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Volume 29. Toronto, September 16, 1915. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

TUNNELLING AND GEOLOGY

THE IMPORTANCE OF GEOLOGIC SURVEYS IN CONNECTION WITH TUNNEL WORK—SIZE AND CROSS-SECTION OF BORES—METHODS OF DRIVING—LINING—UNDERGROUND WATER.

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ON account of the magnitude of tunnel work undertaken lately in this country, and owing to the remarkable progress attained abroad during the past decade, much ink has flown on the subject of tunnelling, and the outcome of various discussions brought forth has stimulated to no small extent the activity of tunnel men. The result is that to-day the high rate of driving progress attained in Europe has been equalled and even surpassed in several instances, in this country, when driving headings and tunnels of small cross-section. Generally, however, the improvements made in this field of engineering have been chiefly connected with details, which, in large tunnels, are of vital, though secondary, importance. Other items of still more vital or basic importance, such as the method of attacking a bore of large cross-section, a railroad tunnel for instance, also the method of timbering and lining same, have received less consideration, and yet, it is precisely such features which are of greatest bearing on the cost and success of large tunnel enterprises. Mention should be made here, however, that new tunnelling methods are being used in connection with driving the Mount Royal and Roger's Pass tunnels; in the first instance, reasons of unusual character, aiming probably towards the rapid completion of a large railroad terminal station, in a well-populated city, have prompted the adaptation of tunnelling methods similar to those used abroad, while in the second instance, expected economy and rapidity in construction have guided the contractor to adopt a method which is at least practicable if not of absolute necessity.

The extent of geologic surveys in connection with tunnel work has also been closely limited in this country, and it is surprising to note that huge enterprises, involving millions of dollars, have been undertaken without first providing the contractor with adequate information as to the nature of the materials expected to be encountered, not to mention the fact that the engineers in charge of the work were often hardly aware of the difficulties which the contractor was expected to overcome, at his own expense. More recently, however, the need of more definite geologic data, serving the purpose of outlining obstacles liable to be encountered during construction, has prompted those in charge of large enterprises to make due allowance for preliminary geologic surveys. In this respect, the surveys made in connection with the Catskill aqueduct, for instance, have contributed to no small extent to the successful completion of this mammoth enterprise.

Briefly reviewed, geological surveys made in connection with tunnel work serve the following purposes: (1) to ascertain the feasibility of the project as a whole; (2) to determine the size and number of bores; (3) to determine the distance between bores in case of twin or more tunnels; (4) to select the shape or cross-section of the bore or bores; (5) to determine whether the bore is to be left unlined or is to be lined, partly or throughout its length; (6) to determine the dimension, and to design the various elements entering into the construction of the lining and timbering; (7) to select the driving method most suitable for a particular case; (8) to estimate the probable amount of underground water expected to be taken care of during construction, and further, to determine the probable rock temperature in the tunnel, the time necessary to drive the tunnel, and the approximate cost of the bore.

It is obvious that the geologic formation of a range to be tunnelled does not bear alone on the above items, but, as hereafter illustrated, it has some bearing on any one of them.

Size and Number of Bores.—The geologic formation of a range and the overlying depth have probably more bearing on the size and cross-section of long tunnels than any other features; whereas conditions of clearance and traffic usually determine the dimensions of short tunnels. In long tunnels, the driving methods, strength of the lining, ventilation during construction, etc., all depend to a marked extent on the materials penetrated and their stratification, cohesion, etc. Ground pressure may become so intense as to render the construction of a double track bore prohibitive if not impossible. An idea can be gained as to what would become the thickness of the lining of a double track bore subjected to a pressure similar to that resisted by the 66-in. thick cut stone masonry lining of the single track Simplon tunnel. In the Karawanken double track tunnel, where ground pressure was only 20 tons per sq. ft., the lining had a thickness of 59 in. A pressure similar to that encountered in the Simplon tunnel would, in a double track bore, require a quantity of timbering almost beyond conception during construction. When it is borne in mind that, other things being the same, the lining of a double track tunnel can carry only one-half the load supported by a single track tunnel, it becomes evident that, in certain instances, ground pressure limits to a marked extent the possibility of driving tunnels accommodating two or more bores.

Distance Between Bores.—The double-bore system of tunnelling has attracted much attention during the past years, and much has been learned from the experience gained in driving the Simplon tunnel. When the latter project was considered, little information was available to guide the engineers in charge of this work as to the distance suitable centre to centre of bores, and 56 feet were then considered adequate for the purpose intended. During construction of this bore, heavy ground pressure and shelling took place in apparently hard and sound rock such as gneiss, and it became necessary to line certain sections of the parallel heading at the very outset. As years passed, more shelling occurred at the roof, side walls and floor of the unlined parallel heading, in certain instances partly choking it with loose rocks, and it became evident that, unless it were lined with masonry, or

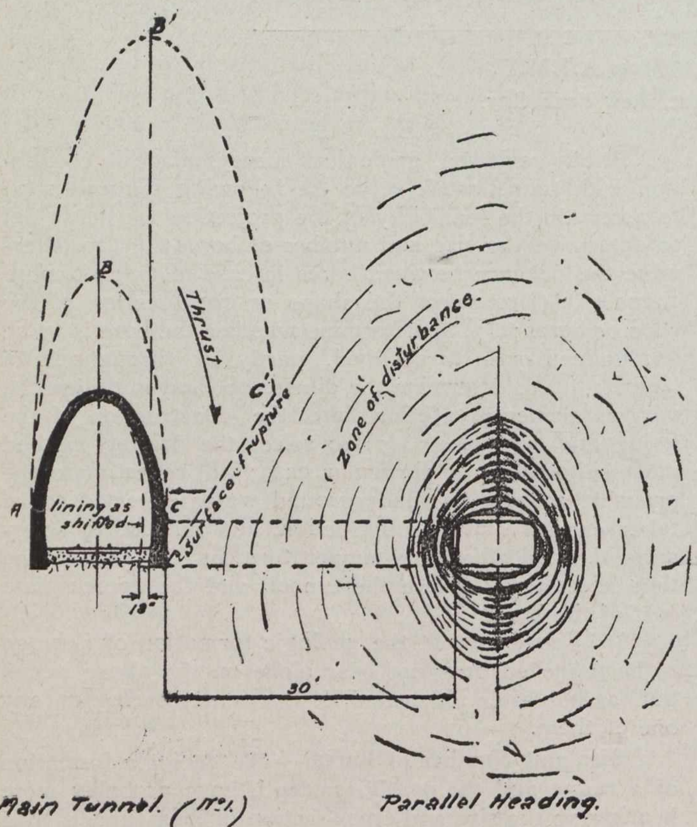


Fig. 1.

else enlarged to full section, and then lined definitely, extensive damage would result, with the possibility for the latter to extend over to the main bore.

Work of enlarging the parallel heading was then started and in July, 1914, as this work was going on between kilometer 3 and 3.5, heavy shelling took place at kilometer 3.3. The bottom of the drainage canal was lifted 10 in. and the side walls were shifted sideways about 12 in.; the width of the canal was reduced from 24 to 12 in. Seven days later, heavy shelling took place again in the parallel heading, and the masonry side wall in tunnel No. 1 was moved sideways 18 in., as illustrated in Fig. 1, and the width of the drainage canal was reduced also. Thus, after 14 years, the mountain, far from having reached a state of rest, was still exerting its crushing effects. The lining in the main tunnel had been completed in 1901, and as the ground stood well, at this particular point, the minimum lining section had been provided, *i.e.*, an arch thickness of 13.7 in. and, as no lateral or upward pressure was anticipated, the side walls were made light and no masonry invert had been provided. Thus, Prof. Heim's theory of "latent plasticity" had been demonstrated.

In Fig. 1 an attempt has been made to illustrate the occurrence of the disturbance referred to above. On account of the enormous pressure acting on the unlined parallel heading, shelling and crushing of the roof, side-walls and floor took place. This loosening and disturbing action, on the surrounding strata, and especially of the material lying between the main tunnel and the parallel heading, rendered same unfit to resist the thrust of the material overlying the main tunnel. Thus, the overlying weight, originally limited within the line A-B-C (Fig. 1) was increased in magnitude and shifted over to A-B′-C′, thus subjecting the tunnel to eccentric pressure. Lateral pressure was then exerted on the side wall lining of the main bore, shifting it 18 in. out of place. The compression in the material adjacent to the side wall nearest to the pioneer bore, which originally could be represented by a-d-c-b (Fig. 2) was subsequently changed to d′-a′-b′-c′. The latter, representing a cross-section of Roger's Pass tunnel, now being driven through the Selkirk Range, in British Columbia, illustrates also the possibility for disturbances to take place in a bore, when the adjacent bore is left unlined. The tunnel system here consists of a main double track bore and a 7 x 8-ft. heading or pioneer bore driven some 31.5 feet from it.

On the assumption that the side walls are solid and capable of resisting the excess weight of the ground brought upon by tunnelling, the weight acting on the roof of the main bore (Fig. 2) can be represented by the parabola A-B-C. Through the process of tunnelling, it becomes evident that the weight or pressure w-x-y-z, acting upon the bore must be resisted by the side walls of the bore, and the intensity of the stresses in these can be illustrated by a-b-c-d, the maximum compression occurring at the side wall, and the minimum or normal, at a certain distance therefrom, at c-b for instance, where, other things being the same, c-b is equal to w-x. The location of B above the tunnel roof, that is, the load acting on the tunnel roof depends on: (1) the width of the bore; (2) the cohesion of the overlying material, and (3) the skill displayed in tunnelling. The wider the bore and the less the cohesion of the overlying material, the more will become the roof deflection, and the greater will be the disturbed zone. Also, the heavier the blasting, the more shattered will be the surrounding material. It is obvious that the same remark holds good also for the pioneer bore. Now, if the material lacks cohesion, in a crush zone, for instance, or if it possesses a low compressive strength, as for instance, soft sandstone or shale do, and if the overlying depth is large, the side walls will yield, crush, and the stresses will then become a maximum at a certain distance away from the side walls' face, at a′, for instance (Fig. 2). Also, if the material is well stratified, with layers of clay or other soft material, the pressure may become so intense as to squeeze out the soft material, thereby causing the strata to drop and break at right angle to the bedding planes, as shown in Fig. 2, on right-hand side of main bore. In a wet tunnel, water may also, in course of time, wash away the soft material and cause a similar effect.

If the materials penetrated are such as laminated clays, shales, schists, etc., which, when exposed to air, swell or disintegrate, the sides and roof will part, pull away from the adjacent material or strata in more or less concentric rings, and cause disturbance in the surrounding material, as shown. The time necessary for such disturbances to take place depends on the care exercised in blasting, timbering, lining, etc., and on the formation of the range, whether badly faulted or contorted, and chiefly on the care taken in checking at the very outset initial movements of the strata. Other things being the same, the surface or plane of rupture will depend on the angle of repose of the material penetrated, it being admitted for practical purposes that the plane of rupture has an angle of $45 + \frac{\alpha}{2}$ with a horizontal line passing at the elevation of the tunnel floor, as shown in Fig. 2.

From the above it becomes evident that disturbances are liable to take place, more or less slowly, in a range pierced by a bore, and made up of materials possessing a low crushing strength. If, on the other hand, harder materials, such as crystalline rocks, are tunnelled, results of an apparently different, though similar nature, are also capable of causing disturbances, in a slower period of time, however. Reference is made here to such mechanical actions as expansion or contraction of the rock, also shelling or popping of same, and of chemical actions such as oxidation and carbonization of certain rock-forming minerals.

Shelling of Rocks.—The phenomenon of rock shelling or popping has been observed in many instances in mines, tunnels, shafts and quarries, both in this and other countries. Prof. Heim expressed himself on the subject as follows: "The sudden separation from tunnel walls of rock slabs takes place in various kinds of rock; shelling has been observed in granite, aplite, porphyry, gneiss, diabase, sandstone, quartzite, limestone, dolomite, coal and others, always under the condition that the rock was homogeneous, compact, solid, without cracks or seams. The slabs loosen themselves from and parallel to the tunnel walls (periphery) often not immediately after blasting, but frequently after weeks and months, often increasing in intensity as time passes, and increasing especially with the size of the bore."

Prof. Dr. Schmidt noticed that in the Simplon tunnel rock shelling increased with the overlying depth, and that in steeply inclined strata of gneiss, with 2,300 ft. burden, no shelling took place, whereas in the same rock, with 4,000 ft. overlying depth, heavy shelling took place.

Rock shelling has been observed to occur at various depths below the surface of the ground, and in horizontally, vertically and steeply inclined strata, as, for instance, in the gneiss of the Simplon tunnel, in gneissoid granite of the Wattinger, Leggistein and Pfaffensprung tunnels. Lazarus White states that shelling took place in the west shaft of the Hudson siphon, in granite gneiss and that "the rock appeared to be under considerable stress and peeled off in layers for three or four weeks and continued to scale and pop, although perfectly sound when first exposed." A similar phenomenon was observed in the shale and limestone formation crossed by the Rondout siphon. In the Leggistein tunnel, shelling took place in the roof, several years after its completion and would last for a month at a time. In the Wattinger tunnel, violent shelling occurred in the tunnel floor, and in the Tauern tunnel, throughout its periphery. In every instance the phenomenon has taken place in sound and solid rock.

Effects on Rocks of Oxidation and Carbonization.—Moisture in tunnels is high, usually varying from 80 to 100 per cent., and those rocks which contain iron pyrites soon become oxidized and sulphuric acid is formed, the effects of which, on rocks, cause disintegration, more or less rapidly. Carbonization leads also to disintegration, and, the larger the percentage of carbondioxide contained in the air, the more rapidly rocks will disintegrate. Air contains about 0.045 per cent. of carbondioxide, by weight, and in tunnels a large amount is exhaled by human beings and animals, also by the consumption of explosives, the use of artificial lights, etc. The chemical action of agencies such as referred to above has but a slow action on the rock surrounding a bore; nevertheless, the combined action of the several elements capable of destroying the strength or cohesion of rocks is worthy of due consideration. For instance, if in Fig. 2 the rock surrounding both the main and pioneer bores was to reach a high state of disintegration, it becomes evident that, in due time, the width or thickness of the material between the bores would become inadequate to resist the

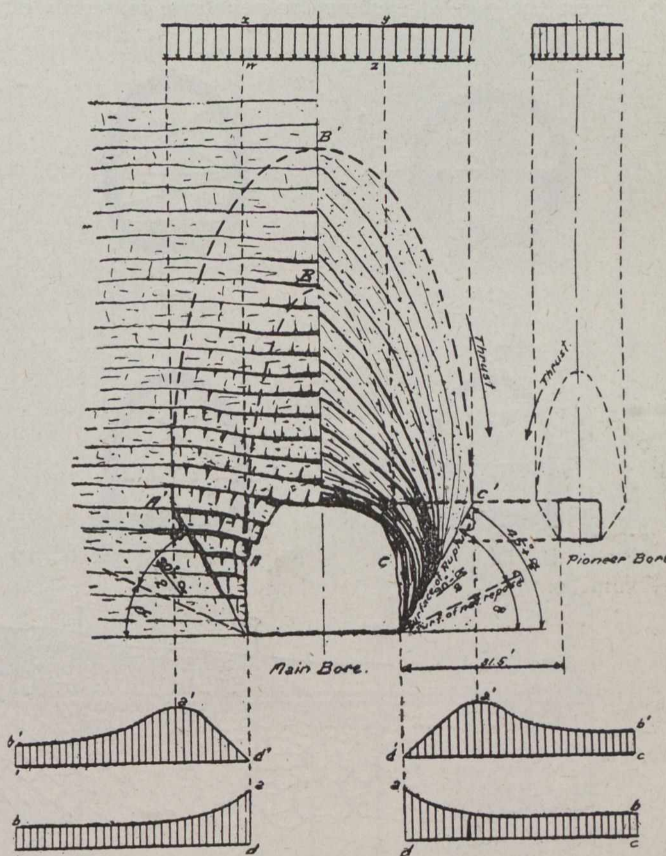


Fig. 2.

thrust of both the main and pioneer bores, in addition to the overlying weight, and crushing could then take place in a manner similar to that observed in the Simplon tunnel.

Thus, the question as to the distance to provide between bores of a twin tunnel system, and the necessity of lining the parallel heading or the pioneer bore, when deeply overlaid, becomes an item of vital importance, both from a standpoint of construction and maintenance.

