing. It is likely that some of the undertakings now in course of construction, and which might even be postponed without disadvantage, will proceed if the funds for the work were obtained prior to the outbreak of war. On the other hand, those enterprises which have not been financed and which, to any degree of convenience can be postponed, will undoubtedly be stopped. There are certain works which must continue, and it is probable that these have been financed completely, except unusually large undertakings, such as the Toronto Union Station, the Greater Winnipeg Water District scheme, and the Harbor Board's development at Toronto. The total cost of these and similar undertakings in each case is high. The Toronto Harbor Board raised funds by the sale, some months ago, of several million dollars worth of bonds, which will finance their work for some little time to come. The Greater Winnipeg Water District Board obtained $2,000,000 in London last month, and that sum will finance their work for some months. The railway companies interested in Toronto's Union Station probably have enough money to proceed, slowly at any rate, with the work of construction.

Works which have been proposed but which are capable of convenient postponement, will undoubtedly be delayed to some extent, if not lengthily postponed. This applies more particularly to the undertakings of private corporations. There are certain proposed works which it is highly desirable to continue, such as, for instance, certain improvements and extensions of the Ontario Hydro-Electric Commission's general scheme. Private corporations probably will not consider it justifiable, in view of events in Europe, to proceed with any extensive proposed works and which were thought perhaps to be necessary.

Some new work may be undertaken in Canada due directly to the outbreak of hostilities. This would likely be in ship-yards chiefly, in connection with naval and military operations generally, and with war engineering.

In considering these factors, we must subdivide them again into:

(1) Works of private capital.
(2) Works of government authorities.

The writer has been of opinion always that governments in times of extreme trade depression should spend money on public works, so far as proper economy dictates. In a time such as the present, and in view of the fact that the theatre of war is not actually on Canadian soil, the Dominion Government well might employ fairly substantial sums upon certain public works. Private borrowers will hesitate considerably at present because Canada's chief lender (Great Britain) has a bigger job on hand now than loaning money to its overseas dominions. Indeed, private borrowers, in which are included corporations, are almost helpless, except for funds in hand and for the possibility of borrowing elsewhere than in Great Britain.

On the other hand, the Dominion's credit is better than that of any other borrower in the Dominion, and there are several methods, such as the raising of temporary loans, which the government might use in case of necessity. The citizens of Canada likely would not protest against any action taken by the government to give employment to the citizens and to their industries, in such a time as this, any more than they will protest when the government imposes a special tax on tea and other commodities for war purposes in the British Empire.

Aside from that particular phase, the situation is regulated considerably by the fact that Great Britain, which has loaned Canada altogether £500,000,000, cannot, for the time being, continue to lend. One naturally turns to our nearest neighbor, the United States, which in its time has borrowed enormous sums of money from Great Britain, and which has in recent years become one of the two minor lending countries, the other being France, Great Britain taking first place. The United States has enjoyed for several years sixty per cent. of Canada's import trade. If the United States is able at this time to finance the immediate needs of Canada, there is a pleasing likelihood that a fairly substantial amount of construction work will proceed. This will be further emphasized if the Dominion Government, having due regard to the menace of war, will go on with a certain amount of public work.

THE QUEBEC STREAMS COMMISSION.

The second report of the Quebec Streams Commission, organized in December, 1911, has just been issued, and contains a statement of the studies of a general nature that were carried on during 1913. The personnel of the Commission consists of Chairman, S. N. Parent, C.E.; Commissioners, Ernest Bélanger, C.E., and Wm. I. Bishop, C.E.; Engineer, Olivier Lefebvre, C.E.; Secretary, H. L. de Martigny. It submits a somewhat lengthy investigation on the determination of the legal character of rivers in Quebec and their classification. Other studies are based upon the regulation of the construction of dams and other hydraulic works on these rivers, and upon the improvement of rivers for floating logs, and the authorized tolls. Still others include the regulation of the flow of the St. Francis River and its tributary, the Magog, by means of storage dams to be erected at the outlet of the principal lakes which feed them. Such a problem requires the consideration of several distinct elements, as, for instance, the general usefulness of the project, the technical difficulties to be overcome, the cost of the proposed works, the practical results, the revenue to be derived, and the methods of financing and carrying out the undertaking.

