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The Canadian Engineer

A weekly paper for engineers and engineering-contractors

TUNNEL VENTILATION DURING CONSTRUCTION

IMPORTANCE OF CAREFUL ATTENTION—QUANTITY OF AIR REQUIRED — MODERN METHODS OF REFRIGERATION AND VENTILATION IN LONG AND DEEPLY OVERLAID TUNNELS.

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THE successful completion of over half a dozen long tunnels within the past 15 years has thrown much light on the ventilation and refrigeration of such tunnels during and after construction, and the progress of medical science, together with that of sanitary and mechanical appliances, has made possible for men to work, not only a few days, as, for instance, under the regime of the Cæsars, but for a lifetime, in tunnels subjected to high rock-temperature, deadly gases, and a high degree of humidity. The research work of the United States Bureau of Mines, in connection with the sampling and testing of mine and tunnel air, also that of inflammable gases and explosives, has added valuable information to that obtained from the driving of the long European tunnels.

Vitiation of the Atmosphere of Tunnels.—When exhaled by the human body, air contains about 4.4 parts of carbon dioxide and 15.4 parts of oxygen, as against 0.03 and 20.7 parts, respectively, when pure; thus, air exhaled by men, and incidentally by animals, is vitiated by a lack of oxygen and by an increase of carbon dioxide. A certain amount of water vapor is also expelled by exhaling and by the body, the amount depending on the percentage of humidity in the surrounding air. The amount of carbon dioxide excreted by the human body varies according to the degree of bodily activity; it has been estimated by various authorities that a man of average size gives out .6 to .7 cu. ft. of carbon dioxide per hour, but a man working hard gives out about 1.2 cu. ft. per hour. For certain practical purposes in connection with the subject treated in this paper, it is assumed that a tunnel-man, working under average conditions, excretes 1 cu. ft. of CO_2 per hour; practically similar conditions prevail with animals, and it has been determined that the amount of CO_2 excreted by a horse or mule is about 8.5 cu. ft. per hour.

Carbon dioxide to the extent of 2 per M. is not injurious to human beings or animals; as a matter of fact, human beings oftentimes spend several hours daily in rooms containing a larger proportion of CO_2 without experiencing discomfort. Railroad and street cars contain as much as 3 per M. of CO_2; cafes and theatres from 3 to 5 per M.; class-rooms up to 10 per M. Generally, however, little or no muscular efforts are exercised by people present in the above places; furthermore, their stay is relatively of short duration. In the Simplon tunnel, the amount of CO_2 varied from 0.5 to 7.5 per M. on the south side, and from 0.7 to 4.8 on the north side. Driving of the St. Gothard tunnel often proceeded with as much as 10 per M. of carbon dioxide.

The effects of carbon dioxide on men, animals and lights is quoted by different authorities to be as follows: Up to a content of 2 per M. of CO_2 in air, men and animals are capable of accomplishing hard and continuous work; with 10 per M. of CO_2, men are still able to work under normal conditions. without resenting ill effects; in a proportion of 50 per M., human beings are affected and lights burn poorly. Great danger for human beings when air contains 80 per M. of CO_2, and animals die when inhaling air with 130 per M. of CO_2.

The presence of gases has occurred not only in coal mines or coal-bearing strata; traces have been observed, and even large quantities of gases have been encountered in limestone, sandstone and shale formation, both in dry and wet tunnels. These gases, consisting chiefly of methane and hydrogen, are produced either by carboniferous, sulphuric or ore deposits, or by the chemical action of water, air, or both. Vegetable detritus and remains of dead animals lying on the ground surface, are carried by water together with air, into cracks or faults of the earth, where a chemical action takes place, and, according to the density of these gases and also of the structural formation of the ground, they either rise to the ground surface or penetrate deeper in the ground; whence their appearance in tunnels under construction.

In tunnel work, the daily consumption of some 800 to 1,000 lbs. of dynamite contributes largely to the vitiation of the air, especially in headings, where 50 to 80 lbs. of explosives are consumed per round, 6 to 8 blasts being fired in 24 hours. The effect on human beings of the gases of dynamite, consisting chiefly of carbon dioxide, carbon monoxide, nitrogen, and a smaller percentage of hydrogen and methane, is too well known to dwell upon here; poisoning, if not total asphyxiation, caused by inhaling some of the gases referred to above, has occurred only too frequently in ill-ventilated tunnels, and the engineer is confronted here with the complex problem of the preservation of life with a minimum consumption of time and power.

It is generally accepted that the explosion of 1 lb. of dynamite produces 3.4 to 3.6 cu. ft. of carbon dioxide. The burning temperature of nitro-glycerine has been found to be about 5,400° F., and it is estimated that the heat given out by the consumption of 1 oz. of dynamite was about 135,000 B.T.U.; yet, from observations made in tunnels of small cross-section and in headings, where the consumption of explosives was high, it has been found that their influence on the air temperature was very small; due undoubtedly to the rapidity with which their combustion takes place, and owing to the low specific heat of their gases.