Cross-section of Bore.—Other things being the same, the shape or cross-section of a tunnel plays by far a greater part than the thickness of its lining, and economy will be realized by giving a bore the shape best appropriate to resist the weight of the overlying material rather than by keeping the internal stresses in the lining within a reasonable limit, by increasing the thickness or dimension of its various elements, beyond a reasonable or practicable limit. As the geologic formation of a range varies very often, within a limited distance, also the overlying depth, it is obvious that the burden or load acting upon a tunnel lining varies also in intensity or direction, or both. Theoretically, there is but one tunnel section that is most economical, with reference to a given condition of loading, but, in actual practice, it would be impractical to change the cross-section very often. Furthermore, certain clearance lines for the rolling stock and for other purposes have to be strictly observed. It is also desirable that the forms and tunnel centres be made as uniform as possible. For the above reasons, it is usually the practice to design a few types of lining sections, the strength of which is determined *a priori*, adapting these where found necessary, according to the conditions of loading, or pressure acting on the lining.

In Fig. 3 an attempt has been made to illustrate several typical tunnel cross-sections adaptable to resist best ground pressure, under various conditions of loading. Here the bore is assumed to penetrate materials of purpose of resisting this pressure, the intensity of which may be high, the side walls of the tunnel are arched, and an invert is required, most usually to counterbalance the reaction of the side walls, at floor elevation, and incidentally to take care of upward pressure, should such pressure develop. As the intensity of ground pressure is a function of the width of the bore and of the cohesion of the material penetrated, it becomes evident that the bore should be given as small a width as practicable; therefore an elliptical section here answers better the purpose than would a circular section.

Zone 3 consists of weathered materials, not water-bearing, and exerting chiefly vertical pressure on the tunnel roof, and little lateral pressure, if any. Owing to the comparatively low compressive strength of the material penetrated, the base of the side walls is given a

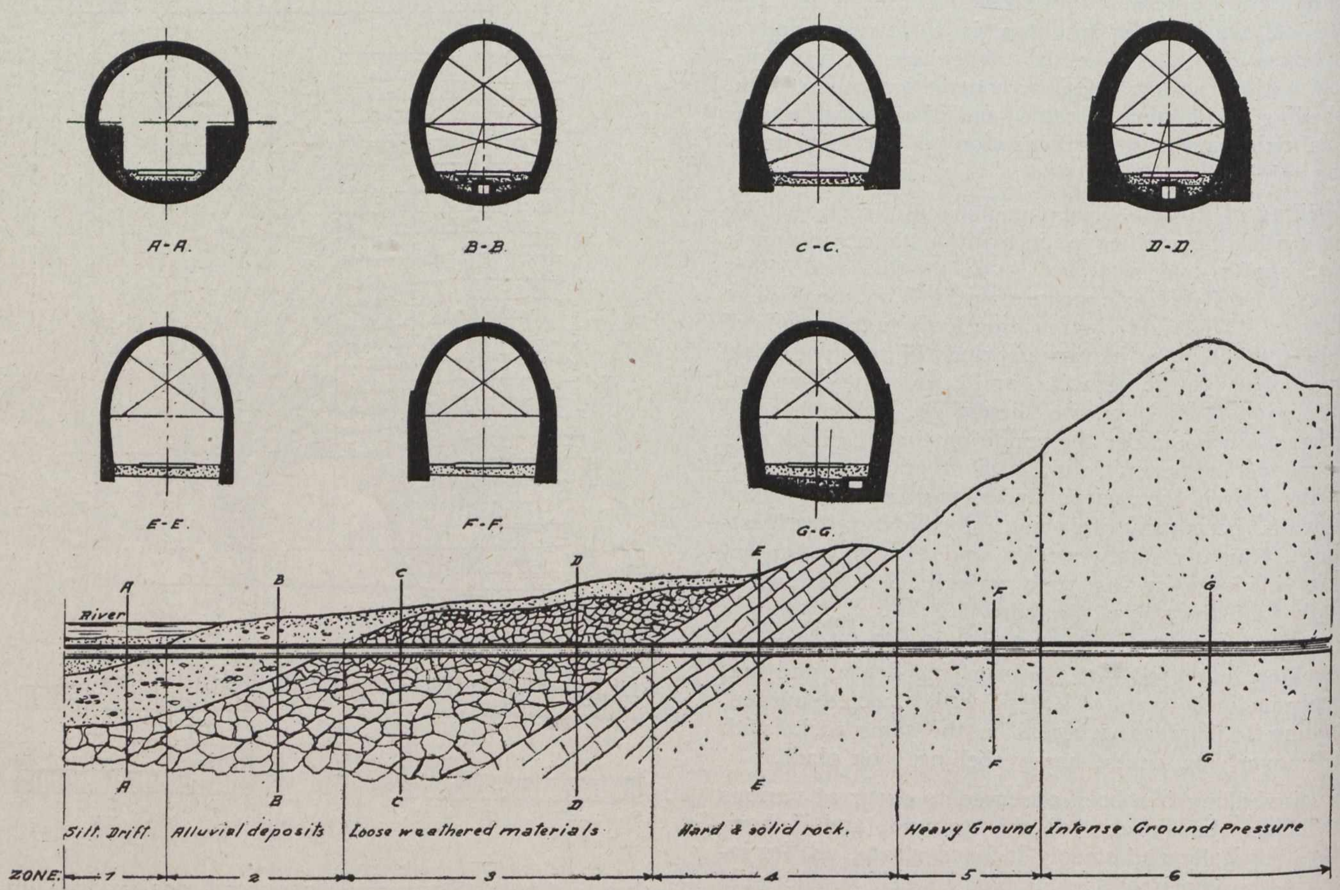


Fig. 3.

variable cohesion, at a variable depth below the surface, and for the sake of illustration, zones of variable formation have been assumed. Section A-A, Fig. 3, is that usually adopted for stream or river under-crossings, when the material penetrated consists chiefly of silt, mud, drift, sand, quicksand, and, in general, materials well saturated, and exerting pressure throughout the periphery of the lining. The tunnel section best suitable to resist the internal stresses thereby borne is circular. This section has been adopted in connection with the several tunnels driven under the Hudson and East Rivers, the Thames River, as well as other tunnels in America and abroad.

Zone 2, Fig. 3, consists of alluvial or glacial deposits, such as sand and gravel, boulders, clay, etc., materials more or less stable and capable of being tunnelled without the assistance of compressed air or of a shield, but exerting, nevertheless, lateral pressure on the lining on account of the small angle of repose of such materials. For the broad dimension. as shown in section C-C, so as to provide adequate abutments for the tunnel roof or arch, thus reducing the intensity of passive pressure on the material adjacent to the tunnel side walls, at springing line elevation. Should now the intensity of pressure on the roof of the bore become such as to cause possible settlement or sinking of the side walls below floor elevation, then a masonry invert is provided, as shown in D-D.

Zone 4 consists of hard and solid stratified rock, capable to stand without timbering upon being tunnelled, except that occasional falls of rock, loosened through the process of tunnelling, are to be anticipated. In such a case, a lining having a minimum practical thickness with vertical or slightly battered side walls answers the purpose.

Zones 5 and 6 consist of hard and solid materials. The bore is deeply overlaid, and in zone 5 vertical pressure develops in the roof, thus necessitating a heavy lining.

In zone 6 ground pressure becomes so intense that shelling of rocks, crushing of the side walls, and uprising of the floor necessitates a heavy lining throughout the periphery of the bore.

From the foregoing, it becomes evident that the shape or cross-section of a tunnel and of its lining depends largely on the material penetrated, its cohesion, stratification, and the depth overlying the bore. The yardage of masonry lining, per lineal foot of tunnel, may, in certain sections of a tunnel, vary by 100 per cent. from that of adjacent sections. For instance, the cost of the lining of the Simplon tunnel varied from $28 per lineal foot for the light sections to $229 per lineal foot for the heaviest sections.

Lining Tunnels.—The necessity of lining a tunnel, partly or throughout its length, depends chiefly on the nature of the material penetrated, its stratification, cohesion, etc. A bore with little overlying depth, driven through a simple formation from portal to portal, can be left unlined, if the material has not been, and is not liable to become, affected by weathering, and if, during construction, it has been demonstrated that the rock is solid, and that slips or falls are not to be anticipated. In complex formation, where alternate strata of igneous, metamorphic and sedimentary rock are expected, an exact knowledge of the location of contact zones and of the length of the sections of different formation becomes necessary, in order to decide whether and where a lining is to be provided.

The following classification can be established with reference to the necessity of lining tunnel: (1) Tunnels necessitating a lining at the very outset, *i.e.*, immediately following the excavation, as, for instance, bores driven through materials possessing little cohesion, such as sand, gravel, weathered rocks, and rocks subjected to intense pressure, causing it to crush upon being tunnelled. (2) Tunnels capable of being driven without making the lining follow closely the excavation, when the walls and roof are capable to resist ground pressure without heavy timbering or lining, for several months, as, for instance, bores driven through materials sound and solid upon being tunnelled, but which, when exposed to air or humidity for any great length of time will swell and disintegrate, lose their compressive strength, and thus become inadequate to resist heavy ground pressure. (3) Tunnels capable of standing alone, for years, without timbering or lining, but which, eventually, will require a permanent lining to check or prevent chemical action to disintegrate slowly, but continuously, the periphery of the bore, or else to check slips of rocks loosened by the slow eroding action of underground water. (4) Tunnels capable of standing permanently without a lining, when driven, for instance, through hard and solid rock, not subjected to weathering, and free from underground water or minerals, capable of being disintegrated by mechanical or chemical action.

It is not abnormal to encounter in one bore, one or several of the classifications referred to above, all depending upon the geologic formation of the range; therefore, the better the knowledge of the formation, the closer will be the actual cost of the bore to that estimated. In short tunnels, where maintenance and reconstruction work can be carried on under favorable conditions, the question of lining the bore at the very outset becomes of secondary importance, whereas in long tunnels, the cost of lining or re-lining, without interruption of traffic, runs from two to three times that of lining at the very outset.

Driving Methods.—The driving method best adaptable to a particular case depends chiefly on the formation

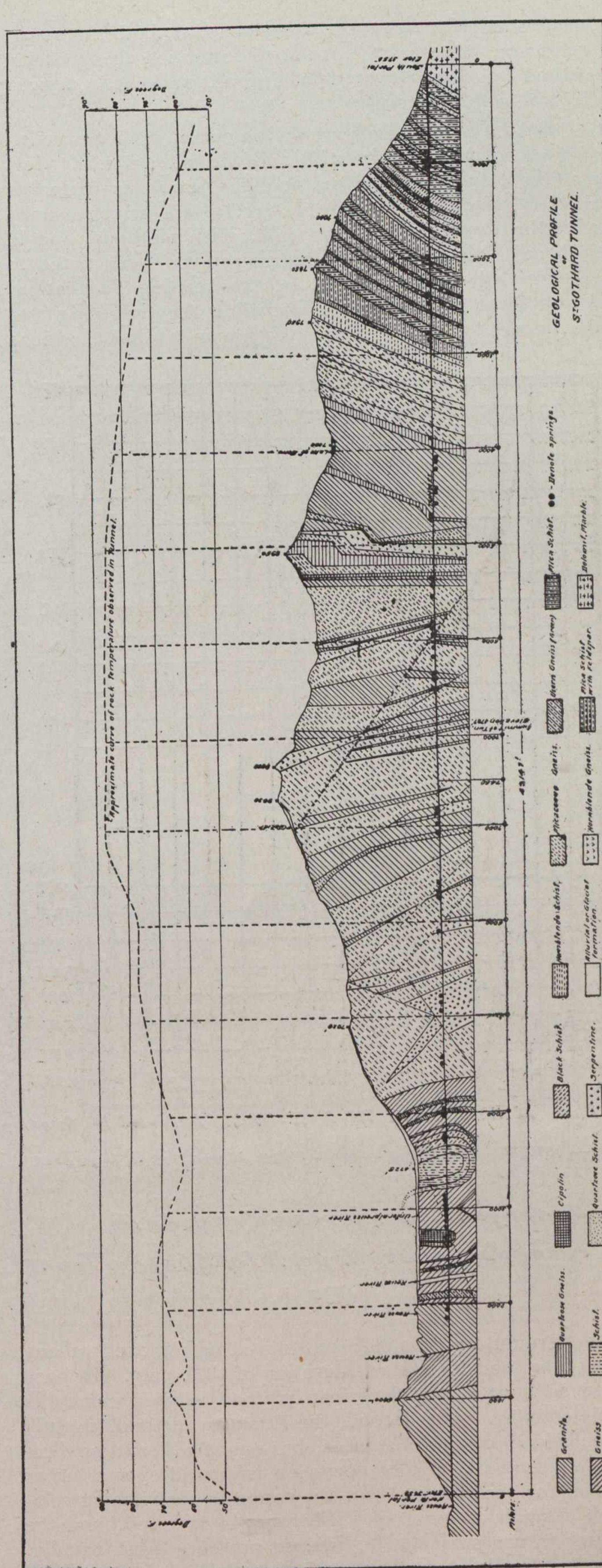
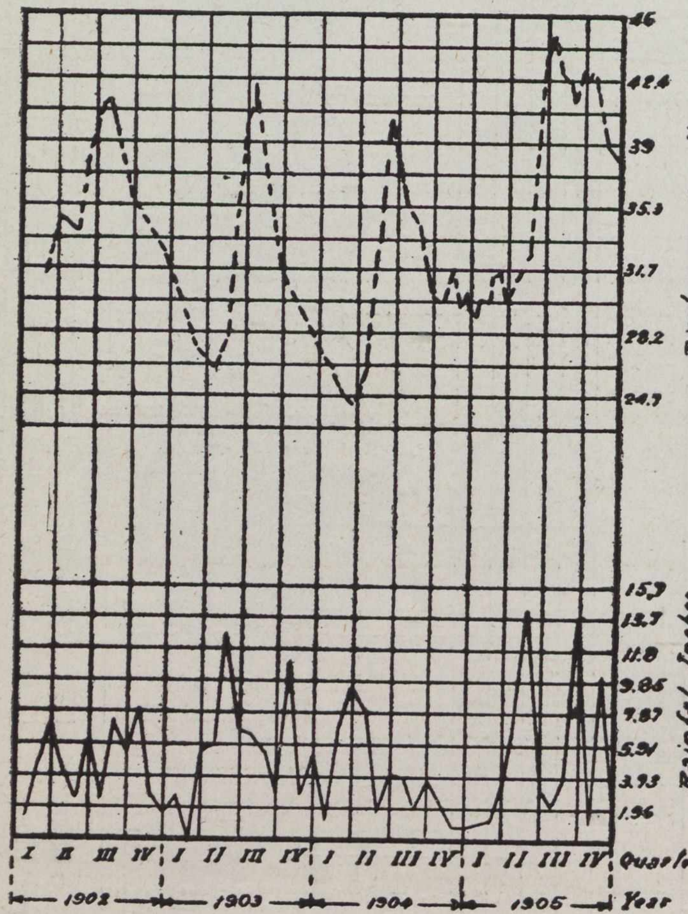


Fig. 4.—Geological Profile of St. Gothard Tunnel.

of the range to be tunnelled. The so-called American, German, Belgian, English, Italian and Austrian methods of tunnelling were originated and adapted to overcome natural obstacles of varying character. In very treacherous ground, for instance, the Italian method has found broad use, whereas in more solid formation the Austrian method has been favored in Europe, and the American method in this country.

Subaqueous tunnels are driven chiefly with the assistance of compressed air, with and without a shield. Soft materials, such as sand and boulders, earth, or materials such as referred to in zone 2, Fig. 3, are driven usually with the American, Belgian or English methods, and in such cases the field of mining operations is restricted to relatively short zones; that is, the heading excavation, enlargement to full section, including the timbering and the lining, follow each other within a few feet, and as



Underground flow and rainfall recorded at South portal of Simplon Tunnel.

Fig. 5.

little ground as possible is disturbed or removed at any one time, and for a short duration of time only. In hard and solid rock, the American method is used chiefly in this country, while abroad, the Austrian method, slightly modified in certain instances, has found a broad application. Here the field of operation is spread over a larger zone, for the formation of the range is such that a relatively small amount of timbering is required, and the latter is not subjected to intense pressure most usually. As the bore increases in length, and the difficulties due to geologic formation increase in magnitude, it becomes necessary to spread the field of operation over a large zone, hence the use of the bottom heading method adopted chiefly in connection with long and deeply overlaid tunnels. This method can be sub-divided into (1) the centre cut, and (2) chambering.

The first method, which consists in driving a bottom heading first, and then stoping down the overlying material, clear up to the tunnel roof, is used chiefly in connection with bores or sections thereof driven through materials not subjected to intense ground pressure, when the amount of timbering is relatively small. The second method, used where rock pressure forbids large sections to be excavated without being heavily timbered and lined within a short time, consists in driving a bottom heading first, then a top heading, and in enlarging the bore to full sections over a short distance at a time.

Too much emphasis cannot be laid on the necessity of using such driving methods that will best serve overcoming natural difficulties. The best, safest and most economical driving method is that which possesses flexibility in being capable of adaptation to suit natural conditions.