The object of the St. Francis River equalization is primarily to reduce the height of flood waters, thus minimizing the risk to bridges and other structures along the waterway, preventing overflow upon adjacent lands and minimizing present losses to lumbering operators caused by the breaking of booms, etc. It would increase the present low-water flow to approximately double the present figures, increasing the available continuous water power, and the capacity of manufacturing plants, as well as the advantages that would accrue to log driving by increasing the length of time each year for operations. Besides, the petitioners claim that the prevention of extreme low-water periods would greatly improve sanitary conditions and domestic water supplies in towns and villages along the river.

TO ESTABLISH A MERIDIAN AT ANY TIME, BY HOUR ANGLE.

By J. A. Macdonald, Ottawa, Ont.

BY the peculiar and ingenious arrangement, prepared originally by Mr. J. B. Shinn, of the U.S. General Land Office, Washington, and issued by the commissioner, a new set of tables designed to enable observations for azimuth to the nearest minute to be made at any hour by an observation of Polaris is now obtainable. By the use of this table, an observation for azimuth can be made at any time when Polaris is visible. All the data necessary to make the observation are presented on two pages. Every surveyor knows how inconvenient it is to await the time of elongation of Polaris, especially in the cold, winter weather, while at times both elongations occur in the daylight hours. By means of this simple table, the observation can be taken at pleasure, simply noting the time (local mean time); the azimuth of the star may be taken out later for that particular time. The annexed diagram shows in their proper relation the various aspects of Polaris in its daily apparent motion around the North Pole.

Hour Angle of Polaris.—In the figure the full vertical line represents a portion of the meridian passing through the zenith, Z (the point directly overhead), and intersecting the northern horizon at the north point N, from which, for surveying or draughting purposes, the azimuths of Polaris are reckoned east and west. The meridian is pointed by the plumb line when it is in the same plane with the eye of the observer and Polaris on the meridian, and a visual representation is also seen in the vertical wire of the transit, when it covers the star on the meridian.

When Polaris crosses the meridian it is said to culminate; above the pole, at S, the passage is called the Upper Culmination, in contradistinction to the Lower Culmination, at S'. The engineer will better understand the diagram by holding it up perpendicular to the line of sight when he looks toward the pole—Polaris is supposed to be on the meridian, where it will be about noon on April 10th of each year. The star appears to revolve around the pole in the direction of the arrows, once in every 23 hours 56.1 minutes, mean solar time. It consequently comes to and crosses the meridian, or culminates, nearly four minutes earlier each successive day. One-quarter of the circle will be described in 5 hours 59 minutes, one-half in 11 hours 58 minutes, and three-quarters in 17 hours 57 minutes.

The hour angles of Polaris expressed in mean solar time (common clock) are counted from the upper meridian, at S, to the west, around the circle from 0 hours 0 minutes to 23 hours 56.1 minutes, and may have any value between the limits named. The hour angles measured by the arcs are 1 hour 8 minutes; 5 hours 55 minutes; 9 hours 4 minutes; 14 hours 52 minutes; 18 hours 1 minute; and 22 hours 48 minutes respectively; their extent is indicated graphically.

All the surveyor has to do, then, is to subtract the time of upper culmination (as found in the tables) from the correct local mean time of observation. The remainder will be the hour angle of Polaris expressed in