The methods that serve the purpose of increasing the speed of driving long tunnels, involve a large amount of materials to be drilled, blasted and removed, thus producing much dust, which naturally also adds to the discomfort of tunnel-men. In driving the Loetschberg tunnel, as many as 560 lin. ft. of holes were drilled in

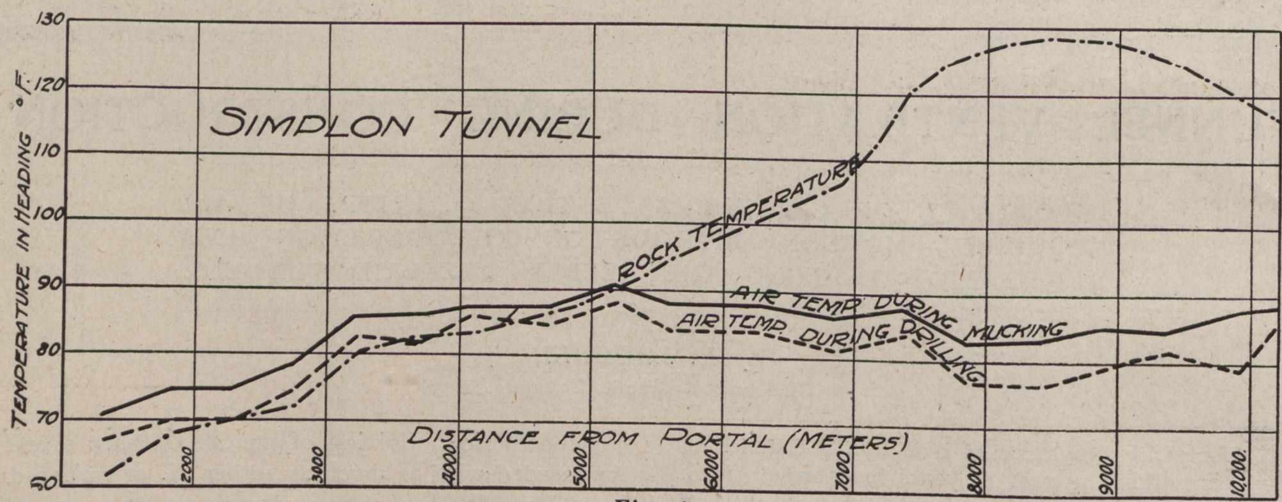


Fig. 1.

The removing and hauling of excavated and other materials necessitate the use of a large number of work trains. In the Simplon tunnel, for instance, 24 trains were usually run per day; in the Loetschberg tunnel, the traffic was still more intense, there being one train every

24 hours in the heading (limestone formation), thus causing some .75 cu. ft. of rock to be pulverized every hour, and when, in addition to this, some 500 to 600 yds. of materials were excavated daily, a large amount of dust was forcibly carried away by the powerful ventila-

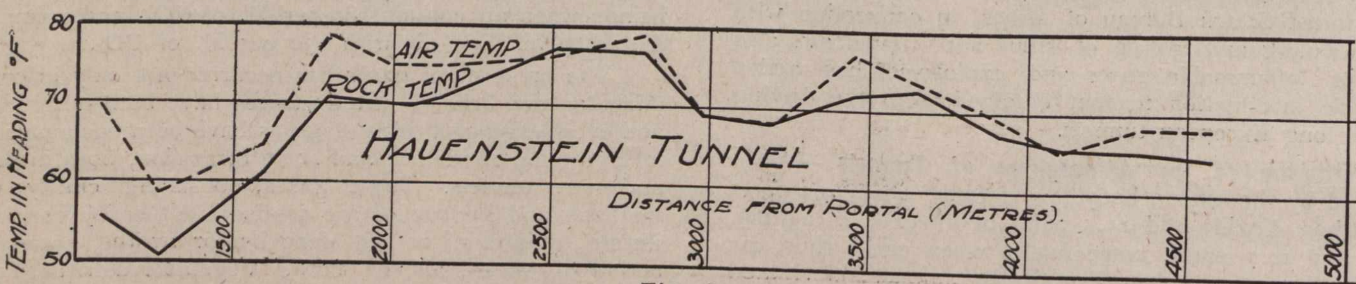


Fig. 2.

45 minutes; that is, 30 to 34 trains per day. Under similar conditions it becomes evident that the use of steam locomotives becomes prohibitive, for, besides being of no assistance to ventilation, like compressed-air locomotives, which in some cases exhaust from 2 to 5 per cent. of the total volume of the air introduced in a tunnel, they generate heat, gases and steam. The gases consist chiefly of carbon dioxide, nitrogen, some carbon monoxide and sulphur fumes. Gasolene locomotives have

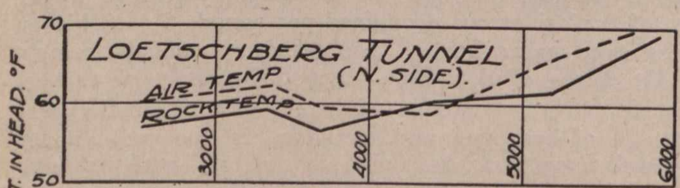


Fig. 3.

been used quite extensively, and when run properly they do not present such inconveniences as do steam locomotives. Under normal conditions, the gases exhausted consist of nitrogen, carbon dioxide and water vapor. When run in such a way as to cause incomplete combustion, the gases exhausted contain an appreciable amount of carbon monoxide, and in several instances this inconvenience has justified their abandonment.

tion. The introduction of water-core drills, together with the practice of sprinkling the muck before handling it, is a marked improvement in tunnel work. Certain materials, when drilled and blasted, give out less dust than others. For instance, mica-shist, and in general tough rocks, produce less dust than more brittle ones, like granites or limestones. The practice of allaying dust is

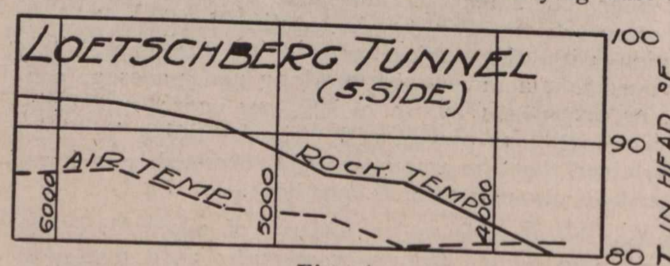


Fig. 4.

to be recommended, not only for the sake of the tunnelmen's health, but also to reduce the wear of tools and machinery.