Underground Water.—A knowledge of the approximate amount of water to be encountered during construction is valuable, for experience has demonstrated time and again that a large percentage of delays in driving and lining tunnels was directly chargeable to underground springs. Moreover, when owing to topographical reasons it becomes necessary, for instance, to give the bore a uniform grade from portal to portal, then an estimate of the capacity of underground water to be tapped by the bore becomes of absolute necessity. In such a case the tunnel can be driven from one side only, unless adequate means are provided to prevent flooding of that end of the bore driven down grade.

The determination *a priori* of the quantity of water to be encountered in driving a tunnel is impossible practically, and as no two identical cases have ever been recorded, no fixed rules or formulæ have been advocated that would suit any or all cases. The amount of underground water depends chiefly on the amount and distribution of rainfall, on the topography and geologic formation of the site, and although the exact amount of water to be encountered underground is an unknown quantity, yet a general idea can be gained as to whether a tunnel will be wet or dry, and also the approximate location of probable wet zones, provided accurate data are available as to the geologic formation of the range to be tunnelled. The depth overlying a bore plays an important part, not only with reference to the capacity, but also to the distribution, of underground water. This is obvious, for, in little deeply overlaid tunnels, water travels but a short distance from the surface down to the bore, and usually the spouting point lies not very far below the source of supply. In deeply overlaid tunnels, when the formation is complex, the spouting point in the tunnel may lie several thousand feet from the source of supply; an idea of such an occurrence can be gained from Fig. 4, being a longitudinal section of the St. Gothard tunnel, prepared by Stapf. Seven thousand feet from the north portal, the tunnel is overlaid with some 5,000 feet burden, also with a glacier. Water found access in the bore through a fault, spouting in the tunnel approximately 6,500 ft. further towards the south portal, after a travel of some 9,000 ft. along the fault. Similar occurrences have been recorded elsewhere, and experience has taught that the depth overlying a bore is more a criterion in the distribution rather than in the capacity of underground water.

There exists an intimate relation between underground water and fissures in the ground, also faults, bedding planes, jointing, cleavage, as well as the kind of materials penetrated. The belief often prevails that tunnels driven through igneous rocks such as granitoid or porphyritic rocks are dry. This may have been the case in many instances, and no inrush of water of large magnitude has ever been recorded to last for any great length of time in such formation. That water penetrates and travels at great depths through practically any kind of formation, has been proved time and again, and large caves, water-worn contact zones, etc., resulting from erosion or corrosion have been recorded in driving tunnels, shafts and mines. In the Simplon tunnel, springs tapped by the bore, several thousand feet below the surface, were found to have (1) a temperature equal to that of the surrounding rock; (2) a temperature lower than that of the surrounding material, or (3) a temperature higher than that of the rock penetrated; showing that, in the first instance, cold surface water, flowing from high altitudes, had acquired a relatively high velocity, and had not absorbed the temperature of the material penetrated, and that it had travelled but over a short distance, whereas those springs possessing a higher temperature than that of the rock penetrated had travelled more slowly, at greater depths than the tunnel, and thus had acquired the temperature existing at such depths.

Another striking example was found in that section of the St. Gothard tunnel, between meters 4,000 and 5,000 from the south portal (Fig. 4) underlying the Lake of Sella, situated 7,300 ft. above sea level, that is, some 3,500 ft. about tunnel grade. Stapf had noticed that, in winter, the temperature of the lake was still 38.1° F. at a depth of 18 ft., whereas, water in the St. Gothard Lake, lying nearby, at an elevation of 3,240 ft., had a temperature of 35.9° F. only at a depth of 42.6 ft. Also, that fish were living in the lake of Sella, free of ice, during four months of the year only, whereas no fish could live in the St. Gothard Lake. Stapf concluded that water from the lake of Sella undoubtedly penetrated a great depth in the range, through fissures, thereby becoming heated, and, by rising again to the surface, was increasing the temperature of the lake. His hypothesis was fully justified, for, when that section of the tunnel underlying the lake was driven, much water was encountered, together with a fissure 3 feet wide. At a distance of 4,540 meters from the south portal, the rock was so fissured and water-bearing that four months were required to excavate a very short section.

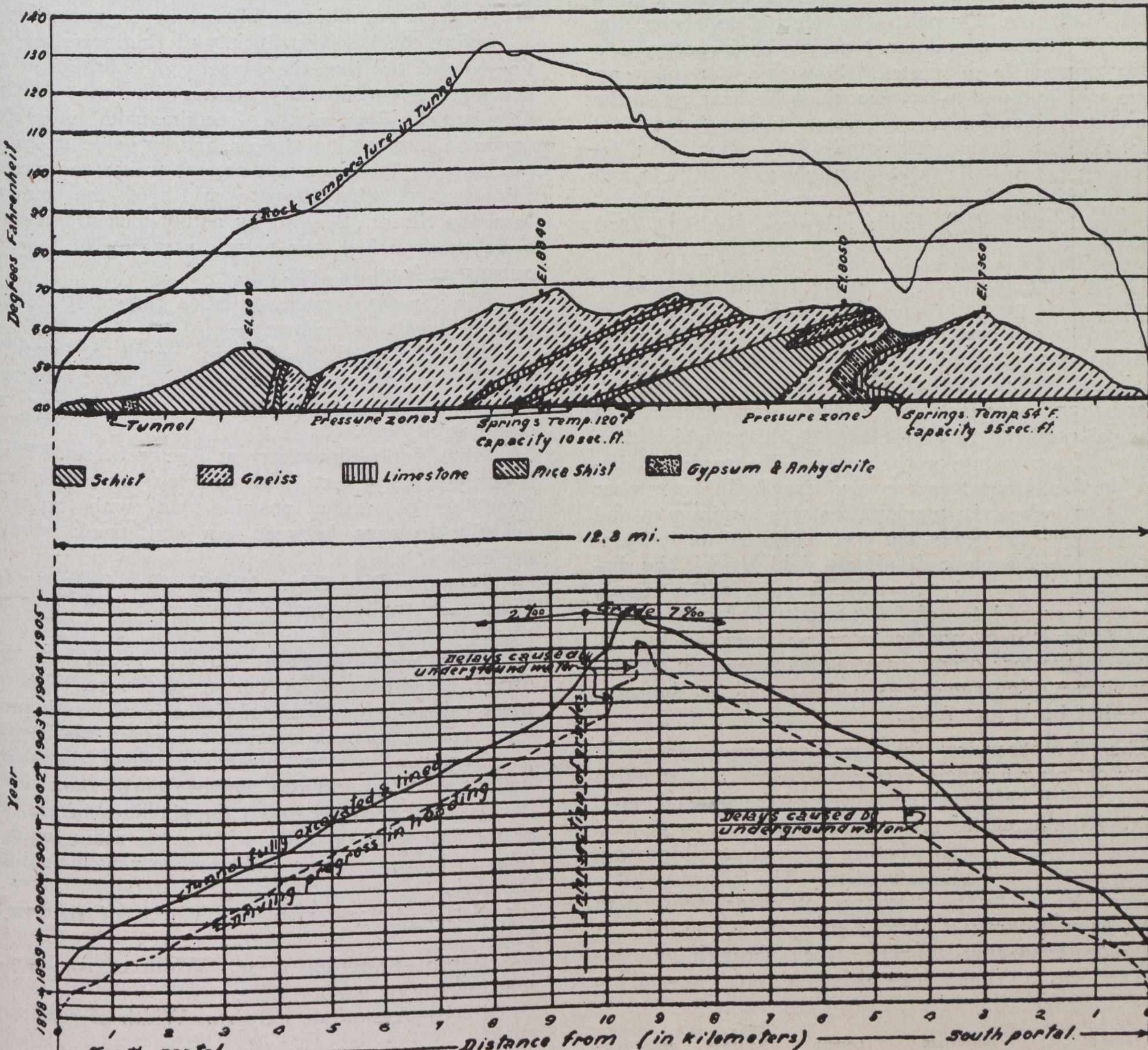


Fig. 6.

The circulation of underground water causes both erosion and corrosion of the surrounding material. It also increases or decreases its temperature. Erosive and corrosive effects are more apparent in limestone formation, in gypsum and anhydrite deposits. These effects take place more rapidly in such formations than in silicious and crystalline rocks. Through an analysis, Prof. Schardt found that certain springs in the Simplon tunnel contained 1 gram of lime sulphate per liter of water, and that, yearly, some 5,000 cu. yds. of material were extracted from the range in the vicinity of the tunnel, thereby causing extensive cave-in in the Cairasca Valley on the south slope of the range. A large cave was encountered during construction of the Granges tunnel, in Switzerland, both erosive and corrosive effects being perceptible.

Approximate Determination of Discharge of Underground Water in Tunnels.—As referred to above, the amount of water encountered during construction is a quantity impossible to foretell. However, the following features will be found to have considerable bearing on the amount and distribution of water underground: (1) amount and distribution of rainfall; (2) evaporation; (3) absorption; (4) run-off; (5) topography; (6) altitude and latitude; (7) overlying depth; (8) stratification; (9) material penetrated; (10) faults, fissures, bedding and weathering.

In northern latitudes, or at high altitudes, a large percentage of precipitation takes place in the form of snow, and thus a certain amount of the precipitation is stored during winter and the run-off takes place more or less slowly during the summer months. In the St. Gothard tunnel, for instance, the minimum discharge in the tunnel occurred in March and April, at which time snow would accumulate on the range. The maximum discharge in the tunnel was recorded usually in September and October, when the precipitation was a minimum and after the snow-clad peaks had been subjected to the summer heat. In the more deeply overlaid tunnel, the discharge of underground water, as recorded in the tunnel, did not correspond to rainfall periods, but would take place two or three months later, as shown in Fig. 5, whereas in the less deeply overlaid Weissenstein tunnel, the maximum discharge corresponded usually to the rainy season, in March and April.

Thus, by observing the discharge and number of streams draining a range, a rough idea can be gained as to the porosity or absorbing power of the ground, and, by taking the many features referred to above, a general idea can be gained as to whether unusual conditions are liable to prevail during construction. The following table gives an idea as to the discharge of water recorded in driving tunnels through various kinds of formation. It will be observed that tunnels driven through aqueous rocks are wetter than those driven through crystalline rocks.

Name of tunnel.	Materials penetrated.	Length considered.	Max. discharge sec.-ft.	Average discharge per min. per 100 t
Granges, N.	Limestone ..	13,930 ft.	8.5	3.6 cu. ft.
Granges, S.	Gypsum and anhydrite ..	14,163	22.0	9.3
Hauenstein	Limestone shale	19,225	3.3	1.03
Weissenstein ...	Limestone ..	12,150	15	7.4
St. Gothard, N...	Granite gneiss	23,265	1.73	0.45
St. Gothard, S...	Granite mica schist	25,882	8.13	1.88
Ricken	Sandstone conglomerate ..	28,200	1.0	0.21
Simplon, N.	Schist gneiss.	40,790	7.1	10.4
Simplon, S.	Limestone gneiss	22,983	44	11.4
Loetschberg, N..	Limestone ..	12,170	..	3.0
Loetschberg, S. .	Granite schist.	17,000	..	1.0

Such tunnels as the Mont d'Or and the Bosruck tunnels, where the discharge of underground water amounted to 100 and 78 sec.-ft. respectively, have not been included in the table, for, in such cases, large surface streams or rivers found access to the tunnel, and they therefore can be considered as abnormal cases.

WIDTH OF BRIDGES AND HIGHWAYS.

In connection with the width of bridges, Prof. Charles M. Spofford, of the Massachusetts Institute of Technology, Boston, Mass., in a paper presented before the Western Society of Engineers, calls attention to the fact that the capacity of a bridge in vehicles per hour is considerably greater than that of the ordinary street, due to the freedom from interruption of traffic on intersecting streets, and by vehicles stopping at the curb to discharge and receive freight or passengers. For example, the effective width of the roadway on Boylston Street, Boston, by actual measurements is not more than 36 feet, the vehicle standing at the curb requiring at least 14 feet.

Mr. Spofford cites statistics regarding other well-known streets as follows:—

New York—Fifth Avenue, south of 59th Street. Width of roadway, 55 feet between curbs; no street railway; six lines of traffic possible in addition to vehicles standing at curb.

New York—Broadway at Rector Street. Width between curbs, 35 feet, with double-track street railway; four lines of traffic possible, but with no room for vehicles to pass between car and truck standing at the curb.

London—Piccadilly. Width of roadway, 37 feet; no street car traffic; traffic between 8 a.m. and 8 p.m., 15,284 vehicles.

Boston—Washington Street, south of Summer Street. Width between curbs, 32.5 feet, with double-track railway; four lines of traffic in all, with just room for a vehicle to pass between a car and the curb.

Boston—Boylston Street, between Berkeley and Arlington Street. Width between curbs, 50.2 feet, with double-track railway; room for six lines of traffic in all or for four lines of traffic with ample room for a vehicle to pass between a car and another vehicle standing at the curb.

Berlin—Leipzigerstrasse. Width of roadway, 52.5 feet.

Berlin—Friedrichstrasse. Width of roadway, 26.25 feet (narrowest part).

Paris—Avenue de l'Opera. Width of roadway, 52.5 feet.

Vienna—Praterstrasse. Width of roadway, 36 feet.

Paris—Rue de Rivoli. Width of roadway, 39 feet (narrowest part).

A remarkable vein system under the streets of Cobalt has been discovered in the course of recent operations at the City of Cobalt mine, one of the properties controlled by the Mining Corporation of Canada. It is expected that this system will produce as much ore as some of the most famous in the camp. It bears a striking resemblance to the Meyer system of the Nipissing and the Coniagas, and for the most part the veins do not come to the surface. On the 200-ft. level the vein is about 4 ins. wide of high-grade ore, and at one spot it reached 10 ins. wide of bonanza ore. Here a winze was sunk to the 300-ft. level, while a crosscut from the 400-ft. level cut a remarkably rich vein.

THE ENGINEER IN MUNICIPAL AFFAIRS.*

By Manley Osgood,
City Engineer, Ann Arbor, Mich.

CIVIL engineering in all of its branches is concerned with directing nature to man's use and convenience. In the municipality, man has come together and organized that he may have various conveniences which are not enjoyed by his brother in the rural districts. What organization could have more use for a man trained to direct nature's forces to man's use and convenience, or where could the civil engineer find a better field for his endeavor?

Early in the history of every city a competent engineer should be employed to devote his whole time and attention to the affairs of the city. Smaller municipalities should consult freely with the engineers of nearby cities or with consulting engineers on all matters of public service. The duties of the engineer employed by any city should be whatever he may find to do in the service of the people of the city, together with the keeping of such records of all that he does as will be intelligible to a man of like pursuits many years later.

In selecting their city engineers I would suggest that the larger cities should draw from the smaller cities, taking only engineers whose work has been of the highest class; and the smaller cities should depend upon the recommendation of successful engineers in the larger cities or in private practice. Cases in larger cities may be found when it is advisable to promote the assistant engineer to the vacant position of city engineer, but as a general rule the position of city engineer in a smaller city will better equip an engineer for the position in the larger city than will the subordinate position in the same city in which the vacancy occurs. Too much care cannot be exercised in selecting a good engineer.

For purposes of comparison, I gathered statistics from the various city engineers in Michigan cities ranging between 15,000 and 25,000 population. The results in several instances were appalling to anyone who realizes the value of engineering service to the municipality. In one case a city of 15,000 to 20,000 people employed one man part time only at the sum of $900 per annum, and allowed him one man to help when necessary at $2 per day—the wages of a man without any intelligence. Other cases were nearly as bad. I know from my own experience that it is absolutely impossible for a city of this size to have even the most necessary engineering work done with such a department. And yet the tax rate in cities where such conditions prevail is higher than where adequate departments are maintained.

Politics should never enter into the appointment of an engineer, and your city engineer, once appointed, should hold his position as long as his work is up to a high standard. He should have the authority to hire and discharge his assistants. I have worked for a city in another state where the mayor appointed the city engineer and all of the engineering department employees. There was a complete change in the department every two years, for no mayor succeeded in holding office two successive terms. You can well imagine the result as far as efficiency was concerned. Each administration found few records and left few. There was no index or system of any kind and no incentive to make one, for it would hardly be completed before the maker would be replaced by the next mayor. The condition and accessibility of records are an excellent indication of the character of the engineering department in any city. These records should be the property of the muncipality in all cases and maintained for the use of its people.

The engineer of to-day spends as long a time in preparing himself for the work that he is to undertake as does the lawyer or the doctor. Is he not, then, entitled to the same consideration? No city would attempt to conduct its affairs without the service of an attorney, but yet the lack of engineering advice is quite as costly as the lack of legal advice, and may be even more so. No man hesitates to call in a doctor when he thinks his life is in danger. The lack of engineering, also, may be responsible for the death of one, or many, in places where the layman would suppose no danger lay.