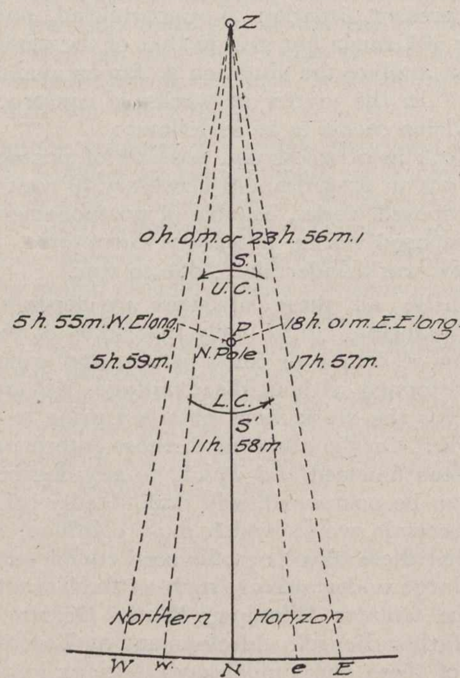


Fig. 1.

time. The table of culminations answers for all latitudes, and in general, for all longitudes, hence its simplicity. The table, Part II., answers for latitudes 30 deg. to 50 deg., and also distinctly for each year.

Example.—Required the hour angle and azimuth of Polaris for a point in latitude 41 deg. 12 minutes N, at 6 hours 16 minutes a.m., November 19th.

	h.	m.
Astronomical time of observation, Nov. 18th..	18	16.0
Astronomical time U.C. Polaris (Table, Part I.)	9	34.6
(Subtracting)	8	41.4

With this hour angle of Polaris, 8 h. 41.4 m., enter table Part II. Azimuth of Polaris at observation (Table, Part II.) 74 m. or 1 deg. 14 m. W.

These tables combine in two operations the essentials which, under ordinary methods, would require about twenty.

The watch time to be used when making observations should be as accurate as can be obtained, for to obtain the azimuth to the nearest whole minute of arc, the local mean time, upon which all depends, except for elongation, should be known within two minutes. When standard railway time is used, as probable in most cases, the observer will correct the same for difference of longitude at the rate of 4 minutes of time for each degree of difference in arc. This difference of longitude can be nearly always taken from a map. The correction will be subtracted from the standard railway time of observation when the surveyor's station is west, and added when east of the standard meridian, to obtain local time.

MINING IN QUEBEC, 1913.

A STATISTICAL review of mining operations in the Province of Quebec during the year 1913, is contained in the recent report of the mines branch of the Provincial Department of Colonization, Mines and Fisheries. According to it, the value of the products of the mines and quarries of the province reached a total of $13,119,811 during the year ending December 31st, 1913. It is the highest annual production recorded to date and exceeds that of 1912 by $1,932,701, or a proportional increase of 17%.

The Mining Law is quite explicit in respect to sending in reports of production. Article 2163 of the Quebec Mining Law states that "Every owner of mining rights, whether he mines himself or by others, and every person working mines shall, during the first ten days of January in each year, furnish a sworn statement of his operations for the past year, mentioning the quantity of mineral extracted, its value at the mine, the quantity and value of the marketable product, and the number of workmen employed, as well as a list of the names of persons killed in working the mines."

As a rule, returns are made promptly. But a few belated reports usually delay the final compilation of the figures. For this reason a preliminary statement is issued each year so as to place the statistics before the interested public at as early a date as possible. Although not quite complete, the early statistical data are sufficiently near the truth to give a very good idea of the state of the industry. This year's preliminary report, noted in brief in a preceding issue of this journal, appeared in the latter part of February. In 1913, there is a difference of 1.6% between the total of the early statement and the figures as finally compiled. In 1912, they differed by 1½%, and as a rule, the difference is less than 2%.

The table of production shows the greater proportion of the total is made up of the value of the structural materials. They make up 63%. The products of metalliferous mines enter for 7½% only in the total. It is a slight increase as compared with the previous year, 6.09%, and quite an appreciable one as compared with 1911, when the proportion was only 3.17%. This increase is due solely to the further development of old districts, for we have yet no production to record from the northern fields. That these will eventually contribute to the mineral production, there is no doubt. Promising geological and mineralogical conditions exist in the Kienawisik Lake region, whence discoveries of gold have been reported. In this connection, it may be mentioned that, in the Report of Mining Operations in the Province of Quebec for 1912, a report on the northwestern part of the Province of Quebec, by Dr. Bancroft, was published, as well as some notes on the gold discoveries at Lake Kienawisik.