The presence of candles, oil and acetylene lamps in a tunnel affect also to a large extent the degree of purity and the temperature of the air. In long tunnels as many as 300 to 500 lamps are used daily, and a consumption of 400 to 500 lbs. of oil or calcium carbide is not unusual. It is estimated that the amount of CO_2 produced by oil and acetylene lamps is about .8 and .53 cu. ft. per hour, respectively. The use of acetylene lamps is increasing rapidly in connection with tunnel work, and they are to be preferred to oil lamps, for, in addition to giving out less CO_2, the heat produced is about 7,500 B.T.U. per hour, more or less, according to the size and make; that is, about one-half only of that given out by oil lamps.

Heat Radiation of Human Beings and Animals, and Humidity of Atmosphere.—It is well known that the human body, also that of an animal, gives out a certain amount of heat by exhalation and by radiation, the amount depending upon atmospheric conditions and also on the degree of bodily activity; more heat is generated

The quantity of carbon dioxide allowed or advocated nowadays in working chambers or zones of long tunnels varies from 1 to 2 per M., according to the conditions prevailing; under normal conditions, i.e., when the rock temperature and the consumption of explosives lie within reasonable limits, the last-named figure can be used, but when the rock temperature reaches 90° F. or more, and when 60 to 70 lbs. of explosives are consumed per blast, in heading work, it is advisable to keep the proportion of CO_2 within 1.5 per M. In the presence of methane or other explosive gases, it becomes necessary to keep the proportion of CO_2 within 1 per M.

Methods of Ventilation.—In driving long tunnels, little reliance can be placed on natural ventilation, for, even with a powerful artificial ventilation, the seasonal

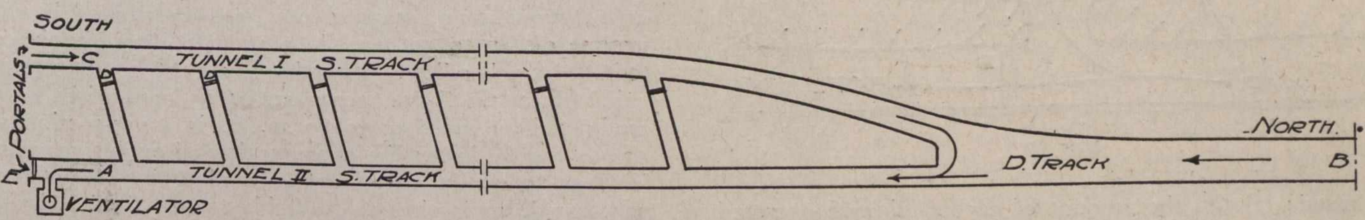


Fig. 5.

by a man accomplishing hard work than by a man at rest. As the result of various observations, it has been determined that with an air temperature of 70 to 80° F. the amount of heat given out by the human body is 10,000 B.T.U. per hour; that of a horse of average size, 95,000 B.T.U. per hour.

The proportion of humidity in the atmosphere plays also an important part in connection with the vitiation and temperature of the air in which tunnel-men are called upon to work. Human beings feel best when, at an average normal temperature, the percentage of humidity is 50 to 60 per cent. Everyone has observed that, when perspiration does not take place freely, a feeling of uneasiness is experienced; the greater the humidity, the

air temperature variations are but little perceptible in a tunnel, save within a relatively short distance from the portal. In the St. Gothard tunnel, for instance, no fluctuation in the air temperature was noticeable 3,500 ft. away from the north portal; in the Simplon tunnel, seasonal variations of the air were quite perceptible for a distance of 2,000 ft.; but 6,000 ft. away from the portal the temperature fluctuations were hardly perceptible. This tends to show that little attention can be paid to external high and low air temperature, and that weight should rather be given to the average yearly air temperature.

Although the basic method of ventilating short tunnels varies greatly, it is rather surprising to note that

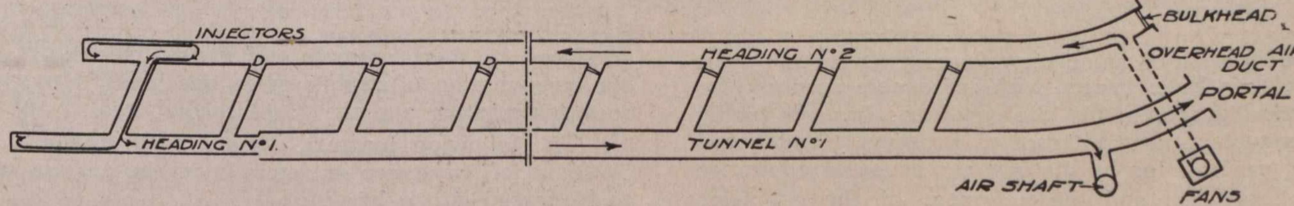


Fig. 6.

greater the discomfort. It has been determined that the amount of water perspired by a man, at 84° F. and a percentage of humidity of 6, was 4 oz.; with the same temperature and 81 per cent. humidity, the weight of water perspired was only .85 oz. Men worked in the St. Gothard tunnel at a temperature of 86° F. and with 100 per cent. humidity; in the Simplon tunnel the percentage of humidity varied from 70 to 98; in the Loetschberg tunnel the humidity was high, reaching 100 per cent.

Miscellaneous Agencies Affecting the Purity of Tunnel Atmosphere.—In addition to carbon dioxide expelled when exhaling, foul or bad odors are excreted by the stomach or the body of men and animals, due either to improper digestion or uncleanliness. Unsanitary conditions, inadequate toilet facilities and poorly-drained tunnel stables for horses are all agencies contributing to the vitiation of the air in tunnels. Where a large quantity of timber is used, decaying or rotting of same, together with other agencies of lesser importance, all add to the evils above referred to.

the plenum method has been used almost exclusively in driving some 10 tunnels from 2 to 12 miles long; this is due chiefly to the fact that conditions not met with in driving short tunnels are encountered in driving long ones. For instance, the driving methods used in connection with the last-named tunnels necessitated that fresh air should be distributed along various working sections of the tunnel, and in order to cool the air in the bore within a practicable limit, fresh air had to be supplied to the heading or other points within a very short time after leaving the fan or blower, so as not to be subjected to heating when coming in contact with the walls of bore, oftentimes warmer by many degrees than the air supply. The necessity also of using, for mechanical, construction and economical reasons, a primary ventilating system, consisting of fans located at the tunnel portal, and of blowers and injectors for the ventilation of the heading, are some of the reasons for giving preference to the plenum method of ventilation during construction. Yet, a combination of the plenum and vacuum methods has been used in a few isolated cases, or when the portal ventilators were to be part of the system to be used in connection with the permanent ventilation after construction.