One of the most important duties of the city engineer is to look as far into the future as it is given one to look. Your engineer has at his command a vast wealth of statistics and the experience of others in his periodicals and in the reports of officials in other places. The interpretation of these statistics and reports, in which the engineer is trained, gives to him a knowledge of what results will follow certain conditions which cannot be had by the layman. The first cost of an engineering project is not to be considered in many instances in the light of the resulting costs to follow. Sometimes an affair which seems of very trifling importance to the layman, and is given only passing consideration, may become a matter of serious consequence in the not distant future.

*From a paper read before League of Michigan Municipalities at Alpena, Mich., on June 25th, 1915.

PHOSPHATE DEPOSITS NEAR BANFF.

A press dispatch from Ottawa refers to a discovery of undoubted importance in connection with the future development of agriculture in Western Canada that has just been made by officials of the Commission of Conservation. Dean Adams, chairman of the Committee of Minerals of the Commission, and W. J. Dick, the Commission's mining engineer, who have returned from the west, report that deposits of phosphate of lime occur in the Banff National Park, in the Rocky Mountains.

In all agricultural countries there is an enormous demand for phosphate fertilizers, and every available source has been eagerly sought and exploited. Large deposits in Florida and South Carolina are nearing exhaustion. The largest deposits hitherto discovered have been found within the last half dozen years in Utah, Idaho, Wyoming and Montana, and the United States Government reserved them from entry.

The distribution and extent of the Banff deposits are to be worked out by the Canadian Mines Department, and it is believed they will prove to be comparable in extent and quality with those of the United States.

The use of the hydro-aeroplane has been extended to assist in the prevention of forest fires. A fire ranger in northern Wisconsin uses one in detecting fires and reported their extent. Heretofore the view a ranger has had of the surrounding country has been limited to that given from a 60-foot tower at the various forestry stations. This ranger recently discovered a fire 30 miles off and on investigation found he had made an accurate estimate of its distance and extent.

WOODEN POLES AND CROSS-TIES IN 1914.

Firms purchasing poles in Canada in 1914 were 381 in number, of which 209 were telephone companies, 17 steam railway companies and 3 telegraph companies, forming one group; and 132 electric light and power companies and 20 electric railroads forming another. The recent report of the Forestry Branch, Department of the Interior, as prepared by R. G. Lewis, B.Sc.F., indicates that the market has fallen off considerably during the past few years. The decreased activity of the different railways in extending their lines has been one factor, while the purchases of telephone companies are generally more or less irregular, although there has been a perceptible falling off since 1912.

The purchases last year showed a decrease of 47 per cent. from those of 1913, which were referred to in *The Canadian Engineer* for November 26th, 1914. The average price, however, increased by 11 cents.

Only nine kinds of wood were reported compared to twelve in 1913. Poles of oak, hard pine, and Douglas fir were reported in 1914, but not in 1913. Decreases occurred with every other kind of wood, the greatest being in the case of tamarack, which amounted to 98.4 per cent. of the figure for 1913.

Eastern white cedar poles headed the list, their number forming over 85 per cent. of the total. Western red cedar from British Columbia and the Western States came second on the list, with over 12 per cent. of the total. Poles of these two woods have formed the greater part of the purchases in past years in spite of the increasing scarcity of good material, especially in the case of the eastern tree.

The steam railway, telephone and telegraph group of purchasers bought 65.7 per cent. of the poles as compared to 87.8 per cent. in 1913. Their purchases in 1914 showed a decrease of 60.4 per cent. from those of 1913. The oak, hard pine, jack pine, and chestnut poles were all purchased by these companies. These companies reported the purchase of 442 treated poles.

The electric railway, power and light companies bought 34.3 per cent. of the poles as compared to 12.2 per cent. in 1913. Their purchases showed a decided increase (49.2 per cent.) over 1913.

Over half the poles purchased in Canada in 1914 were under 26 feet in length, the two cedar species forming 97.9 per cent. of the total in this class. These two kinds of wood formed over 95 per cent. in every length class recorded. Almost a quarter of the total number belonged to the next length class, including poles from 26 to 30 feet in length.

The greater part of the white cedar, red cedar, spruce, tamarack, and chestnut poles and all the jack pine poles belong to the 20 to 25-foot class. Oak poles were mostly from 31 to 35 feet in length. The greatest number of Douglas fir poles were over 41 feet in length, and all the imported hard pine poles were of this same class.

A total of 19,403,646 cross-ties, valued at $8,664,914, were purchased during 1914 by Canadian railways for use in Canada. These companies consisted of forty-seven steam railways and thirty-one electric roads. Of this total, 1,447,576 ties were treated with preservatives to retard decay. This is about 7 per cent. of the total, as compared to 10 per cent. in 1913.

The cross-tie purchases show a slight decrease of 2.4 per cent. from those of 1913, in which year the decrease was 6.7 per cent.

The greatest decreases from 1913 to 1914 were with the western species, Douglas fir, western larch, cedar and hemlock, and the imported woods, such as oak, hard pine, and chestnut. Of the twenty-one woods reported in 1914, eleven showed decreases.

Jack pine makes the most suitable tie material of the cheaper, more abundant woods of Canada. It has headed the list since 1911, when it took the place of white cedar, a more durable wood, but one of which the supply is rapidly becoming exhausted. These two woods have formed the greater part of the ties purchased in past years, and together formed over half the total in 1914.

The average prices paid for cross-ties by the railroads in 1914 showed only a slight increase over 1913. The prices in the last five years have been as follows: 1910, 38 cents; 1911, 39 cents; 1912, 44 cents; 1913, 43 cents; 1914, 45 cents.

The average prices in these tables are based on the cost at the point of purchase, and may or may not include long-haul transportation charges. Only in the case of those woods which are used in large quantities can the value given be taken to represent the relative value of the wood.

In June, 1914, there were in Canada about 38,000 miles of steam railway right-of-way. On over 32,000 miles of this trains were in actual operation, and on the remainder ties at least were laid. The steam roads purchased in that year 19,196,208 ties, being about 500 ties to the mile. A large proportion of these ties were used for new construction at the rate of about 3,000 ties to the mile, and the remainder for maintenance of established lines.

These companies paid an average of 45 cents each for their ties, as compared to 58 cents in the case of the electric roads. The steam railways, with 98.9 per cent. of the total for 1914, purchased all the ties of western larch, western spruce, chestnut, red pine, beech, maple, white pine, and birch.

The electric railways in Canada purchased 207,438 cross-ties, or about 1.1 per cent. of the total. These roads had a mileage of 1,561 in June, 1914, and, therefore, purchased ties at the rate of 133 per mile. These purchases were mostly used for renewals, for which the demand is not so heavy as in the case of steam ralroads.

The total number in this case is a decrease of 47 per cent. from 1913, while the average price per tie is the same. The greatest decreases were with western and eastern cedar and jack pine. Eleven woods were reported in 1914, and fifteen in 1913, western larch, beech, maple, and white pine being dropped from the list.

The Australian Transcontinental Railway will be finished by the end of 1916, according to a recent report by the chief engineer, N. G. Bell. On the West Australian section the final locating survey has been made for a distance of 260 miles and preliminary surveys as far as the South Australian boundary. The line has been completed ready for track laying for 240 miles in West Australia and 264 miles in South Australia.

The Canadian shipbuilding industry was very active during 1914, the aggregate gross tonnage of new vessels built and registered in the Dominion being 43,346, which is the highest figure recorded since the year 1901. Canada's merchant marine at the end of 1914 consisted of 8,772 vessels, of 932,422 tons. Of the new tonnage built in 1914, 23,167 tons was the product of Ontario yards. The shipbuilding industry in the province of Ontario has been making great strides in recent years.

PRODUCTION AND MANUFACTURE OF PULPWOOD IN CANADA DURING 1914.

A VALUABLE report has recently been issued by the Forestry Branch, Department of the Interior, on the pulpwood production last year. This report, prepared by R. G. Lewis, B.Sc.F., shows the quantity and value of pulpwood produced in the various provinces, kind of wood used and the method of manufacture. It also gives the quantity and value of pulpwood exported from Canada and from the several provinces in an unmanufactured state. Another section gives the value of wood-pulp exported from and into the Dominion.

The sixty-six active pulp-mills in Canada in 1914 consumed altogether 1,224,376 cords of pulpwood, valued at the mill at $8,089,868. In addition to this home consumption a total quantity of 972,508 cords, valued at $6,680,490, was exported in the unmanufactured state from Canada to the United States, making altogether a total production of pulpwood of 2,196,884 cords, valued at $14,770,358.

In spite of the widespread disturbances to industry in general occasioned by the war, the manufacture of wood-pulp in Canada is still on the increase. During the calendar year 1914 the quantity of wood used in this industry showed an increase of 10.4 per cent. over the preceding year.

The woods most commonly used in pulp manufacture in Canada vary but slightly from year to year. The increased manufacture of sulphate, or kraft, pulp has enabled the manufacturers to use increasing proportions of jack pine. The use of balsam fir has increased steadily in past years. Hemlock is used to a greater extent than any other wood in British Columbia. In every other province but British Columbia, spruce heads the list of woods converted into pulp.

The proportion of wood used in the manufacture of chemical fibre in Canada is steadily increasing. In 1910, only 22 per cent. of the wood was converted into pulp by the chemical processes. In 1914 this proportion had increased to 47.3 per cent., almost half the total.

In the mechanical process, where the fibres are more or less broken and their strength impaired, only the best quality of pulpwood can be used. The machinery, however, is comparatively cheap and easily installed, and as long as the supply of good pulpwood was convenient this process was largely used. Of late years the quantity of wood used in the sulphite process has steadily increased in spite of the high cost of installing the necessary plant. In this process the wood requirements are not so exacting, and the higher price for the pulp produced compensates for the greater cost of the plant.

The introduction of the sulphate or kraft process for the manufacture of coarse, strong, dark-colored pulp for wrapping-papers has permitted the use of jack pine and other so-called inferior species in a greater proportion than had hitherto been possible.

In 1913 the wood used in the mechanical process for the manufacture of ground-wood pulp formed 54.1 per cent. of the total consumption. This proportion was reduced to 52.7 per cent. in 1914. The proportion in the case of sulphite pulp increased from 33.1 to 35.5 per cent., but a decrease took place with the sulphate or kraft process from 12.3 per cent. to 11.5 per cent. The only actual decrease in quantity was in the case of wood used in the soda process.

During 1914, Canada exported 126,714 tons more of manufactured wood-pulp than in 1913, an increase of 42.5 per cent. While the increase in the exportation of ground-wood was 36.4 per cent., that of chemical fibre was 63.5 per cent. This increase is partly due to the general advance of the industry in Canada and partly to the fact that while the capacity of pulp-mills has increased in the last year, the paper industry has not kept pace with the supply of pulp, and the surplus of manufactured fibre has found a market in other countries. The United States has been our most important purchaser of pulp in the past, and the proportion of Canadian pulp exported to that country in 1914 was almost 70 per cent. of the total. Great Britain also buys large quantities of Canadian wood-pulp, and these two countries together usually take the bulk of the exports from Canada. France imported Canadian pulp in 1914 for the first time since 1910. Other countries, including Belgium, Mexico, Australia, Cuba, New Zealand, and Newfoundland, have imported small quantities of wood-pulp from Canada in the last five years, but the trade with these countries has varied greatly from year to year. The average price of exported wood-pulp changed very slightly. That of ground-wood pulp decreased by a few cents, and that of chemical fibre increased by about one dollar a ton.

In spite of the fact that Canada in 1914 produced nearly a million tons of wood-pulp, valued at approximately twenty million dollars, and exported pulp to the value of eight million dollars, we still import this commodity from other countries. The importations of wood-pulp in 1914 were valued at $426,601, an increase over the imports of 1913 of 19 per cent. Although the greater part of the material comes from the United States (51 per cent.), the value of imports from that country decreased by $87,182 in 1914. A decrease took place in the value of imports from Great Britain, and no pulp was imported from Germany, but increases are to be noted with the other countries on the list, especially Sweden.

Closely related to the preservative treatment of wood against decay by creosote or zinc chloride is the fireproofing of wood. While sprinkler systems are considered the best protection in any type of building, the fact remains that fire retardants are desirable under certain conditions. Realizing this condition, the National Fire Protective Association has recently published an excellent report on "The Use of Wood in Building Construction," which contains results of experiments with various fire retardant materials, including shingle stains, paint, and various mineral salts. It is impossible to summarize this report other than it shows that there is very little difference in the inflammability of various kinds of untreated wood, and that ammonium salts and sodium borate gave more satisfactory results than other chemicals, and that paint is considered a good fire retardant.

Yellow pine, according to American Forestry, has been more extensively treated against decay than any other wood. In 1914 10,600,000 yellow pine railroad ties were treated out of a total of 44,000,000, the only wood used to a great extent being oak. For construction timbers of all kinds, particularly bridges, trestles and marine work treated yellow pine leads the list with Douglas fir second. New uses for treated yellow pine are being developed. It remains to extend a more general knowledge of the possibilities of wood preservation to the smaller consumers. Railroads and other large corporations are at least partially awake to the possibilities, but it is difficult to make retail distribution of treated lumber at the present time, because the user doesn't know what he wants, and the retail yard man doesn't carry it in stock, and the big treating plants and lumber manufacturing companies have not developed this class of trade.

SOME EASTERN BRIDGES, CANADIAN PACIFIC RAILWAY

EXAMPLES OF UNUSUAL AND WIDELY DIFFERING DESIGN, AS FOUND AT SAULT STE. MARIE, AND ACROSS THE ST. LAWRENCE RIVER AND LACHINE CANAL, NEAR MONTREAL.

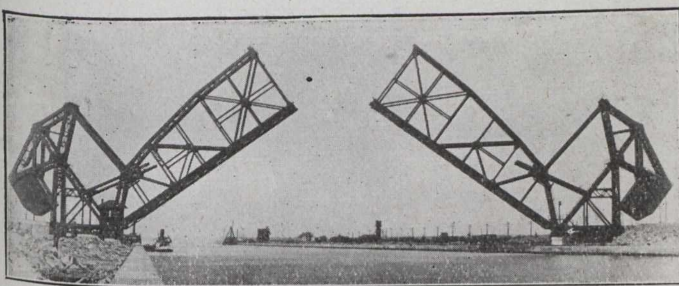
THE Lethbridge, Edmonton and Outlook bridges of the Canadian Pacific Railway distinctively exemplify one type of bridge construction in its most modern stage. These structures present to the traveller a rare conception of size and proportions of design. At the same time, unless his is a practised eye in structural design, dissimilar features may be overlooked and bridge work in general consigned to a narrow category. That enormity in railway bridges does not bide with a single type is better illustrated on a number of the company's lines east of Winnipeg. Among the most interesting are the bascule bridge which connects Sault Ste. Marie on the Ontario side with the Michigan city of the same name; the double-track swing bridge over the Lachine Canal on the Farnham subdivision of the C.P.R., and the St. Lawrence River bridge near Lachine, on the same subdivision. A brief description of each of these is given below.

The Sault Ste. Marie Bascule Bridge.

The single-track bascule bridge over the United States ship canal at Sault Ste. Marie has a span of 336 ft. c. to c. of channel piers. It provides a single unobstructed channel wider than that given by the longest existing movable bridge; besides which it was constructed in record time. It possesses a number of features peculiarly its own. Each leaf consists of a 168-ft. arm and a 45-ft. tower, being accurately balanced by counterweights containing each about 550 cubic yards of concrete and weighing over 1,000 tons. Instead of acting as a cantilever for live load, as is ordinarily the case with double leaf bascule bridges, the two arms are so locked

The C.P.R. Bascule Bridge at Sault Ste. Marie with One River Arm Fully Opened.

together in the centre, when the bridge is closed, that the two halves of the trusses act as a single simple span from pier to pier. The locking of the trusses in the centre is automatic and does not involve moving parts of any kind. The south leaf and its steel tower rest as a unit on rollers allowing a 6-inch transverse movement, which involves the entire tower and attached leaf, and is effected by hydraulic cylinders. Rapid and perfect align-

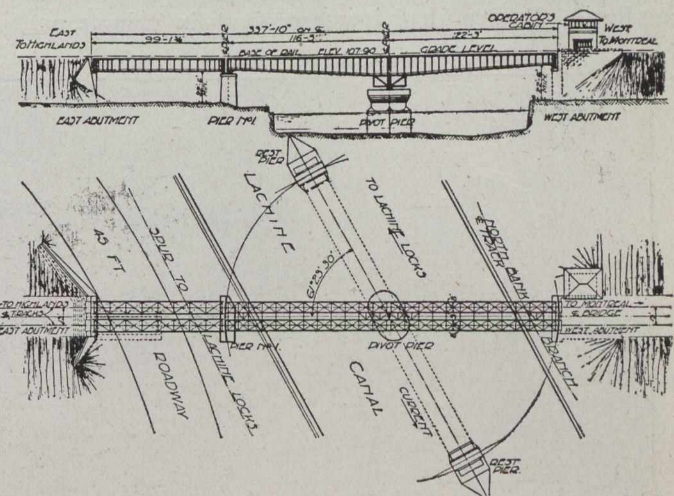


The Sault Ste. Marie Bridge in the Process of Being Opened to Canal Traffic.

ment of the two leaves at the point of closing is a feature that bespeaks some very accurate detailing, both in the matter of design and construction.