The following table gives the annual value of the mineral production of the Province of Quebec for the last ten years:

Year.	Value.	Year.	Value.
1904	$ 3,023,568	1909	$ 5,552,062
1905	3,750,300	1910	7,323,281
1906	5,019,932	1911	8,679,786
1907	5,391,368	1912	11,187,110
1908	5,458,998	1913	13,119,811

We note that since 1904 there is an unbroken series of increases of each year over the preceding one. In ten years the mineral production of the province has more than quadrupled. It is especially gratifying to note that the general business depression which prevailed during the greater part of the year 1913 does not seem to have affected the mining industry in the province. Comparing the production of 1913 with that of the previous year, the Province of Quebec shows a higher proportional increase than any of the other provinces. Quebec's increase in 1913 over 1912 amounted to 17%; Ontario 12.5%; Nova Scotia 2%; British Columbia shows a decrease of 5½%.

Table of Mineral Production of the Province of Quebec During 1913.

Substances.	No. of workmen.	Salaries.	Quantities.	Value.	Value in 1912.
Asbestos, tons	2,909	$1,686,251	136,609	$3,830,504	$3,059,084
Asbestic, tons	....	....	28,473	20,346	23,358
Copper and sulphur ore, tons	292	163,997	87,550	812,899	631,963
Feldspar, tons	6	1,379	74	1,554	2,200
Gold, ozs.	25	8,335	738	14,794	19,924
Graphite, tons	73	45,195	103	9,620	50,680
Iron ore, bog, tons	....	......	......	......	......
Iron ore, titaniferous, tons	36	6,093	4,981	9,824	4,024
Kaolin, China clay	27	15,000	253	4,354	520
Magnesite	....	......	515	3,335	9,645
Mica, lbs.	270	83,533	781,648	117,038	99,463
Mineral water, gals.	21	4,587	77,313	31,728	39,854
Ochre, tons	44	19,529	5,987	40,868	32,010
Peat, tons	....	......	......	......	2,000
Phosphate, tons	5	205	360	3,506	1,640
Quartz, tons	4	800	900	2,363	418
Silver, ozs.	10	3,687	36,392	21,791	14,591
Zinc and lead ores, tons	59	35,500	335	7,370	......
Structural Materials:					
Brick, M.	1,843	590,003	159,408	1,297,592	1,284,232
Cement, bbls.	1,278	1,136,117	2,881,480	3,361,292	3,098,350
Flagstone	....	......	......	......	600
Granite	645	365,378	......	496,588	358,749
Marble	209	108,154	......	120,541	252,041
Lime, bushels	317	163,431	1,922,837	464,424	455,570
Limestone	1,414	747,418	......	1,704,207	1,363,555
Sand	171	65,966	......	405,750	170,600
Sandstone	10	370	......	5,072	......
Slate, sq.	20	12,660	1,337	6,286	8,939
Tile, drain and sewer pipe, pottery, etc.	237	138,114	......	326,165	203,100
	9,925	$5,401,702	......	$13,119,811	$11,187,110

Building construction to the extent of $2,000,000 is under way in Moose Jaw, chief among which is the $1,250,000 Government elevator.

Coast to Coast

Lethbridge, Alta.—The street railway deficit for the year at Lethbridge was estimated in January at $40,000; and for the first six months of this year, the deficit has amounted to $19,185.35.

Winnipeg, Man.—The Grain Growers' Grain Company has secured a further lease of the Manitoba grain elevator system from the Manitoba Government on practically the same terms as previously. No definite period for the renewal was specified.

Gibson, N.B.—Concrete Builders, Limited, has installed a new block tamping machine and brick attachment at its plant at Gibson, N.B. The block tamper is capable of producing 500 concrete blocks per day; and the brick attachment, of 10,000 bricks per day.

Regina, Sask.—The 5,000,000-gallon reservoir which is being built at Regina by day labor comprises an area for excavation of 250 feet by 150 feet. The soil from the excavation which will total 11,000 cubic yards when completed, is being removed to form a covering for nuisance grounds in the city north of Fourth Avenue.