Quantity of Air Necessary for Ventilation During Construction.—This is by no means a matter of guess, as is often believed and done; erroneous assumptions have led to a lack of adequate ventilation in a few instances and to a waste of power in others. The amount of air necessary to overcome the evils caused by the agencies referred to in the first part of this paper can

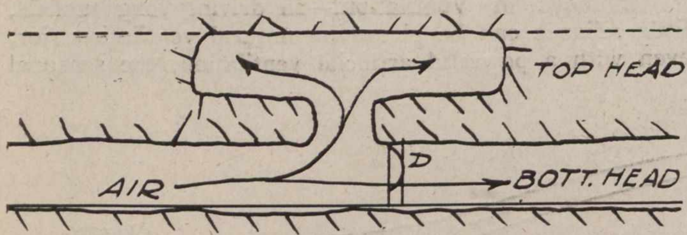


Fig. 7.

be based: (1) On the amount of carbon dioxide excreted or produced by men, animals and lights. (2) On the amount of CO_2 produced by the consumption of explosives. (3) On the heat generated by the presence of men, animals and lights. (4) On the heat occasioned by the temperature of the rock penetrated. (5) On the gases liable to be encountered during the driving period. (6) On miscellaneous agencies affecting the condition of air.

Then in formula 1, A equals 13,582 cu. ft., B = .002, C = 2,400,000 cu. ft., D = .0004, and Q is found to be 6,087,500 cu. ft. per 24 hrs., or 4,320 cu. ft. per min.

Should now the rock temperature be high, and the consumption of explosives very considerable, B should be made .00175, or even .0015. Using these figures in the above example would make Q equal to 5,330 and 6,840 cu. ft., respectively.

Formula 1, if used to determine the amount of air necessary for heading ventilation, would give results altogether too low to meet the requirements of heading work. In driving long tunnels, the field of operation is spread over a large zone, extending over a distance of several thousand feet, and blasting occurs at several points, as against one face only in heading work; also, the mining crews, timbermen, masons, etc., are distributed in small groups of ten to 50 men, in a room of large cubic contents. In a heading, altogether different conditions prevail. Here we have some 20 or 25 men with lights, cramped in a room 60 to 80 sq. ft. in cross-section and 100 to 150 ft. long; the consumption of explosives varies from 50 to 90 lbs. per blast, according to the material penetrated, and when 6 to 8 blasts are fired daily, as little time as possible can be lost after firing so as to enable the mining crews to resume their work. According to the efficiency of heading ventilation, the time lost or spent idly by the men, waiting for fumes to clear off after a blast, varies from 15 min. to one hour, 30 to 40 minutes being a fair average. In such cases, the amount of air necessary for adequate ventilation cannot be based on the amount of carbon dioxide excreted or

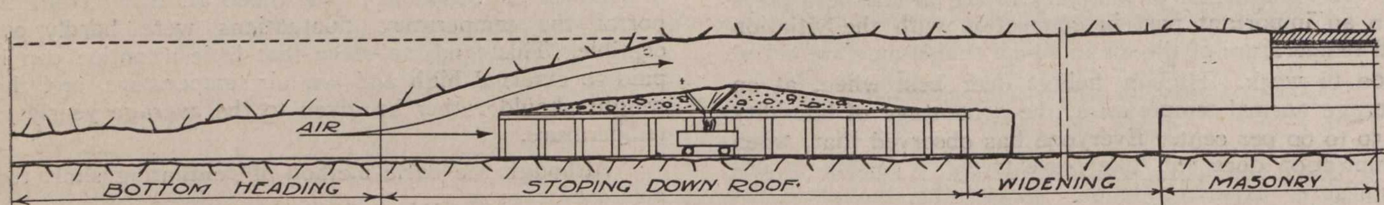


Fig. 8.

The vitiation of tunnel air referred to in items 1 to 4, inclusive, can be estimated with reasonable accuracy for all practical purposes, but the conditions brought on by agencies such as are referred to in items 5 and 6 can only be provided for by making a reasonable allowance for contingencies, and the judgment of the engineer, together with that of the geologist, should govern in this matter.

For nearly all practical purposes the amount of air necessary for the ventilation of a long tunnel during construction, exclusively of that for the ventilation of the heading, can be expressed by the formula:—

$$Q = \frac{A\,(1 - B)}{B - D} - C \quad . \; . \; . \; . \; . \; . \quad (1)$$

Where Q = amount of air, in cu. ft. introduced into the tunnel in 24 hrs.;
A = total amount of carbon dioxide, in cu. ft., given out in 24 hrs, by men, animals, lights and explosives;
B = amount of carbon dioxide allowed in tunnel air;
C = cubic contents (in cu. ft.) of the tunnel section in which crews are working;
D = cubic contents (in cu. ft.) of carbon dioxide in one cu. ft. of air, generally taken as .0004 cu. ft.

Example: In a tunnel driven under fair conditions, 3 shifts of 300 men, each with acetylene lamps and 4 horses, are employed, and 500 lbs. of explosives are consumed per 24 hrs. The tunnel crews are spaced over a length of 6,000 ft., and the tunnel has a cross-sectional area of 400 sq. ft. Carbon dioxide is not to exceed 2 parts in 1,000.

produced by men, animals and lights, but chiefly upon the consumption of explosives in one blast; also on the rock temperature and the gases encountered, if any.