Both leaves may be fully opened to the vessels of larger dimensions and deeper draught which use the centre of the channel; or one may be opened to permit passage of smaller vessels. Owing, however, to the ease of handling both leaves, accomplished by the electrically operated machinery, it is customary for the tower man to open both when canal traffic demands.

structure in being the longest of its kind in existence, and it had similarly associated with its construction some remarkable speed. The improvement was decided upon by the company last autumn. Substructure work began on December 1st, 1914. The bridge seats were ready to re-

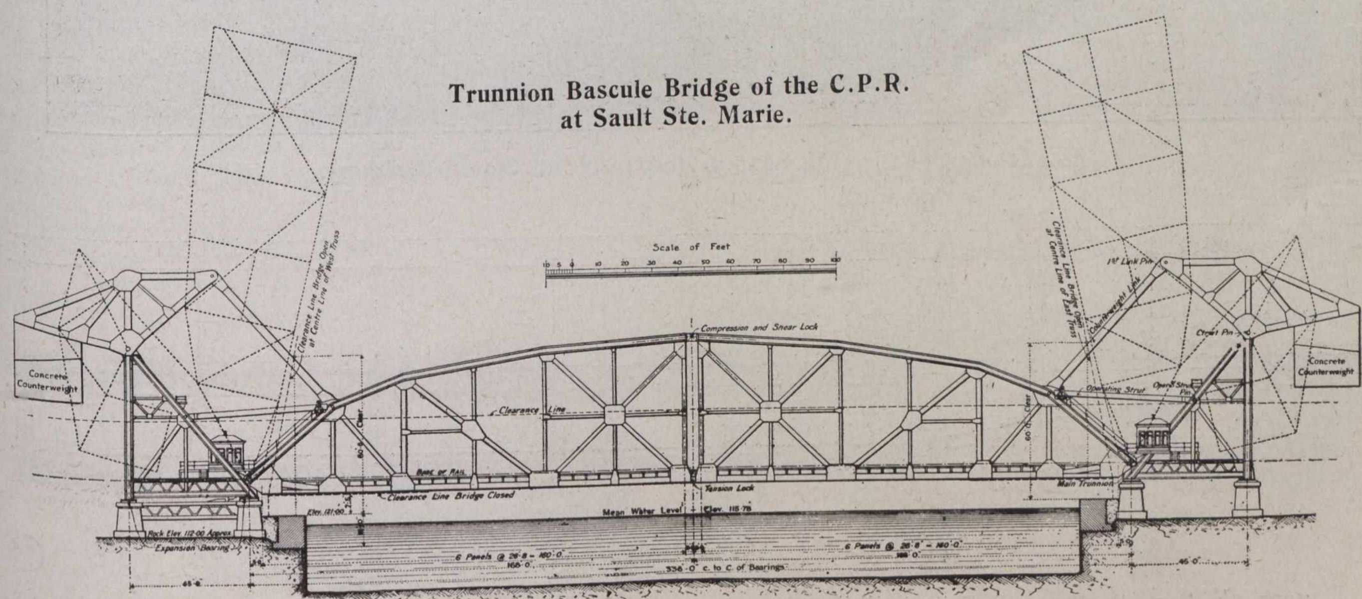


Alignment and Dimensions of the Lachine Canal Swing Bridge.

ceive the girders in ten weeks' time, and in another ten weeks trains were passing over the completed structure.

The swing span is 239 feet 7 inches long, with a girder depth at the centre pivot of 13 feet 6½ inches, diminishing to 8 feet ½ inch at the ends, measured from back to back of flange angles. The span weighs about

Trunnion Bascule Bridge of the C.P.R. at Sault Ste. Marie.



The bridge was put into service in September, 1914. The accompanying illustrations indicate its unique design and the manner of its operation.

Lachine Canal Swing Bridge.

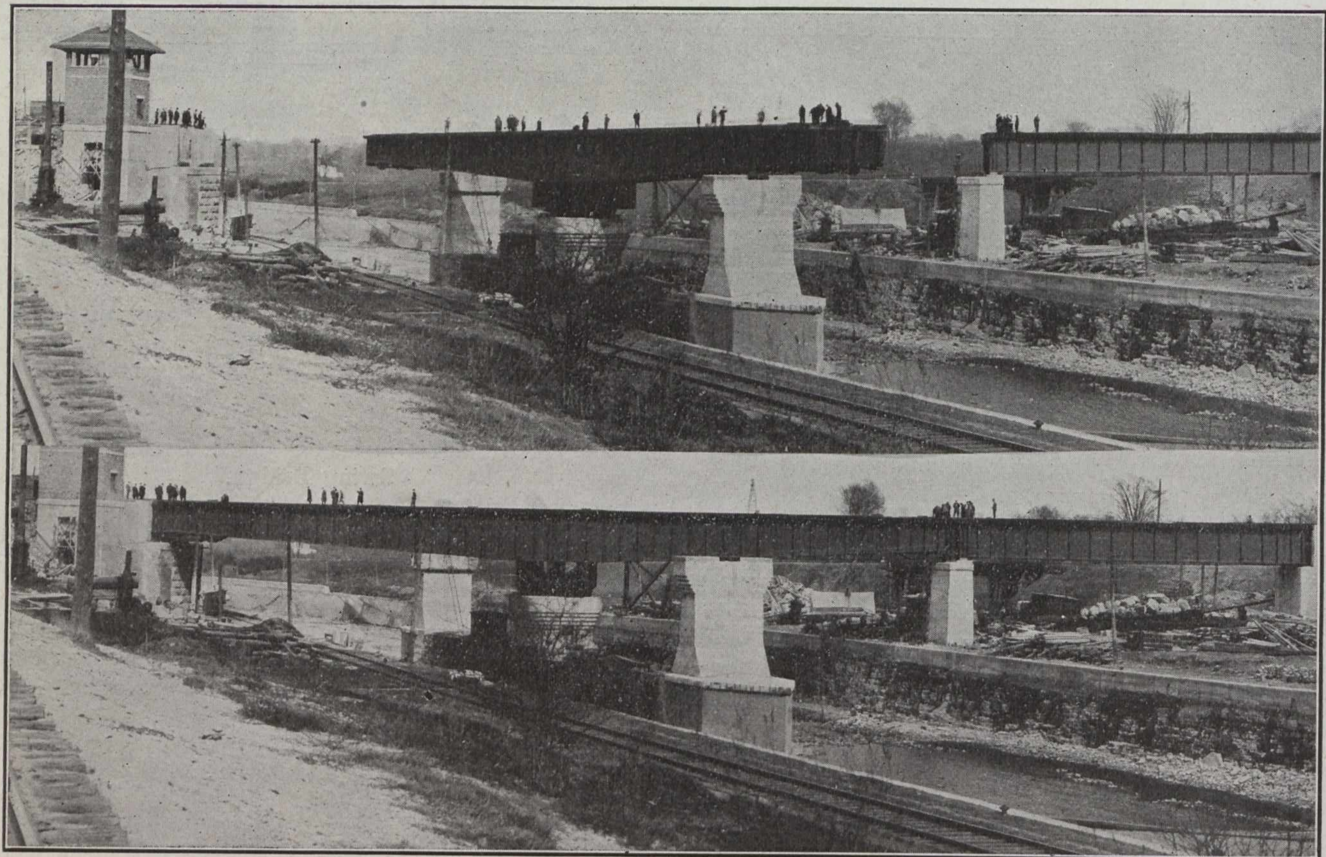
Another structure depicting the advanced stage of the design, operation and control of large bridges of the movable type, is the electrically operated double-track swing span over the Lachine Canal, put into operation last April as a part of the system of double tracking between Montreal and Brigham Junction. This plate girder swing span shares distinction with the Sault Ste. Marie

615 tons, and is operated by 30-h.p. duplex motors, the difference in time between closed alignment for railway service and open alignment for the passage of canal traffic being a period of only 70 seconds. The regulation of traffic on both railway and canal in the vicinity of the bridge is effected by very complete power-operated signal and electric track circuit interlocking systems. All operation is looked after from the operating house on the north bank of the canal. The approach span on the opposite bank, shown in the illustration, is 90 feet long.

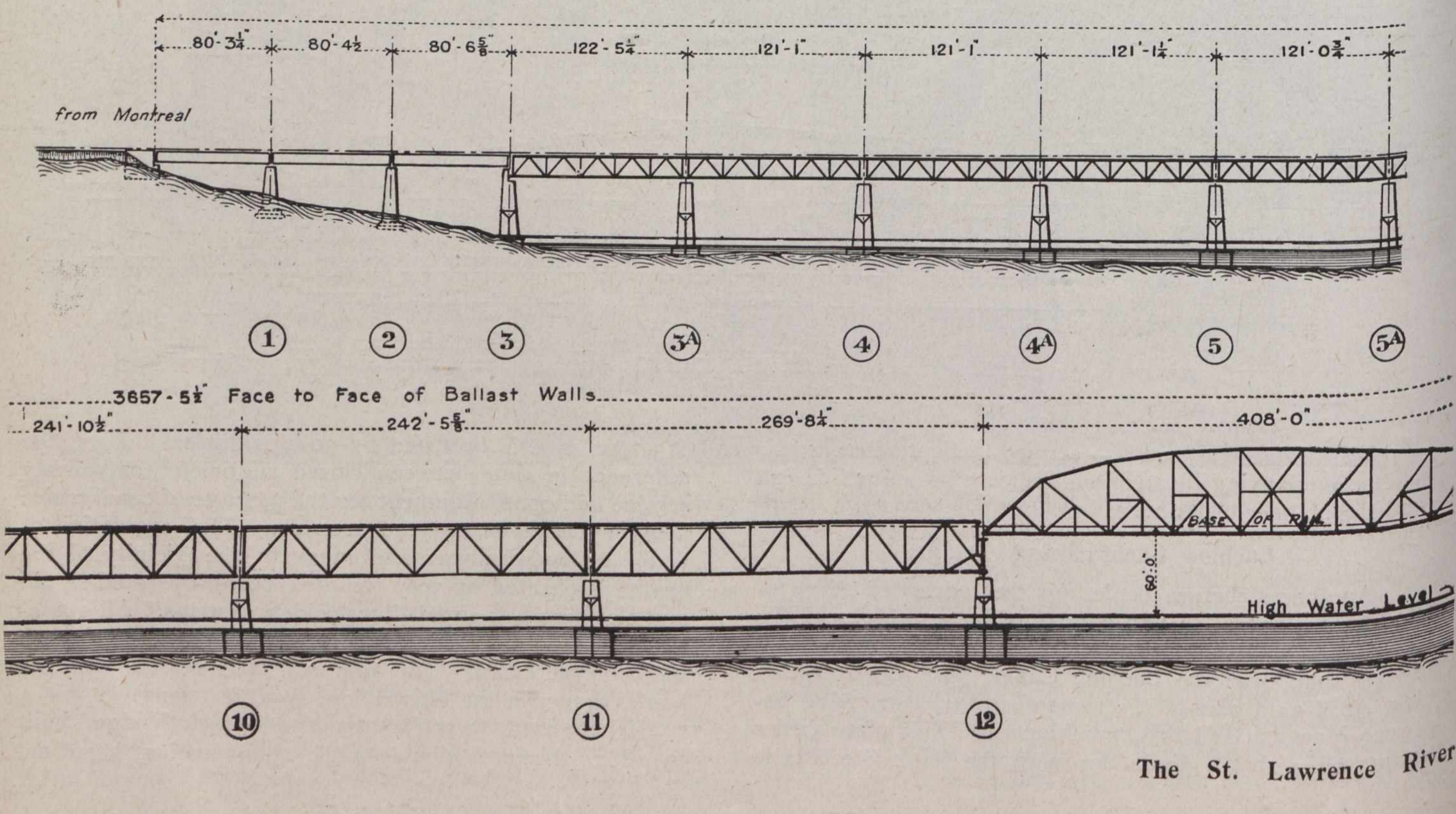
The structure replaces a single-track bridge, built in 1887, the new double-track span having been designed in such a manner by the company's bridge department as to utilize the old pivot pier, without decreasing in any respect the width of waterway for canal traffic.

The St. Lawrence River Bridge.

When traffic on the Farnham subdivision of the Canadian Pacific Railway had increased both in volume and density to such an extent as to demand double tracking between Montreal and Brigham Junction, the reconstruction of the St. Lawrence River bridge between Highlands and Caughnawaga, about 8 miles from the Montreal terminal, presented a number of engineering problems of unusual nature. The old bridge, built in 1886, was a single-track structure, and was in its day considered a



The Lachine Canal Swing Span in Its Open and Closed Positions.



The St. Lawrence River

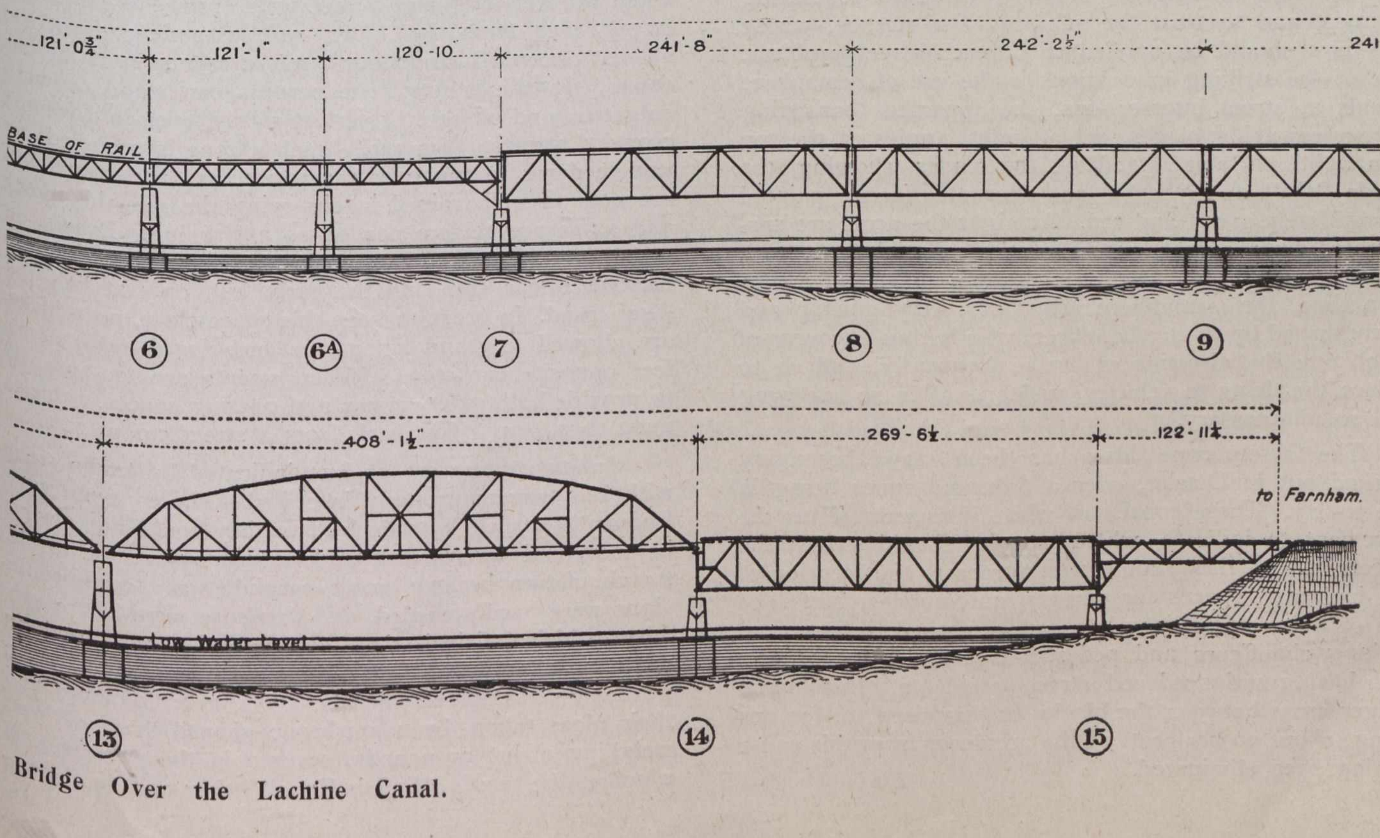
fine example of advanced bridge design. It had three 80-foot deck girders, one 120-foot deck truss span, eight 240-foot deck trusses, two 270-foot flanking spans, and two channel spans each 408 ft. long. Reconstruction was to be carried out without interruption to traffic. The river piers were to be enlarged, some of which were in a current of about 8 miles an hour, and in water 30 ft. deep, the where the tracks approach each other at the north abutment. The down-stream bridge rests on extensions of the old piers, although four new piers were built dividing the old 240-foot spans into eight 120-foot spans. The old piers and abutments involved 12,400 cubic yards of masonry, to which were added some 13,300 cubic yards for the new bridge. The 4,100 tons of steel work in the

The Channel Spans of the St. Lawrence River Bridge.

superstructure in the steamer channels being approximately 70 ft. above water level.