Winnipeg, Man.—On many portions of that part of the C.N.R. which lies in the district west of the western boundary of Manitoba from the Great Lakes, the work of replacing the 60-pound rails on the main line with 90-pound rails, has been proceeding. It is said that before winter the company will have laid in all 300 miles of this heavy steel.

Halifax, N.S.—Building operations are quite brisk and several buildings are now under construction, the principal building being the large Acadia School, which will be a first-class structure, with the most modern improvements. There are also two schools which will have large additions attached to them. St. Joseph's Temperance Hall is well under construction.

Regina, Sask.—The city of Regina has decided to proceed at once with its programme of water main construction for 1914. The work is being done partly by day labor under the direction of the city's waterworks department, and partly by John Brodt, who is employing machines. This is being done that the department may get a comparison of prices in the work on each class of pipe, with the exception of the 24-inch pipe which amounts to only two blocks and will be laid entirely by the city.

Lacombe, Alta.—The first gasoline electric railway to be constructed in Alberta is the line now under construction from Lacombe West to Gull Lake, Bentley, and Rimbey, a distance of around 45 miles. It is reported as well under way, over half the distance being graded, and ties being on the ground the full length of the route. Moreover, the rails are in the yards, and one of the cars is now on the way from England, where it was manufactured; so that it is fully expected to have the line in operation early this fall.

Guelph, Ont.—Operations have ceased for a time on the drilling being done by Peat and Son of Petrolia, who were given the contract to box the artesian well at the Guelph waterworks pumping station. The drill had reached a depth of 870 feet, and indications did not promise that a pure flow of water would be encountered at a lower depth. It is declared that the mineralized water which has already been struck in the city can be utilized; and it is thought that the flow will reach at least 50,000 or 60,000 gallons per day.

Toronto, Ont.—The local hydro-electric commission has recently been experimenting with "half-watt" lamps for street lighting, and the entire Avenue Road hill district and several sections of streets in other parts of the city have been furnished with these. The effect has been to produce on the Avenue Road hill twice as much light as previously. The new nitrogen or "half-watt" lamps give, when new, a radiance of some 200 candle power; while the former tungsten bulb was equal in radiance to 80 candle power.

Toronto, Ont.—The orders recently placed by the C.N.R. company for equipment were given as follows: to the Canadian Car and Foundry Co. for between 25 and 30 passenger and sleeping cars at a money value of about $500,000; to the National Steel Car Co. of Hamilton for 10 baggage cars at a cost of between $50,000 and $60,000; and to the Crossen Car Company and the Preston Car and Coach Company for smaller orders of passenger equipment. The company has not as yet placed any orders for freight equipment, and is not expected to do so for some time.

Toronto, Ont.—The most recent report upon the colonization roads work in progress in Northern Ontario announces that the Port Arthur and Fort William road is being stoned and gravelled; and new roads are being cut into the Pigeon River country, connecting Fort William with the Minnesota State road, which will run through 57 miles of new country in Canada. The State road leads to Duluth, and is 100 miles long. The Sydney to North Bay trunk road will be completed within a year, while the trunk road between North Bay and Mattawa is now finished. Early this season the Sudbury to the Soo road will be open.

Calgary, Alta.—City Commissioner Graves, of Calgary, calls attention to the announcement in our "Coast to Coast" columns of July 9th regarding the surplus for 1913 of the Calgary Electric Railway. The figures given, $177,000, presumably relate to the city electric light department, whose surplus was in the vicinity of that figure. That of the street railway was $71,627.81 at December 31st, 1913, according to the Commissioner. In regard to the deficit of $70,000, reported in our issue of July 2nd, the city authorities are not in a position to state what the outcome for the year will be, under which circumstances the figure mentioned is not justified.