The following formula, if used with judgment, will be found of assistance in determining the amount of air to be forced into a heading:—

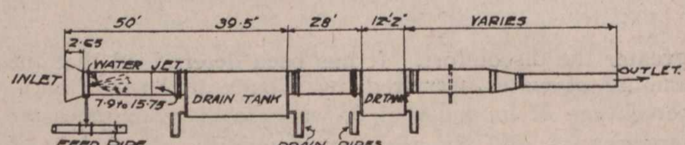


Fig. 9.

$$Q = \frac{\dfrac{A\,(1 - B)}{B - D} - C}{T} \quad . \; . \; . \; . \; . \; . \quad (2)$$

Where Q = amount of air, in cu. ft., introduced in the heading per minute;
A = amount of carbon dioxide, in cu. ft., produced by the consumption of explosives in one blast.
B = amount of carbon dioxide specified for the air in the heading at the end of time, T.
C = contents of heading in cu. ft.
D = .0004.
T = time from explosion of round until resumption of work in heading (in minutes).

Example: In a heading 7 x 10 ft. in cross-section, and 300 ft. long, the consumption of dynamite per blast is 60 lbs.

The men are to work in an atmosphere containing not more than .002 of carbon dioxide, twenty minutes after firing a blast.

Then in formula 2, A equals 210, B = .002, C = 21,000, D = .0004, T = 20, and Q is found to be equal to 5,500 cu. ft. According to the conditions prevailing, Q can be made larger or smaller by giving B or T different values.

The total quantity of air to be forced into the tunnel is the sum of the value for Q as given by formulæ 1 and 2, or in the example selected = 4,230 + 5,500 cu. ft. = 9,730 cu. ft. An allowance of 20 to 30 per cent. should be made for contingencies.

The amount of air to be forced by, and the capacity of the ventilators depends to a large extent on the type of drills used in driving a bore. The Mont Cenis and St. Gothard tunnels were driven solely with the assistance of the ventilation produced by the exhaust of air-drills; the ventilation thus available was poor, however, and insufficient in many instances; yet these bores were completed without other means of ventilation. The rock temperature in these tunnels was not very excessive, and the driving progress very slow. On the other hand, the capacity of the ventilating plant of the Simplon tunnel was remarkable for its magnitude, necessitated by a high rock temperature and by the total absence of air-drills, water-drills being used in the heading, and hand ones in the enlargement. The use of air-drills, and practically the complete abandonment of hand drilling in connection with the driving of recent long tunnels, besides enabling more progress to be made at a lesser cost, has become a valuable auxiliary to tunnel ventilation. In the Loetschberg tunnel, from 4 to 6 large Ingersoll Rand drills and as many as 15 hammer air-drills were used. In the Hauenstein tunnel there was as many as 40 drills at one end of the bore.

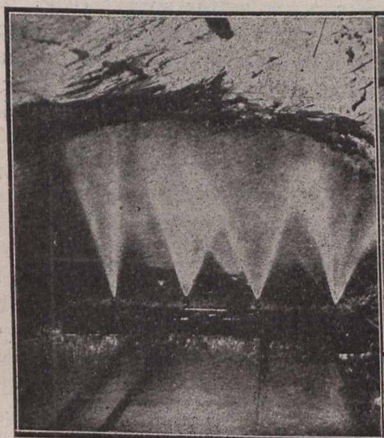


Fig. 10.

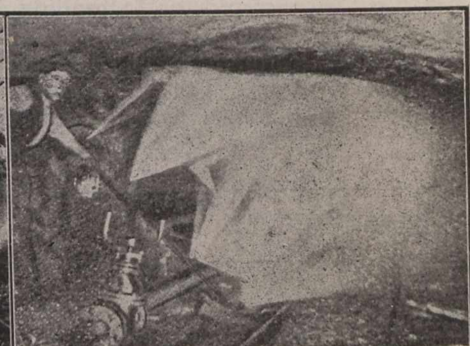


Fig. 11.

Table 1 gives the amount of air introduced into the south side of the Loetschberg tunnel by the ventilating system, together with that of drills and locomotives; thus 7 to 22 per cent. of the total amount of air introduced into the tunnel was exhausted from the drills, while that introduced by the air locomotives was as high as 5.4 per cent. of the total. As a matter of fact, later on, 50 per cent. of the air introduced into the bore was exhausted from the drills. This fact is to be kept in sight, for it demonstrates in a most convincing way that, instead of using a large amount of power for the ventilation alone, it is more economical to use power that will operate drills first, and then be still of utility for ventilating purposes.

From others and the writer's observations, it has been found that, for low rock temperatures, up to, say, about 90° F., the air temperature in a tunnel or heading is 5 to 7° higher than the rock temperature, and also that the air temperature reached a maximum during mucking (see Figs. 1, 2, 3, 4). At this very moment, that is just after firing a blast, the drillers are busy setting up their drills, the muckers are loading the blasted material into cars as rapidly as possible, thus the necessity of doing away with the fumes of explosives in a minimum lapse of time.