The old single-track structure was replaced by two parallel single-track bridges designed for much heavier loading than previously used. One of the bridges coincides in alignment with the old, while the other is down stream 27 feet c. to c., tapering to 16 feet 4 inches c. to c. old structure were replaced by 14,231 tons in the new. It is interesting to note that in the latter there are 3½ million rivets.

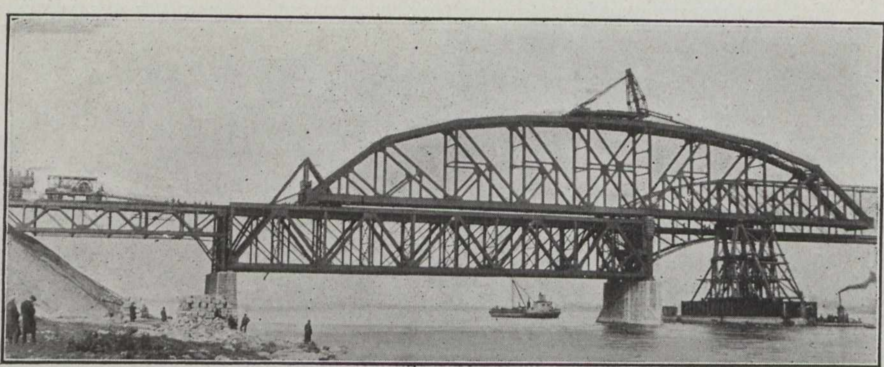
The adoption of two single-track bridges instead of a double-track structure, combined with the use of cross-overs as construction work proceeded, obviated interruption to traffic. Some of the most interesting details of



Bridge Over the Lachine Canal.

bridge construction handicapped by traffic conditions are connected therewith. The extensive cofferdamming in conjunction with pier work and the pneumatic caissons employed in enlarging the deep-water piers, are also well known to engineers.

The finished bridge, as illustrated herewith, consists of the following spans, viewed from the north end: Three 80-ft. deck plate girders; eight 120-ft. deck Warren truss spans (which were the four 240-ft. spans in the old bridge); four 240-ft. deck Warren truss spans; one 270-ft. deck Warren truss; two 480-ft. through Pratt curved-chord sub-panelled trusses; one 270-ft. deck Warren truss, and one 120-ft. deck Warren truss.



One Channel Span of the St. Lawrence River Bridge Moving Into Place.

TRAFFIC REGULATION IN DETROIT AND TORONTO.

WHILE traffic regulation in America originated in New York, and that city for a long time kept the lead, other cities have since introduced such regulation, and, by taking advantage of previous experience, have naturally been able to improve a good deal on the original rules and methods still largely adhered to in New York. To-day, in the opinion of John P. Fox, transit expert, writing in the "American City," Detroit has, perhaps, the best traffic regulation in the country, which is not surprising for the centre of the automobile industry.

The success of Detroit appears to be largely due to a constant attempt to improve existing regulating methods, and to treat the subject as a science, whose principles should be applied to fit each street problem. One of the striking innovations is the use of semaphore signals at street intersections, the apparatus consisting of four revolving blades, set at right angles at the top of a light, portable standard, the blades showing the words "Go" and "Stop" on alternate faces, painted appropriately green and red. At night the arms are surmounted by a signal lantern of the railroad type, with red and green lights. Requiring only a quarter of a turn at a time, the semaphore arms are very quickly and easily turned by the traffic officer, who is thus encouraged to change the direction of traffic frequently, and so to reduce the delay to vehicles, which is often so annoying and so unnecessary.

The safety zone idea has been very thoroughly worked out in Detroit, over a thousand zones being in use to-day. These consist of white lines painted on the pavement to indicate where people should cross the streets, where they should wait for cars, the location of fire hydrants, spaces for parking automobiles, etc. The use of these white lines has had a marked influence in making chauffeurs and pedestrians exercise more care, and has greatly reduced street accidents. People no longer cross between the blocks as they used to, for one thing, about 90 per cent. of the accidents from this cause having been eliminated.

The keeping up of the white lines on the pavement is not as costly or as troublesome a matter as might be expected. Frequent marking is naturally required on streets with heavy traffic, but on other streets the lines will last for months. The paint used consists of cheap white lead, whiting, gloss oil, gasoline and ultramarine blue. It is applied to the pavement by means of a lawn tennis court marker, with a three-inch paint brush inserted in the distributor, the apparatus being carted round on a motor truck.

The near side car stop is in use in Detroit, and at each stop a safety zone is marked off by a white line about 60 feet long and 6 feet wide from the car steps, or 7½ feet from the outer rail, extending from the nearest crosswalk back to where the rear step of the car comes. In this safety zone persons can stand or walk or get on and off cars in perfect safety, even in the most crowded streets. For while such a zone is occupied, no vehicle dares to run over the white line, and chauffeurs are now so well trained in observing the rule that posts and signs are seldom needed as a warning. Except on very narrow streets, automobiles are permitted to pass between a car stop and the curb, but only at half the legal speed. In order to keep this space clear, no vehicles are allowed to stand along the curb for a space of 75 feet opposite car stops. When streets are too narrow to provide both safety zones and passing spaces, vehicles must then stop 6 feet back from a street car at rest.

Safety zones were at first indicated by traffic signs with red targets properly inscribed. These signs were frequently struck by vehicles, as they could not always be seen, and several damaged radiators were the result. As chauffeurs became more careful, such conspicuous signs were hardly needed, and they also were in the way when vehicles wished to pass over a safety zone at times when no cars were stopping and no passengers were waiting in the street. So the signs were removed and their place taken by a mushroom-shaped base of iron, weighing about 55 pounds, secured in the pavement by a spike, the words "Safety Zone" being cast in the top of the metal. The base is corrugated on top and offers no obstruction to vehicles like a sign.

For the purpose of making clear to the public all the special traffic rules in Detroit as they apply to each local case, various kinds of street signs are used, each one having painted on a target at the top a simple but clear explanation of what is meant. This method of instruction is much more reasonable than trying to put every regulation into an unchangeable ordinance, and then to expect every chauffeur and driver to remember the rule for each place. The Detroit ordinance is a very broad and general one, giving the Police Department wide discretionary powers without the continual need of new legislation, allowing constant progress without any delays or hindrances. Again, traffic signs in other cities are often too obscure, with perhaps merely an arrow on them, meaning nothing to the uninitiated. In Detroit each problem is studied and then appropriate signs are painted to suit the need of each place and to explain whatever rule is made.

The Detroit signs are used to mark safety zones; locations of hydrants; whether to park automobiles parallel to the curb or at an angle; time limit on parking; places where no parking is allowed, as in front of theatres and car stops and along certain congested blocks; dangerous street car intersections; warning to lock cars on leaving them; public automobile stands; the direction of traffic on boulevard divisions and one-way streets, etc.

The troublesome problem of the left-hand turn has been solved in Detroit. Vehicles wishing to make the turn wait in line near the centre of the street, and are not allowed to mix in with the other traffic as in New York, where unregulated turning sometimes blocks all traffic for a time. When the traffic direction is changed in Detroit, then the waiting vehicles make the left-hand turn before the cross traffic starts to move, thus getting quickly and completely out of the way. One little improvement is needed here in the Detroit plan, viz., a change in the old rule that a vehicle going to the left should pass beyond and around the centre of the intersection. Instead, the turn to the left should be made just before reaching the centre of the street, this plan enabling two sets of vehicles, coming towards each other, to make the left-hand turn at once without blocking each other as they do under the present rule. Right-hand turns can be made at any time in Detroit, another improvement tending to keep traffic moving.

In some cities persons who prefer to drive their own cars or cannot afford a chauffeur are deprived of riding to and from business because no public parking space is provided where they can leave their cars during the day. While this deprivation may appear to have an advantage in reducing the use of the streets, it is a question whether it really does so, because the automobiles of those who are driven to business must immediately go back to their garages, using the same street four times a day at the rush hours, against twice for cars stored in the business section. Detroit provides special public parking space, Cadillac Square holding no less than 300 automobiles at one time, arranged in four rows, with three passageways for getting in and out of the Square. Vehicles can also be parked parallel to the curb in two rows on each side of the Square, but only for an hour at a time.

In the enforcement of the Detroit traffic regulations Police Commissioner Gillespie has shown much good sense and an occasional touch of humor, which has helped in giving publicity to the work, and in teaching the needed lessons to offenders. Automobiles found parked in forbidden places were sometimes towed away to Cadillac Square, where they were kept until reported stolen by the anxious owner, who, on recovering his car, generally remembered what to do another time. Cars with dazzling headlights have been held up at night and the offending lamps dimmed on the spot with white paint. Such measures, however, are no longer needed, and now the chief question is where to improve and extend the system.

Toronto has a rather novel innovation in traffic regulation, which was adopted after studying the practice of other cities. In Toronto there is no regular traffic squad, but every man takes his turn for two weeks at a time, no officer being permanently stationed at the same corner, as in other cities. This might seem a disadvantage, but it is clearly an advantage when one knows the reasons. It is done to promote efficiency by keepnig traffic men from knowing the regular users of a street too well, and showing partiality as a result, and also in order to prevent an officer from feeling that any special post belongs to him and that he only knows how to handle traffic at that point.

Now these last things which are avoided in Toronto by constant rotation in traffic service are some of the chief weaknesses found in traffic regulation in other cities, and the Toronto plan should be carefully considered by other localities. One of the most common and serious defects in traffic regulation is changing the direction of traffic too seldom. Officers fall into the habit of taking more and more time before blowing the whistle, often waiting for just one more vehicle in the distance to come up, with the result that crossing delays are getting to be more and more serious in the older cities. As the delays to vehicles vary directly with the frequency of changing the direction of traffic, the need of the most frequent possible changes is apparent. In Toronto, with even a heavy traffic of vehicles and street cars, a frequency of 15 seconds between changes has been found, while on Fifth Avenue, New York, it averages nearly a minute sometimes, varying largely with the habits of individual officers. One Fifth Avenue officer was found to change the direction every 22 seconds, an almost ideal frequency, while another man at the same place, with less traffic, averaged over 50 seconds, causing more than twice the delay to all vehicles.

The keeping of one officer at the same corner certainly does encourage a false idea of importance and cause the showing of favoritism with some traffic men; also resulting in the habit of talking too much to friends and regular patrons of the street crossing, instead of watching vehicles and pedestrians. It obviously certainly does not tend to promote the co-operation of chauffeurs with the police department in reducing speeding and street accidents to have them held up for a minute or two every time they pass a certain officer. And so the Toronto plan of rotating men and assigning them always to different corners could well be added to the efficient methods of Detroit.

In pursuance of the policy of the Provincial Department of Roads to provide better road facilities throughout the province of Quebec, the proposal is being made by the department to the authorities of the Provincial Government to build two new bridges, one across the Jacques Cartier River at Donnacona, some 30 miles above Quebec, and the other across the Batiscan River at Batiscan, some 60 miles from Montreal.

A NOVEL SLOPE TRIMMING MACHINE.

In the construction of a 750,000-bbl. reinforced concrete-lined oil reservoir built by Mr. E. D. Cole, Assoc. M.Am.Soc.C.E., at Bakersfield, Cal., a very unique method of slope trimming was adopted. The reservoir has the following dimensions: Inside diameter (bottom), 462 feet; inside diameter (top), 528 feet; depth, 22 feet; width of top of embankment, 11 feet; inside slope, 1½ : 1; outside slope, 1½ : 1; thickness of concrete lining (bottom), 3 inches; thickness of concrete lining (top), 2½ inches.

The method of trimming the slopes, as described by the builder in the August number of the Transactions of the American Society of Civil Engineers, was as follows: On the completion of the main embankment and the refill, the excess material on the inner slope, which ranged in thickness from 1 ft. at the top to 2 ft. at the bottom, was trimmed off leaving the slope smooth and true to grade. Grade stakes were set on radial lines, both at the top and inner toe of the slope, approximately every 10 ft. around the circumference of the reservoir. Men with mattocks and slope-level boards then dug narrow trenches, 1 ft. wide and true to grade, from the top grade stake to the stake at the toe of the slope. Then

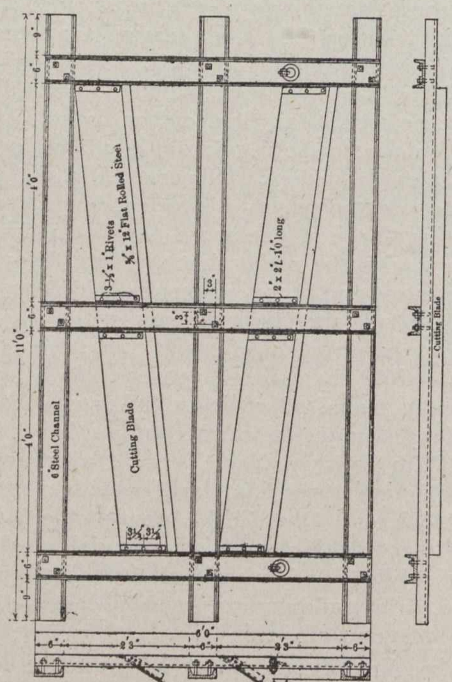


Fig. 1.—Slope-trimming Machine.

2 by 4-in. timbers, 38 ft. long, each faced with a narrow strip of strap iron, were placed in the bottom of each trench to act as guides for a trimming machine which was used to finish that portion of the slope between the hand-dug trenches. Before using the planer, however, all excess material above the top of the 2 by 4-in. timbers was scraped off the slope with a specially made scraper which was dragged up and down the slope, power being furnished by a double-drum hoisting engine at the centre of the reservoir. The back-up line from the engine passed through a 12-in. snatch-block supported at the top of the slope on a portable wooden truss designed for that purpose. This wooden truss was anchored against overturning by two heavy chains fastened to iron stakes driven into the top of the embankment. As each succeeding section of the slope was finished, the wooden truss was moved along the top of the bank with a team of horses.

After the bulk of the material above the top of the 2 by 4-in. timbers had been removed, this slope-trimming machine was substituted for the scraper and used to plane off the remaining thin layer of earth and bring the slope to grade, or flush with the bottom of the guides. Fig. 1 shows the trimming machine, which consists of a rectangular frame, 11 ft. long and 6 ft. wide, built up of 6-in. steel channels bolted together and carrying two cutting blades. The cutting blades are of ⅜ by 12-in. flat rolled steel, and are set at an angle with the frame of 1 to 2½. The blades are also set at a slight angle longitudinally with each other, and the cutting edge projects down 2 in. below the bottom of the frame. The planer is dragged back and forth on the slope until the ends of the frame ride on the top of the guides, and that particular section is shaved off flush with the bottom of the guides, or down to grade. In this way nearly nine-tenths of the slope were finished by machine and at one-half the cost of doing the work by hand. One might naturally suppose that there would be considerable difficulty in keeping the guides in place without staking them down, but very little trouble was experienced. Loose earth would fill in the trenches around the guides as the machine worked above them, and this served to hold them in place. The trenches being dug on radial lines necessarily made them closer together at the bottom of the slope than at the top, but the blades of the planer were long enough to catch all the earth between trenches at the top of the slope and still have room at the bottom without binding between the guides.

PROGRESS IN TORONTO UNION STATION MATTERS.

On September 8th an Order-in-Council was passed in Ottawa confirming the agreement between the Toronto Terminals Company and the Government, by which the postal station is to be constructed as an east wing of the proposed new Union Depot at Toronto. The Government is to pay $17,000 a year for twenty-one years for the lease of the land, and the lease is renewable in perpetuity. The Public Works Department will pay the cost of the new wing, which is to be constructed on plans approved by its architects. The estimated cost is $800,000, and the agreement is expected to be executed in a few days, thus permitting the work to go on without delay.

A further agreement relates to the customs warehouse. If this is required for trackage, the company is to pay $110,000 for the building and allow the Exchequer Court to fix the price of the land. The department is to occupy the building until the new one on Front Street is completed.

There are few countries possessing so many rivers adaptable for working hydro-electric installations as the Caucasus, and yet up to now only about a dozen or so power stations exist there. A concession was granted by the Russian Government in November, 1912, to a British firm, the main feature of which was the erection of power-houses to accommodate turbines and generators for furnishing electrical energy for lighting and commercial purposes to cities, towns and industrial centres of the Northern and trans-Caucasus. Some progress was made during the first half of 1914, and all preliminary works have been completed and plans prepared. The financial side of the question has still to be solved, but it would be unreasonable to expect that this can be achieved before the close of the war.