Montreal, Que.—The Hon. J. A. Tessier, provincial Minister of roads, recently stated in connection with the progress that is being made on the road under construction between Levis and Jackman, Que., that already 13 miles of the road have been completed, and 30 more have been graded ready for the top macadam dressing, the present progress warranting the hope that the entire 70 miles between the two points would be finished this year. The minister also said that at present he is engaged upon plans for the new highway from Montreal to Quebec; and that the whole question of road construction in the province is advancing as never before.

Toronto, Ont.—Three years will be required to complete the proposed project for disposing of garbage in Toronto. The scheme will not only entail the construction of a new central plant, but will necessitate the construction of special cars for the conveyance of garbage; since the transit must be made along street railway lines and must be odorless. The plans also include the installing of special cans for household service, so as to make the new system thoroughly modern, clean and effective. The new method of special preparation of the garbage, and the separation of its various elements, will also make the disposal profitable. The sale of grease and fertilizer will reduce the cost of incineration; and all smell will be eliminated in the process by the deodorizing of gases.

Calgary, Alta.—The Bow Island Natural Gas and Calgary Oil Company, Limited, has altered its proposal to meet the requirements of the city of Calgary that the word "exclusive" should be cut from the franchise it seeks to make with the city for the supply of gas at the city boundary. It will either construct a pipe line from Bow Island to the city limits and supply gas at 10 cents per 1,000 cubic feet, or sell gas at Bow Island at 2½ cents per 1,000 cubic feet, the city to construct the pipe line. The city is asked, however, to contract for a minimum amount of gas, not as yet determined; and, if this amount is exceeded, the city is to be free to continue taking its supply from the company, or if dissatisfied with the service or price, from some other company. The company has already sunk one well which is capable of producing 10,000,000 cubic feet of gas per day, and is anxious to secure a market without delay.

Porcupine, Ont.—A twenty stamp addition to the Hollinger mill has been completed, and will be running in a few weeks. Then the foundations will be laid for the twenty stamps which are to be reserved for the ore from the Acme gold mine, the private property of the syndicate. There is already enough ore on the Acme blocked out to keep them going for some time. Basing calculations upon the stamp duty of the present Hollinger mill, the combined plant will then have a capacity of over a thousand tons a day. It is not expected that the whole of the eighty stamps will be in operation until next February. The main vein of the Hollinger has been cut at the 675 feet level. It is about twelve feet wide, and appears to carry much the usual grade of ore. No. 41 vein has also been picked up on the 200-foot level, and this discovery will add considerably to the probable ore reserves of the mine. Another shaft is being sunk to open up the Hollinger property from the south.

Edmonton, Alta.—An inspection of the Alberta and Great Waterways Railway, now under construction from Edmonton to Fort McMurray, was made recently as far north as Lac La Biche by W. R. Smith, chief engineer of the line, who reports that the first 14 miles of grading is completed. Track is now completed to mile 14, at which point ballasting of the completed portion will be commenced and proceeded with with all possible despatch. Beyond mile 14, despite the handicap of an exceptionally wet season, work is progressing favorably. The completed portions of grade aggregate well over 50 miles. It is thought that the grade will reach the lake by the fall; and the intention is to rush track-laying to mile 26, where the Redwater River crossing will delay operations for a few days, while a bridge is being driven across the stream. When the bridge is completed the track-laying machine will follow the grade northward as it is made ready for the steel.

Ottawa, Ont.—A project of the United States Government to construct a waterway to connect Montreal and New York, has recently been discussed at Ottawa, the representatives from the United States in connection with the scheme being Colonel W. M. Black, of the United States army engineering corps, New York, and Lieutenant-Colonel Harry Taylor, assistant chief engineer at Washington. It is planned that the waterway will be 12 feet deep, and will go by way of the Richelieu. The present water communication is not deep enough to be very practicable. The plan was first proposed some few years ago in Canada; but after a government investigation of its possibilities, nothing was done. The scheme involves the building of a movable dam near St. John, so as to increase the level of the Richelieu River where it leaves Lake Champlain, and thus overcome the rapids around which the Chambly Canal now provides a route. A short canal to La Prairie instead of by way of Sorel is also mooted.