Refrigeration of Tunnels during Construction.—It is beyond the scope of this paper to go into lengthy details pertaining to the refrigeration of long tunnels during construction; however, let it be pointed out briefly that the cooling of air by air is only possible or economical within a certain limit. In the Simplon tunnel, for instance, this limit was reached when the air temperature in the tunnel was 100° F. In order to cool the tunnel by the introduction of fresh air, when the rock temperature is high, it would be necessary to force in a large amount of cool air from outside; but, as the size of ventilating pipes or conduits is limited to certain practical dimensions, depending on the room available, the velocity of the air conveyed by these would soon reach too high a velocity; the friction would increase rapidly, thus generate heat, and the air would reach its destination at too high a temperature to be effective for refrigerating purposes. Should the fresh air supply be a few degrees warmer than the rock temperature when reaching the heading, it would have little cooling effect, if any, on the air temperature. Fortunately, in most cases, the ventilating air has a lower temperature than that of the rock. With a high rock temperature of, say, 100° or more, other means of refrigeration have to be resorted to. As it is not proposed to describe here the methods that have been or are being used to ventilate long tunnels in each case, the reader is referred to Table 2, giving the characteristic features pertaining to the ventilation of 12 tunnels 12,000 to 65,000 ft. long; yet it is interesting to review the methods advocated or used at various epochs of modern construction.

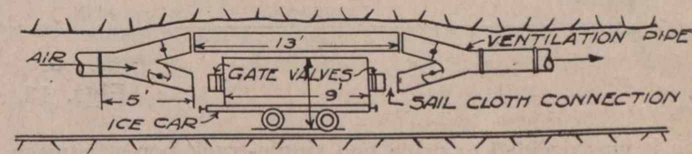
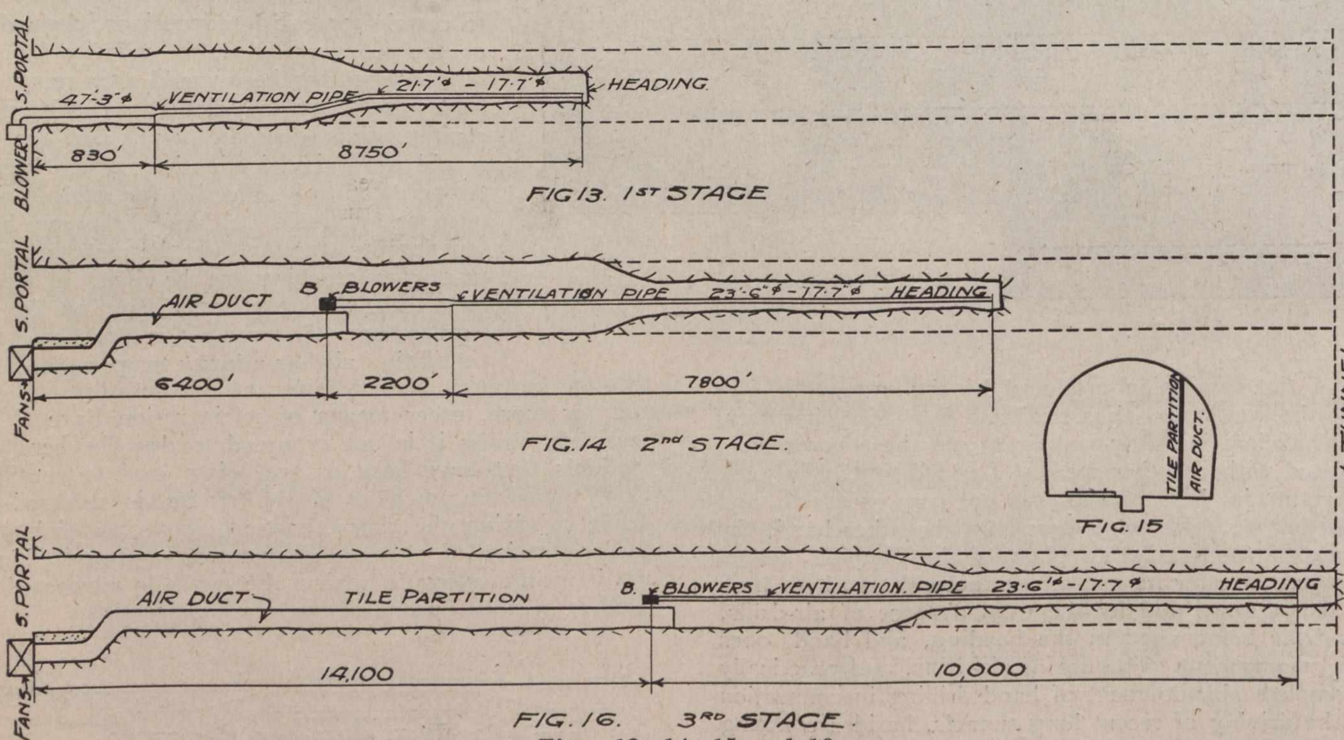


Fig. 12.

The experience gained in driving the Mont Cenis and St. Gothard tunnels had demonstrated clearly the inconvenience caused by inadequate ventilation, and when the driving of the Arlberg tunnel was started, an elaborate ventilating plant was provided at each portal. On the east side of the bore, where air-drills were used, the capacity of the plant was 5,300 cu. ft. per minute, and on the west side, where water drills were used, 6,350 cu. ft. Iron pipes served as means of air conveyance. Later on, the capacity of both systems was increased to 12,600 cu. ft. per min.

In 1891, when the Simplon tunnel project was considered anew, it was estimated that, having regard to the high rock temperature to be expected (107° F.), an adequate system of ventilation would be required, and the following plan of construction was advocated (Fig. 5). From the north portal to about half-way between portals the tunnel was to have a cross-section accommodating two tracks; the bore would then branch off in two single-track tunnels extending to the south portal and connected at intervals with cross galleries. During construction, on the south side, a ventilating plant at the portal of Tunnel 2 was to exhaust the vitiated atmosphere of Tunnel 1 through the cross galleries; Tunnel No. 2 was to be closed at the portal by a bulkhead, E. Thus, fresh air would rush in at C during construction, and also at B after completion of the tunnel. During the driving period the cross galleries, except that nearest to the heading, were to be closed by bulkheads, D. On the north side, the ventilation was to be provided by forcing in air from the portal through a 31.5-in. diam. pipe. It was estimated that, theoretically, 56 cu. ft. of air per sec, and per h.p. could be forced in through the ventilating pipe, and 9.5 cu. ft. per sec. and per h.p. through the double tunnel system on the south side. Thus, for equal power consumption, the intensity of the ventilation would be 17 times greater with the double heading system than with the ventilating pipe. Later transverse gallery next to the heading's face. Power-driven blowers were used also to some extent, but with little success. The intake end of the injectors was located in heading No. 2, and one pipe conveyed air to each heading. Each injector consisted of a nozzle through which 3.8 cu. ft. of water was discharged per min. at 1,100 lbs. pressure and 280 ft. vel. per sec. About 2,100 cu. ft. of air was thus forced per minute, at 5.6 oz. pressure, through 300 ft. of 15.7 and 8-in. diam. pipe. As many as four injectors were installed on one conduit, 1,300 ft. long.