Editorial

MY DESIGN—YOUR GUARANTEE.

When city engineers design pavements, and inspectors strictly enforce the specifications, should contractors be required to guarantee the pavements?

The contractor's experience may convince him that under certain conditions, he should deviate from the specifications laid down by the engineer. He may have made a careful study of the street, its traffic, sunshine, grade, and other influencing conditions. He may feel certain that the street requires certain modification of the specifications that apply to other streets. But unless he can persuade the engineer to adopt that view, he must lay the street according to the engineer's design and the inspector's commands, but he must guarantee it for from two to ten years.

That hardly seems fair. The contractor who signs a city paving contract mortgages his birthright. He stakes his own reputation and his own money on a design laid down by someone with whom he may disagree.

A city should either exact a long guarantee from the contractor and then give him an entirely free hand, or else it should lay down rigid specifications, cause them to be carried out to the letter by means of close inspection, and not expect or require any guarantee from the contractor.

It is almost absurd to say, "This is my design, but you guarantee it. Lay it our way, but you be responsible for it."

CLASSIFICATION OF SOILS.

A proper classification of soils is highly important in earthwork construction. The following is given by the United States Department of Agriculture, prepared by Messrs. Fletcher and Bryan. A list of screens to be used in making classifications by mechanical analysis is also given:

Material	Size.		Screens.	
			Pass	Retain
	mm.	mm.	through.	on.
Fine gravel	2.	1.	No. 10	No. 18
Coarse sand	1.	0.5	" 18	" 32
Medium sand	0.5	0.25	" 32	" 70
Fine sand	0.25	0.10	" 70	" 160
Very fine sand	0.10	0.05	" 160	" 230
Silt	0.05	0.005	......	......
Clay	0.005	0.0000	......	......

By the number of sieve is meant the number of meshes per lineal inch of wire cloth, woven from brass wire, having the following diameters for

	Diameters.
Sieves Nos. 10 and 18	0.0165 inches.
Sieve No. 32	0.0112 "
Sieve No. 70	0.0045 "
Sieves Nos. 160 and 230	0.0024 "

The mesh should be regular in spacing, and the cloth should be mounted on the frame without twisting. The last two sub-divisions, silt and clay, are more difficult to determine, but the method is fully set forth in Bulletin No. 84, Bureau of Soils, United States Department of Agriculture, above referred to. If the above subdivisions are adopted, various soils can then be classified by giving the percentage of the materials contained. The percentage of water contained in each sample of soil should also be determined by weighing, drying and re-weighing, as the moisture content has a decided influence on the bearing power of many soils.

SIR WILLIAM VAN HORNE.

With the development of the Canadian Pacific Railway no name has been more closely associated than that of Sir William Cornelius Van Horne. Under his direction as general manager the line was pushed across the prairie provinces and through the Rockies with marvellous speed and vindicative judgment. When the last spike was driven at Craigellachie by Lord Strathcona in 1885, the problem of creating traffic returns began. Subsequently, the gradual removal of temporary structures and erection of permanent ones, the reduction of grades and elimination of curvature, the substitution of heavier rolling stock, and the development of foreign trade were problems met and solved by him as president of the road. Many tales are told of his fortitude, his optimism and his magnetic indomitable will, in the face of defeat and discouragement. He accomplished his great task, one effecting to an unmeasurable extent the development of the Dominion.

"To have built the C.P.R. was a greater achievement than the building of any other railway had ever been; a greater achievement than any future railway on this continent can be. For he built through an unknown, untried land; he had to be prophet as well as pioneer; seer as well as general."

THE TRACKLESS TROLLEY IN CITY TRANSPORTATION.

The trackless trolley is in general use in the cities of Leeds, Bradford and Rotherham, in Yorkshire, and in several other English cities, also in various parts of the British possessions, notably, in one or two cities in South Africa. It is employed in certain communities, where, on account of sparsely settled districts, the construction of a special roadbed is deemed inadvisable, to serve as a feeder to the main system. Results from Leeds and Rotherham are, so far as the ratio of operating expenses to gross income is concerned, but very little less than the corresponding ratio of regular street railway operation.

There is one trackless trolley operating in the United States, which gives no foundation for recommendations to electric railways that this means of transportation has yet passed the experimental stage.

The situation with reference to the operation of the motor bus has been materially changed during the past year, owing to the advent of the "jitney."

EXPANSION OF CONCRETE.

THE following notes relate to proper provision for expansion and contraction in concrete structures, together with provisions for waterproofing such arrangements. They have been abstracted from a report to be presented by one of the committees at the San Francisco convention of the American Electric Railway Engineering Association:

Restrained Structures.—When a reinforced concrete structure is restrained by outside forces and when that structure contains steel reinforcement that is not evenly distributed throughout a large mass of concrete (heavy reinforced concrete wall where practically all the steel is concentrated on the tensile side of wall) then the stresses

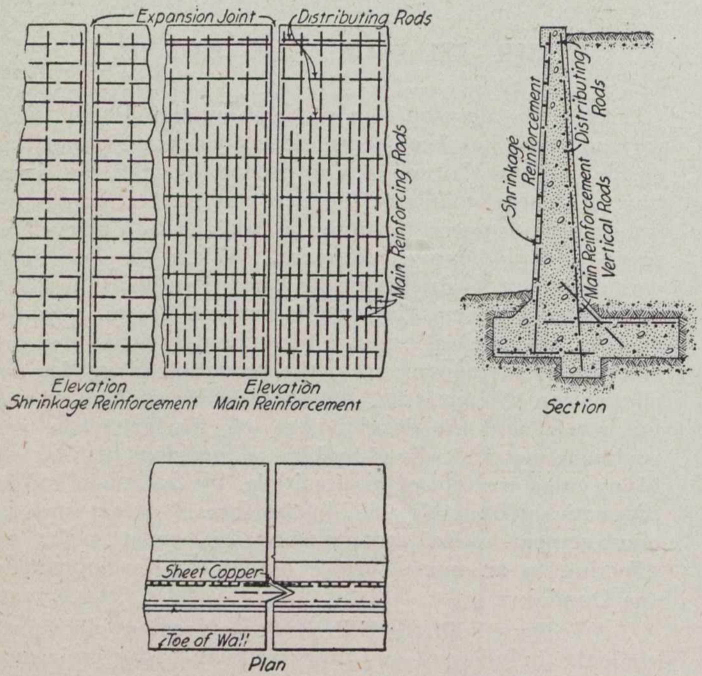


Fig. 1.—Expansion Joint in a Reinforced Concrete Retaining Wall of the Cantilever Type.

resulting from a drop in temperature equal to about 15 deg. F. will stress the concrete sufficiently (in tension) to cause excessive cracks in the opposite side of the wall to that containing the main reinforcement. To prevent these contraction or shrinkage cracks from being noticeable (minute cracks will still be there) about 0.4 per cent. of steel reinforcement placed near the exposed face of the wall will suffice. In practice this amount of steel will do the work but theoretically almost twice this percentage is required.

As an example of finding the amount of steel necessary to minimize the shrinkage cracks assume a wall or slab to be 12 in. in thickness. Then the amount of steel required in the wall would be 12 in. (thickness) x 12 in. (width or length) or 144 sq. in. x 0.004 = 0.576 sq. in. of steel per foot width or length of slab or wall.

No amount of steel will entirely eliminate cracks but the more steel used the smaller will be the cracks. The steel should be placed about 2 in. from the surface that is exposed to the temperature changes to be effective. Small rods spaced close together or a mesh should be used rather than large rods spaced far apart that would give the same area of steel. (See Fig. 1.)

Unrestrained Structures.—In reinforced concrete structures which are free to expand and contract the stresses from shrinkage and temperature changes are due

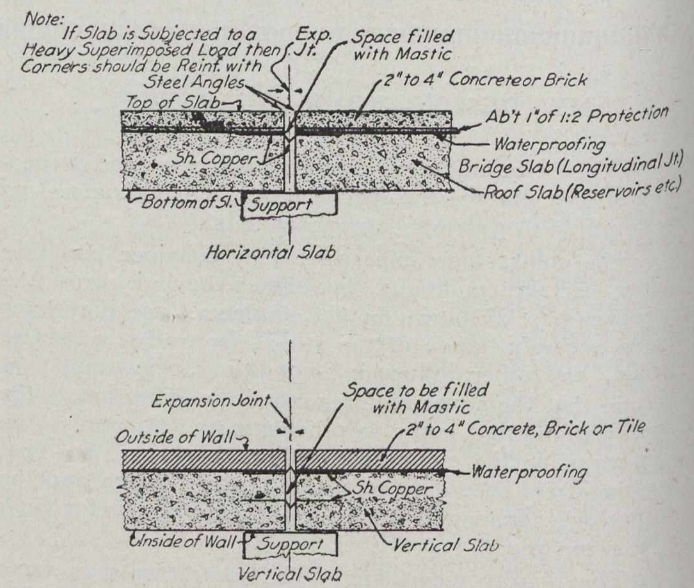


Fig. 2.—Waterproofed Expansion Joints for Plain and Reinforced Concrete Slabs.

to the mutual action of both the concrete and steel. These stresses have been proven to be of so little importance that they may be ignored in practice. In this type of

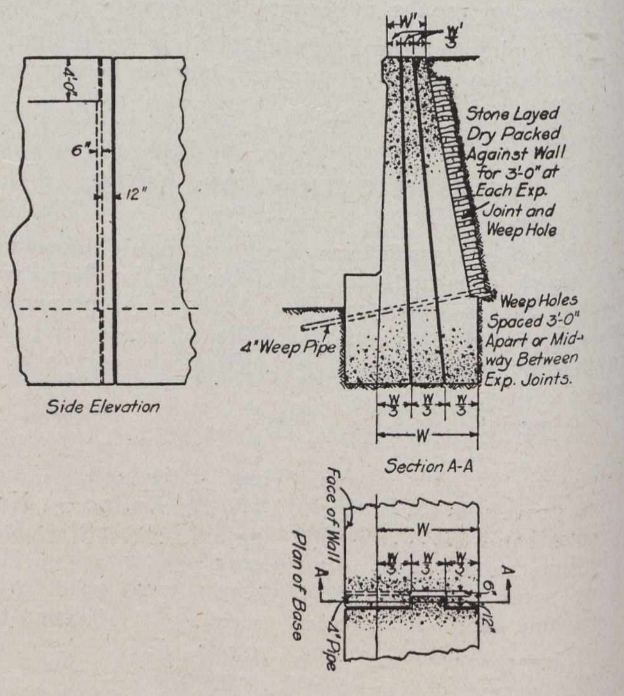


Fig. 3.—An Expansion Joint for Plain Concrete Walls.

structure the stresses from temperature alone are negligible because concrete and steel have practically the same coefficiency of expansion. They both expand or contract about a sixty-five ten millionth of their length for each Fahrenheit degree change of temperature.

Therefore, a wall built in 30-ft. lineal sections subjected to a change of 50 deg. (Fahr.) rise in temperature will expand as follows:

$$30 \times 0.0000065 \times 50 = .0098 = \text{about } 1/8 \text{ in.}$$

Slab Bridges.—Reinforced concrete slab bridges should be limited to spans of about 35 ft. This is because

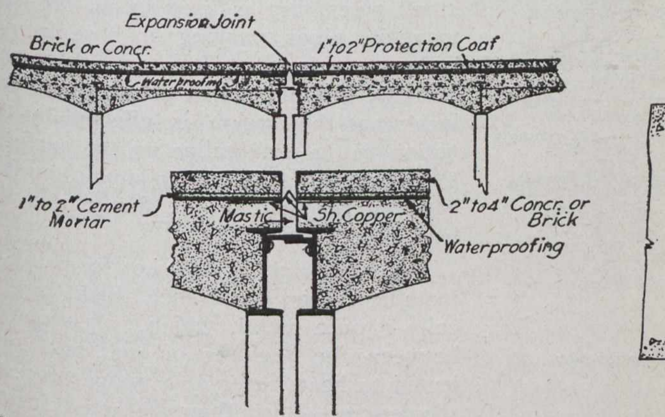


Fig. 4.—A Waterproofed Expansion Joint in an Arched Roof or Side Wall.

it is difficult to allow for free expansion the way that it is done in a steel bridge. The width of a slab bridge rarely exceeds 50 ft. and therefore there need be no provision for expansion in this case. If in a slab bridge it is necessary to provide for expansion and contraction in order to maintain the true alignment of tracks a longitudinal joint similar to the one shown in Fig. 2 might be used.

Fences, Railings, Coping Walls, Etc.—When a fence, railing or coping wall, etc., is restrained or is part of a restrained structure expansion joints should be provided about every 30 ft. Examples of such structures would be a long reinforced concrete fence or a fence, railing or coping on top of a retaining wall.

A railing, coping or parapet wall on an ordinary building need not be provided with expansion joints. In fact it would be useless to provide joints for same when

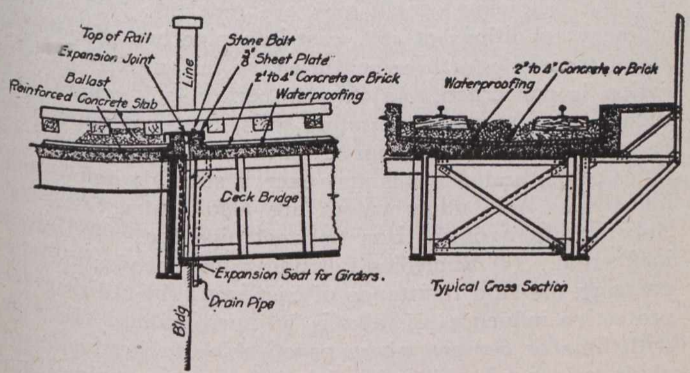


Fig. 5—Showing Type of Expansion Joint.

there is not provision for expansion made in the roof of said building.

Type of Joint.—Expansion joints in the ordinary retaining wall, parapet wall or fence may be either the rectangular or triangular tongue and groove type. These types of joints insure the wall against lateral movement that would throw same out of line.

The maximum distance that expansion joints should be spaced is 50 ft. (applies to restrained structure). This spacing will be ample for large, gravity retaining walls, etc.

When a wall is not several feet in thickness and is subjected to 50 deg. seasonal change of temperature, joints should be provided at about 30 ft. centres. Joints should always be placed near all corners or turns in a wall, and the corner or turn should be specially reinforced to take care of the greater strain.

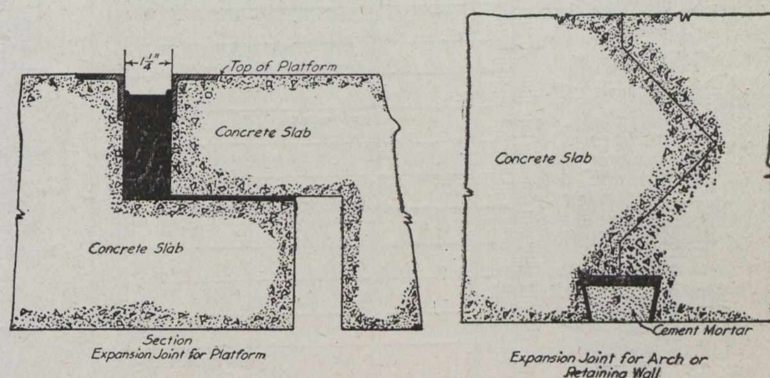


Fig. 6.—Expansion Joints for Platform and Arch or Retaining Wall.

To determine the size (width of opening) of joint in ordinary practice it is sufficient to do as follows:

Change in temperature is commonly taken to be 50 deg. and the coefficient of expansion for concrete and

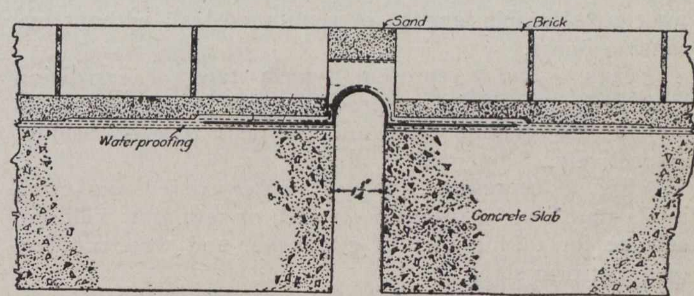


Fig. 7.—Method of Waterproofing Bridge Slab Expansion Joints.

steel to be 0.0000065. If the joints are spaced 30 ft. apart and the structure is free to move (unrestrained) then the gap of the joint might be as great as

$$50 \times 0.0000065 \times 30 = 0.00975 = \text{about } 1/8 \text{ in.}$$

If joints are 50 ft. apart

$$50 \times 0.0000065 \times 50 = 0.01625 = \text{about } 3/16 \text{ in.}$$

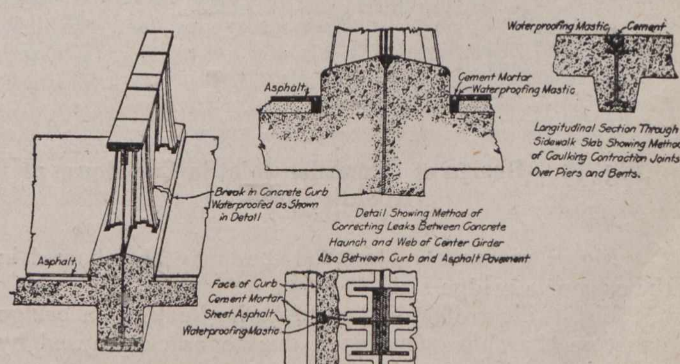


Fig. 8.—Detail of Method of Waterproofing Breaks in Curb.