Montreal, Que.—Messrs. Warren and Wetmore have completed plans for the temporary passenger station which is to be erected at Montreal by the C.N.R. The structure will be a modern one of steel and concrete 150 feet front by 100 feet depth, and will have two storeys above and one below street level. From the front street, there will be seven doors leading into a vestibule 21 feet wide and 100 feet long and thence into the passenger waiting room, 60 by 100 feet and 30 feet high. This will be flanked by all the various rooms and offices customary at railroad stations. Immediately below the vestibule is the concourse with easy ramps leading to the platforms. There will be 3 double platforms and 6 tracks; and it is understood that these tracks will be permanent and will form a part of the future track system of the C.N.R. permanent terminals in this city. The baggage will be handled in a separate portion of the building in the rear approached by special driveways; and from the platforms it will be handled by lifts.

Vancouver, B.C.—Work has commenced on the wharves and slipways which constitute part of the drydock construction being undertaken by the Dominion Shipbuilding Company at Vancouver. The amount to be expended on the enterprise will be $2,500,000; and it will be a couple of years before the plant is prepared to handle ships. According to the plans of the company a big floating drydock, capable of lifting big vessels, will be built; and shops equipped to carry out the largest kind of repair jobs will be erected. The work of dredging, filling and laying out of the foundations of the buildings is being done by the British Columbia Granitoid and Contracting Co., Limited, of Seattle. The first two buildings to be erected will be the machine shop and boiler shop; and the plant of the Mainland Ironworks, of Vancouver, which has been absorbed by the new undertaking, will be moved at once to the north shore site in order that the new company will be able to proceed with this branch of the work. Lynn Creek will be dredged over an area 2,900 feet long, 100 feet wide and 25 feet deep; and all the sand and gravel taken from these dredging operations will be conveyed by suction and placed over the entire site.

Montreal, Que.—The chief features of a scheme of tunnel and terminal construction which has been devised by Napoleon Hebert, a controller of Montreal, are:—(1) a union station on the site of the present Place Viger station to accommodate passenger traffic of the Canadian Pacific, Canadian Northern, and Grand Trunk and the various lines, including the Intercolonial, that have running rights; (2) the purchase of the Bonaventure station site and the present rights-of-way as far as St. Henry, the demolition of the structures, and the removal of the tracks; (3) a provision for more freight terminal space in compensation for the expropriation of the Grand Trunk Bonaventure station, probably in St. Gabriel ward; (4) a line to provide connection with the proposed union station, opening from St. Henry, and proceeding by elevated tracks along the river-front streets; (5) the removal from the river-front of the Canadian Pacific tracks and the establishment of a new entrance to Place Viger by constructing a tunnel or subway from Mile End; (6) the removal of Moreau Street station of the Canadian Northern and the construction of a tunnel to give a new entrance to the proposed union station; (7) a provision of space in the tunnel for the Tramways Company, running northwards from Place Viger to Mile End.

Moncton, N.B.—The city council of Moncton has adopted a proposition which will be submitted to Mr. F. P. Gutelius, General Manager of Government Railways, for ratification; and, pending the agreement being satisfactory to him, a plebiscite vote will be taken on the proposition at as early a date as possible. The proposition deals with the question which has been discussed at different meetings of the city council and representatives of the I.C.R.—i.e., the elimination of level crossings in the city of Moncton; and provides for, first, the elimination of all grade crossings, save one, between Main and Union Streets; secondly, a permanent overhead bridge, 70 feet wide, at Union Street; thirdly, an overhead bridge at St. George Street, and one at Victoria Street; fourthly, a subway at Main Street and a slight change in Archibald Street; fifthly, a 6-foot concrete sidewalk on railway property from Robinson Street to Main Street on the western side of the Railway; sixthly, a pedestrian subway under Lutz Street, Queen Street to remain open for 3 years or until some arrangement is reached between the railway and city council; and last, the entire programme of construction to be done by the railway, and the city to contribute $5,000 to the company upon the completion of the work.

PERSONAL.