Owing to the increase in temperature, the primary and secondary ventilating systems soon became inadequate, and the following methods of refrigeration were resorted to: In heading No. 2, 21 water sprays (Fig. 10) were installed, forming a water curtain 65 ft. deep, through which passed the air, forced in by the portal fans. The air thus cooled off, but containing much humidity, was forced through wire screens located in



Figs. 13, 14, 15 and 16.

on it was decided to drive two single-track bores between the end portals.

Ventilation and Refrigeration of the Simplon Tunnel as Actually Built.—The primary ventilating plant consisted of 2 fans, 12.3 ft. in diam., each driven by a 200 h.p. hydraulic turbine, located at the portals (Fig. 6). When running in parallel, the capacity of the fans was 105,900 cu. ft. per min. at 5.7 oz. water pressure. Air was forced into heading No. 2 and exhausted through Tunnel No. 1, being conveyed from one bore to the other through the gallery nearest to the heading's face, and the others closed by a bulkhead, D.

In order to ventilate the top heading, a sailcloth curtain (Fig. 7) was provided at each upraise to deflect the air current upwards. In the very hot sections, however, the ventilation of the top heading became so inadequate that, instead of driving a top heading, it became necessary to stope down the rock, overlaying the bottom heading, on a timber platform (Fig. 8). This method of ventilation was found to be more effective, the air being thus given a better circulation through both the top and bottom headings. The secondary ventilation consisted of water injectors (Fig. 9) installed at the front of the sprays. This system, although very effective, was a serious hindrance to traffic, and it was superseded by that illustrated in Fig. 11. The above appliances enabled air to be cooled by about 17° F., the temperature of water used for spraying purposes varying from 39 to 62° F., according to the season.

In order to cool the air conveyed by the ventilating pipes in the headings, ice cars were branched on the ventilation pipes (Fig. 12) and air forced through these. Each car contained 513 vertical tubes 1½ in. diam., 31 in. long, presenting to the ventilating air a surface of 540 sq. ft. This cooling system necessitated twelve ice cars per day; after five months' use it was abandoned altogether, being too costly and very cumbersome. In addition to the above refrigerating systems, perforated pipes located at intervals in the tunnel or headings served the purpose of sprinkling the walls of the bore with cold water.

From observation it has been determined that in heading No. 1, for instance, when the rock temperature was highest (130° F.), the cooling effect due to air and water supplied for this purpose was as follows: During drilling 11.6 B.T.U. were absorbed per sq. ft. of rock surface and per hour, and during mucking 6.4 B.T.U. per sq. ft. per hour.

Ventilation of the Loetschberg Tunnel.—The system of ventilation used on the south side of this bore will be described only, that on the north side being similar, although somewhat less elaborate.

TABLE I.

Date.	Air exhausted by drills. Cu. meters.	Per cent. of total.	Air exhausted by locomotives. Cu. meters.	Per cent. of total.	Air exhausted by ventilation. Cu. meters.	Per cent. of total.
June, 1909	105,680	7	18,720	1.2	1,382,400	91.8
September, 1909	102,000	7.2	19,000	1.3	1,300,000	91.5
December, 1901	132,000	18.8	26,000	3.7	542,000	77.5.
March, 1910	132,000	18.8	30,000	4.3	538,000	76.9
June, 1910	132,000	22.2	32,000	5.4	430,000	72.4
September, 1910	132,000	14.1	23,400	2.5	777,600	83.5

TABLE II.

o.	Name of tunnel	Length of tunnel Feet	Over-laying depth Feet	Rock Temper-ature Deg. F.	Air Temper-ature Deg. F.	Explos. con-sumption Lbs. 24 hr.	Air for venti-lation Cu. ft.	Power con-sumption H.P.
1	Simplon	65,042	7,100	130	96	1,100	76,000	400
2	St. Gothard	49,147	5,570	87	87	660	4,200	...
3	Loetschberg	47,680	5,200	94	86	1,000	34,000	350
4	Mt. Cenis	42,142	5,430	85	86	440	2,100	...
5	Aarlberg	33,600	2,360	65	..	770	12,600	250
6	Ricken	28,200	1,740	78	77	500	8,400	200
7	Granges	28,093	2,880	72	70	600	8,000	150
8	Arthus Pass	28,060	1,000*	..	..	500	3,000	55
9	Tauern	27,965	5,150	74	..	450	12,360	420
10	Albula	19,240	2,370	59	..	...	2,000	30
11	Bosruck	15,630	3,530	48	..	500	12,360	280
12	Weissenstein	12,136	1,640	55	55	300*	6,000*	...

* Denotes approximate figure.