The above gives the maximum value; friction, etc., are neglected. (See Fig. 3.)

Expansion joints serve another purpose. (Referring particularly to gravity retaining walls.) They act as settlement joints, thus eliminating the danger of a wall-face being ruined with cracks caused by slight uneven settlement in the footings.

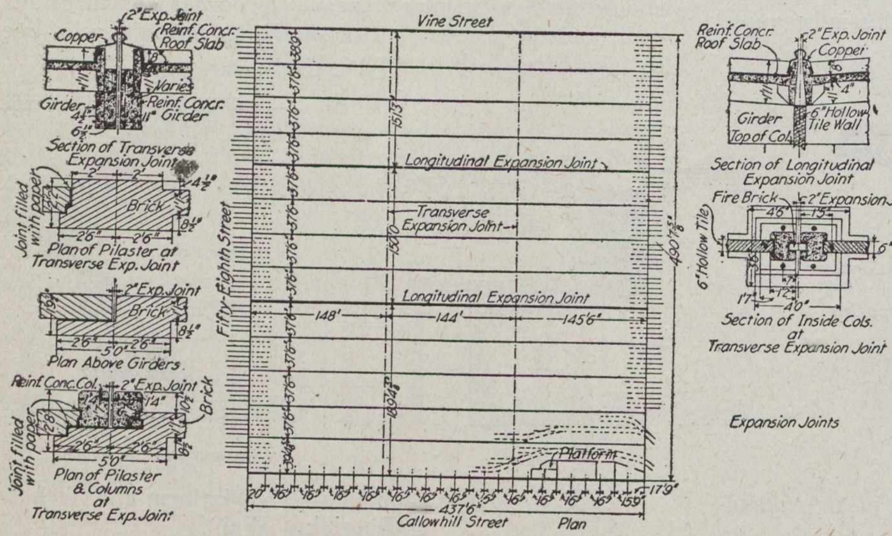


Fig. 9.—Expansion Joints in Car House, Philadelphia Rapid Transit Co.

In a reinforced wall the steel will reduce shrinkage and contraction cracks to a minimum and the steel will hold a wall true to line and grade when a plain wall joint might settle. It is possible by proper reinforcing to erect considerable lengths of reinforced wall without expansion joints.

Figs. 4 and 5 represent typical type of expansion joint and method of waterproofing same in the case of an arched roof or side wall and the deck type of bridge, respectively.

Fig. 6 represents types of waterproofed expansion joints that may be used for an arch or retaining wall and scheme for taking care of expansion and waterproofing of a platform slab.

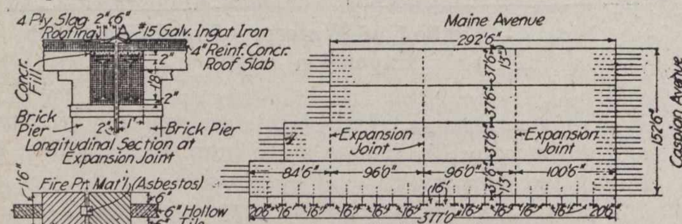


Fig. 10.—Design of Expansion Joint in Car House at Atlantic City.

Fig. 7 represents a method that may be followed in the case of a bridge slab.

Fig. 8 illustrates method of curing leaks in a bridge structure that have developed due to cracks caused by expansion and contraction.

Figs. 9, 10 and 11 clearly show details of this very interesting case for both roof and side walls.

NEW PROCESS FOR LEAD JOINTS.

A new material called "amalgaline" has been introduced in England for making joints between lead surfaces, and it is said to have been widely adopted by shipbuilders in Scotland and the north of England, as it is useful in flanging and the seaming of lead used in lining refrigerating chambers.

The system is not confined to use on small pipes, but is used in an ordinary way on pipes varying in bore from 3 inches to 9 inches. It is an autogenous process, but instead of using an intense local heat the fusion is effected by the action of the amalgaline on the surfaces to be welded, forming an amalgamation between the lead of the flange and the lead pipe.

The material is in the form of a metallic ribbon 0.002 inch thick, practically a pure metal, which, when placed between the surfaces of lead and subjected to heat, fuses at a temperature of 160 degrees—lower than the actual fusing point of lead—and in fusing it causes the lead surfaces to run together at a lower melting point than that of the body of the lead. This running together has an autogenous effect, and the minute particles of amalgaline are dissipated into the body of the lead, which, by reason of the absorption, becomes stronger at the junction than elsewhere.—"Engineering Digest."

EXTERNAL CORROSION OF CAST-IRON PIPE.

In a paper read before the American Society of Civil Engineers, Mr. M. R. Pugh mentions instances, in several countries, in which cast-iron water-pipe has remained in perfect condition after a hundred years' service or more when laid underground or immersed in fresh water. When, however, they have been laid in salt marshes or immersed in sea water their useful life is measured by a few years only. From a comprehensive analysis of the subject the following conclusions are reached: (1) Under ordinary conditions of soil, cast-iron pipe has a probable life of from one to three centuries, so far as external corrosion is concerned. (2) Under certain soil conditions, such as salt marshes or saline soils, cast-iron pipe may be rendered useless in from seven to twenty years. (3) At times cinder and slag fills may exert a strongly deleterious influence. Acid mine waters are also destructive. (4) Substituting wrought iron or steel pipe for cast iron is ineffectual. (5) Remedies fall under four heads: (a) Increasing the skin resistance of cast iron; (b) utilizing the protective influence of alkalis by surrounding the pipe with lime or cement where practicable; (c) exclusion of acids, salt or air; (d) galvanizing the cast-iron pipe, thus protecting it at the expense of the zinc.

Drilling has been commenced by the O'Brien Mining Company on its property in Gillies Limit. A shaft will be sunk to the 200 ft, level. The vein is strong, and galena, with a low silver content, have been taken out. The intention is to sink the shaft to the contact, which, from observations on the neighbouring properties, should be reached at about 200 ft.

COAST TO COAST

Hamilton, Ont.—The Kenilworth Avenue subway will be completed and ready for traffic in a few weeks.

Oshawa, Ont.—On September 20th the town will vote on a by-law for a new structural steel industry to employ 1,500 men, the first unit of buildings to cost $350,000.

Chilliwack, B.C.—The new sewerage system which was described in *The Canadian Engineer* for June 10th, 1915, was officially turned over to the city by Messrs. Cleveland and Cameron a few weeks ago.

Guelph, Ont.—Work on the Toronto-Suburban Railway line between here and Toronto was resumed a short time ago, and it is expected that the overhead work will shortly be installed. Several stations have been built along the line.

Ridgetown, Ont.—The town has four new wells, three of which are over 135 ft. in depth and the fourth 96 ft. deep. At a recent test, using the airlift system, the three deep wells delivered 125,000 gallons, and the fourth 30,000 gallons per day.

Vancouver, B.C.—While the Canadian Northern Railway have made arrangements to use for the present the depot of the Great Northern Railway Co., it is likely that work will be commenced shortly on the construction of its own terminals in Vancouver.

Camrose, Alta.—The C.N.R. have commenced operations on the laying of steel on its southeast branch from Camrose, the grade of which has been completed for about two years. It is the intention to finish the road as far as Battle River, some 60 miles distant.

Calgary, Alta.—The north retaining wall of the Centre Street bridge is at present being poured and pile-driving is in operation for the river piers. Cofferdam work will be started immediately on the north side, while that on the south side has been in progress for several weeks.

St. John, N.B.—Douglas Avenue is being graded and it is probable that some water-bound macadam will be constructed this fall. It is proposed to lay a bituminous surface next summer, at which time the street railway tracks will be raised and permanent pavement placed in the track allowance.

Hope, B.C.—Construction on the Hope-Coquahalla section of the Kettle Valley Railway will be completed by the middle of November, including snow sheds. Under the terms of a joint agreement between the C.P.R. and the Great Northern, this branch will be used by the latter also. At Hope, the G.N.R. will link up with the Canadian Northern Pacific Railway and run over its line into Vancouver.

Montreal, Que.—Construction work is being rushed on the new million-dollar addition to the Harbor Commissioners' elevator No. 1. Pile drivers have been in operation for about six weeks, and about 3,000 reinforced concrete piles have been placd. The form work for the elevator walls and sections has now attained the height of about 50 feet, concrete being poured through a number of tremies.

Toronto, Ont.—Within a week or two the Hydro-Electric Power Commission will have completed statistics and reports for the various municipalities interested in the construction of a network of radial railways throughout the western portion of the province. The Commission has had requests from some 300 municipalities along 1,600 miles of roads, in the districts from Whitby on the east to Sarnia and Windsor on the west.

Ottawa, Ont.—Hon. Robert Rogers, Minister of Public Works, made an official visit in August to a number of harbor and river works that are being carried out under the direction of the Department. The lock, sluiceways, dam and dredging at the mouth of the St. Charles River are well under way, while excavation work in connection with the dry dock at Levis is rapidly proceeding. The Quebec post office is nearing completion, and the new docks at Three Rivers are under way.

Niagara Falls, Ont.—Another power scheme has been proposed. Mr. W. H. Barker, of Montreal, has submitted a proposition to generate 2,225,000 h.p. under the Horseshoe Falls, without impairing the beauty of the Falls or surroundings. He proposes to build a submerged dam, deflecting about 75 per cent. of the water for power purposes after it passed over the crest, and to return it to the cataract before the water reached the lower portion of the river. Penstocks would project into the fall and the power house would be in a tunnel behind it.

Winnipeg, Man.—It is reported that the Dominion Bridge Co. has secured the contract for the fabrication and erection of the superstructure of a large bridge to carry the Edmonton, Dunvegan and British Columbia Railway across the Smoky River. The bridge will consist of two 85-ft. deck plate girder approach spans, six 128-ft. deck truss spans, as well as one 125-ft. through truss span, which will be over the main channel of the river. The steel in the superstructure weighs approximately 1,100 tons, and will all be fabricated in the company's Winnipeg shop.

Magog, Que.—A section of the retaining wall forming part of the canal and power dam of the Dominion Textile Co., was carried away, making a gap about 35 ft. wide and 18 ft. deep. The rush of water against the remaining portion of the masonry deflected the current, undermining the power dam, with the result that a large section of the dam, including gates and gate houses, was also carried away. The accident resulted in lowering the water of the Magog River about 8 ft., and endangered a number of other dams in close proximity. The power house has a capacity of between 2,500 and 3,000 horse-power.

Edmonton, Alta.—J. D. McArthur, president of the Alberta and Great Waterways Railway, states that steel-laying will begin by the end of September, and that the line to McMurray will be completed before the end of the year. According to the same authority, who is also president of the Edmonton, Dunvegan and British Columbia Railway, the temporary bridge across the Smoky River has been completed, and track-laying will reach Spirit River in a few weeks. On the Grand Prairie branch steel will be completed by January. On the Canada Central line extending north from McLennan to Peace River Crossing, the steel will all be in place before the end of the year.

INSTITUTE OF MARINE ENGINEERS.

The above institute has been removed from the premises at Romford Road, Stratford, to those on Tower Hill, and all communications should therefore be addressed to: The Secretary, Institute of Marine Engineers, The Minories, Tower Hill, London. E.

PERSONAL

Judge H. A. ROBSON, public utilities commissioner for Manitoba for the past five years, has resigned.

J. L. DOUPE, chief surveyor, Western Lines, Canadian Pacific Railway, Winnipeg, has been elected a member of the American Railway Engineering Association.

E. T. WILKIE, chief engineer of the Toronto Suburban Railway, has resigned. Mr. H. T. Hazen, formerly consulting engineer to the company, succeeds him.

C. E. BROOKS has been appointed superintendent of motive power for the Grand Trunk Pacific Railway. Mr. Brooks, who was previously acting superintendent, has his headquarters at Transcona.

GEO. L. GOUILLET, formerly assistant professor of mechanical engineering in McGill, Montreal, has been appointed acting professor of mechanical engineering in Queen's Faculty of Applied Science.

W. J. GILMORE, assistant professor in the department of agriculture of the Manitoba Agricultural College, has resigned to take charge of the engineering department of the Oregon Agricultural College at Corvallis, Ore.

E. V. NEELANDS, B.A.Sc., manager of the Cobalt Comet, and formerly manager of the Hargraves mine, Cobalt, Ont., has been appointed manager of the Peters mine, New Guiana, and is leaving for South America next week.

WILLIAM ROGER, elevation draftsman, Canadian Pacific Railway, Montreal, read a paper at the September meeting of the Canadian Railway Club on 14th inst entitled "Hydraulic Presses vs. Power Presses in Connection With the Manufacture of Cartridges and Shells."

JAMES HAMILTON, assistant engineer, sewer department, Edmonton, Alta., who designed the new sewage disposal plant, is now superintending its construction. In our issue of August 19, we mentioned Mr. J. Ryan as superintendent, but Mr. Ryan, we are corrected, is one of the inspectors.

JOHN L. FEENEY has been appointed road engineer to the provincial government of New Brunswick. Mr. Feeney, who graduated five years ago from the civil engineering department of the University of New Brunswick, has had some valuable experience in road and municipal engineering in Western Canada. He has recently been in the service of the Department of Public Works, Ottawa. The New Brunswick government has created the new position, after much consideration, and while the appointment is understood to be only temporary, a permanent appointment will follow later.

OBITUARY.

The death occurred in Montreal on September 11th of Sir William Van Horne, one of the most prominent of Canadian railroad men, at the age of 72. The deceased was in large measure responsible for the speedy construction and successful development of the Canadian Pacific Railway, of which he became general manager in 1882. He was made president in 1888 and occupied the position for 11 years, resigning to become chairman of the Board of directors, in which capacity he served until 1910. He remained a director of the company until his death.

He received his early railroad training with the Illinois Central, the Michigan Central and the Alton. In 1874 he became general manager of the Southern Minnesota, and president three years later. In 1880 he became associated with the Chicago, Milwaukee and St. Paul as general superintendent, which he resigned two years later to become general manager of the C.P.R.

Among his other business connections the following may be enumerated: President, Laurentide Paper Co., Canadian Salt Co., Cuba Railway Co., and Demerara Electric Co.; vice-president, Dominion Steel Corporation; Director, Duluth, South Shore and Atlantic Railway, Dominion Iron and Steel Co., St. Paul and Sault Ste. Marie Railway, Dominion Coal Co., Mexican Light and Power Co., and Winnipeg Electric Street Railway. He was also formerly a director of the Mexican Consolidated Electric Co., Havana Electric Co., Commercial Cable Co., Postal Telegraph Cable Co., Rio de Janeiro Tramway, Light and Power Co., and Port of Para Dock Co.

ST. JOHN AND QUEBEC RAILWAY.

The reorganized St. John & Quebec Railway Company held their first meeting in Fredericton on September 8th. The following officers were elected by the directors: President, I. R. Todd, St. Stephen; first vice-president, R. A. O'Leary, Richibucto; second vice-president, W. S. Fisher, St. John; treasurer, John D. Palmer, Fredericton; secretary, E. Girouard, Moncton.

COMING MEETINGS.

AMERICAN ELECTRO-CHEMICAL SOCIETY.—Twenty-eighth annual general meeting to be held in San Francisco, Cal., September 16th to 18th, 1915. J. M. Muir, 239 West 39th Street, New York City, Chairman of Transportation Committee.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Calvin W. Rice, 29 West 39th Street, New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, F. L. Hutchinson, 29 West 39th Street, New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

INTERNATIONAL ENGINEERING CONGRESS.—To be held in San Francisco, Cal., September 20th to 25th, 1915. Secretary, W. A. Catell, Foxcroft Building, San Francisco, Cal.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Annual convention to be held in San Francisco, Cal., October 4th to 8th, 1915. Secretary, E. B. Burritt, 29 West 39th Street, New York.

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Annual convention to be held in Dayton, O., October 11th and 12th, 1915. Secretary, Will P. Blair, B. of L. E. Building, Cleveland, O.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Annual convention to be held in Dayton, O., October 12th to 14th, 1915. Secretary, Charles Carroll Brown, 702 Wulsin Building, Indianapolis, Ind.