D. ROSS has been appointed locomotive foreman in charge of work at the Southwark terminals of the Grand Trunk Railway.

J. R. ESSON, ROBT. McKAIG, and ROY ROBERTSON, of Petrolia, left last week for Mexico to carry on oil-drilling operations there.

R. H. SPERLING, general manager of the British Columbia Electric Railway Co., has resigned and is being succeeded by Mr. George Kidd.

H. H. BOYD, of Saskatoon, has taken up, at Moose Jaw, the duties of superintendent of the Moose Jaw division of the Canadian Pacific Railway.

A. N. BEER, who has been engineer in charge of the Waterworks Department of the City of Ottawa during the past year, has handed in his resignation.

M. C. McCONNELL, of the Geological Survey of Canada, is in the Omineca Mining Division of British Columbia investigating the geology of the Hudson Bay mountain.

R. H. CAMPBELL, Superintendent of Forestry, Ottawa, has been made an honorary member of the Royal Scottish Arboriculture Society at its recent conference at Edinburgh.

C. A. MEADOWS, B.A.Sc., has just returned from Europe, where he has spent three months on an investigation of improved machinery for wire and ornamental iron work.

WILLIS CHIPMAN, C.E., Consulting Engineer, Toronto, has been retained by the City of Edmonton to report upon the several electric power schemes now under consideration.

C. G. TITUS, B.A.Sc., for three years engineer and assistant manager of the Temiskaming Mines, Cobalt, Ont., has been appointed superintendent of the Renfrew Molybdenum Mines.

CHAS. GRASS, of Waasis, N.B., formerly concrete inspector on the I.C.R., has been appointed assistant bridge inspector, under Mr. Eugene Savage, on the Canada Eastern Division of the I.C.R.

WM. SNAITH, secretary-treasurer of the Thor Iron Works, Toronto, has just returned from a five months' absence in California, where he was superintending for his company the construction of a number of large oil tanks at Oilfields, Cal.

FRANK SCOTT, of Montreal, treasurer of the Grand Trunk Railway for 13 years, and of the Grand Trunk Pacific since 1906, has been appointed the vice-president and treasurer of the company, a new position occasioned by the death of Mr. M. M. Reynolds, formerly vice-president.

S. NAKAGAMI, vice-councillor of the Imperial Government Railways of Japan, arrived in Canada from Tokio last week and will remain in this country for several months investigating its railway systems. Interviewed in Montreal, Mr. Nakagami stated that Japan had now about 6,000 mi. of railway in addition to several new lines under construction and others in contemplation. It is in connection with this contemplated work that the present visit of Mr. Nakagami is involved.

OBITUARY.

The death occurred in Victoria, B.C., recently of Mr. John Niblock, a prominent railroad man in Western Canada. Mr. Niblock, born near Toronto in 1849, entered the service of the Canadian Pacific Railway in its early days and was train-master at Winnipeg for a number of years. Later he was placed in charge of the shops at Medicine Hat. Afterwards he was superintendent of the C.P.R. from Swift Current to Laggan.

PEAT CONVENTION AT DULUTH.

The American Peat Society will hold its eighth annual meeting in Duluth, Minn., August 20th, 21st and 22nd. Important papers on the peat industry, peat lands, and the use of peat for fuel will be presented by numerous investigators and experts from various countries. There will also be an exhibition of peat, peat products, and machinery and apparatus for its preparation and development.

ASSOCIATION OF RAILROAD SUPERINTENDENTS.

The twenty-seventh annual meeting of the American Association of Railroad Superintendents is to be held in New York City on August 20th and 21st, at the Hotel Woodward.

COMING MEETINGS.

WESTERN CANADA IRRIGATION ASSOCIATION.—Eighth Annual Meeting to be held at Penticton, B.C., on August 17, 18 and 19. Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

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

CANADIAN FORESTRY ASSOCIATION.—Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Secretary, Will P. Blair, 832 B. of L.E. Building, Cleveland, Ohio. Eleventh annual convention and paving conference, Buffalo, N.Y., September 9th, 10th, 11th, 1914.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chaussé, 5 Beaver Hall Square, Montreal.

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th. 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.