During the first construction period, that is, until the tunnel had reached a length of about 11,500 ft., the ventilating plant consisted of 2 Capell blowers (Fig. 13), located at the portal, and having a total capacity of 4,200 cu. ft. per min. at 10.8 oz pressure. Air was forced through wrought-iron pipes, 47.3 in. diam. at the blower outlet and 17.7 in. in the heading. When the pipes had

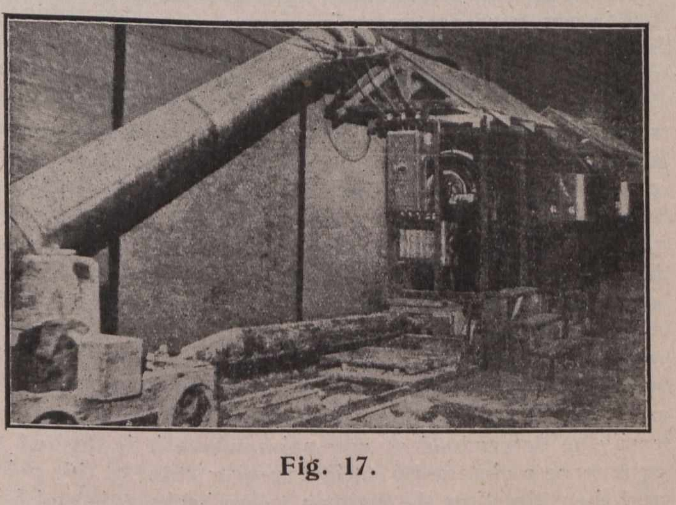


Fig. 17.

reached a length of 7,300 ft., two water injectors were installed on the pipes, this system being used until the tunnel reached a length of 11,500 ft., and as many as 4 injectors were used on the air conduit. Soon after the ventilating plant, which was to be used during the operation of the tunnel, was put in operation; it consisted of two fans, 11.5 ft. diam., driven by 175 h.p. electric motors, and having a total capacity of 106,000 cu. ft. per min. at 5.7 oz. pressure. Air was conveyed in the tunnel through a duct of 68 sq. ft. area (Figs. 14, 15 and 16), consisting of blowers "B" of 100 cu. ft. capacity per sec., taking air from the main ventilating duct and forcing it through the heading at 3.8 oz. pressure through pipes varying in dia. from 47.3 to 17.7 in. At intervals, water injectors were provided on the pipe, and, as work progressed, the masonry duct and the secondary ventilating plant, the latter being carried on trucks (Fig. 17), were moved forward. According to the rock temperature, as many as 3 electrically-driven blowers were provided on the ventilating pipe. When available, large quantities of snow were also introduced into the tunnel. During construction, the primary ventilation was found to be of too high a capacity, and the air supply was reduced to 10,000 cu. ft. per minute.

No.	Type of Haulage	Size of vent. pipes Head	Enlarg't	Type of Drill	Type of Lights	Number of men per 24 hr.
1	Air loc.	8"	15.75"	Water	Oil Acetyl.	800
2	Air / Steam	none	none	Air	Oil	400
3	Air	17.75"	47.25"	Air	Acetyl.	1000
4	Horses / Steam	none	none	Air	Oil	250
5	Horses / Steam		E. 19.75" / W. 15.75"	Water / Air	Oil	700
6	Horses / Steam	13.8"	31.5"	Air	Oil Acetyl.	400
7	Air		23"	Air	Acetyl.	550
8	Gasolene / Electric	9"	16"	Air	Acetyl. Electric	250*
9	Electric / Benzine	19.7"	31.5"	Water	Acetyl. Electric	400*
10	Horses	—	—	Water	Oil	—
11	Steam	11.8"	19.4"	Air	Oil Gasolene	300*
12	—	13.75"	23.6"	Air	Oil Acetyl.	500

* Denotes approximate figure.

Conclusions.—For tunnels 25,000 to 35,000 ft. long, a ventilating system consisting of fans at the portals, forcing in a large quantity of air at low pressure, and of power-driven blowers and water injectors, for the ventilation of the heading, will be found amply adequate in most instances; for, let it be pointed out here, that there exist a relation between the length and the mass, or height of material overlaying a bore; one can hardly conceive a short tunnel very deeply overlaid.

For double-track tunnels, 40,000 to 50,000 ft. long, when the rock temperature is not expected to exceed 100° F. by many degrees, a duct system similar to that used in the Loetschberg tunnel will prove ample and feasible in most cases. For longer tunnels, where a high rock temperature may be encountered, the double-bore system, consisting either of 2 single-track tunnels, or of a double-track tunnel with an auxiliary bore of smaller dimension, driven parallel to and connected at intervals by cross galleries with the main bore, may have to be resorted to.

LAYING OUT SIDE HILL ROADS.

THE following method of laying out contour grades for side hill roads is from a paper written by Capt. A. C. Gardner, Chief Surveyor, Land Titles Office of Saskatchewan for the Regina Engineering Society. At the outset he emphasizes the desirability of the engineer appointed to such work being thoroughly practical, and claims the following as valuable assets: a good knowledge of the country, as to climatic conditions, nature and extent of the different seasons and general requirements, also a well developed faculty for recognizing suitable road locations.

A few years ago, in addition to probable amount of traffic, the most serious question was to obtain a satisfactory road at much below minimum cost of suitable construction and the views of the engineer had in many cases to be sacrificed, in order not to exceed the amount allowed. At the same time some kind of an outlet for traffic had to be provided, and that in many cases quickly. This state of affairs was unfortunate, as a certain amount of discredit has been reflected upon the engineers who had to lay out roads of this nature, and who are entirely blameless as to excessive grades and poor locations. The engineer has generally a choice of locations, the first considerations in choice being the most direct, easiest grade, minimum cost of construction and up-keep. This choice can readily be determined with a climometer and the assistance of one or two men. Whether starting from the valley or upland, very often a good idea of feasibility of location can be determined in the following manner, viz.: Starting at the approximate point of commencement and sighting on some conspicuous point at the approximate outlet, the angle of elevation is read and knowing the distance approximately between the two points it is a simple mathematical problem to work out what the probable grade would be and if results are at all satisfactory much time has been gained. These rough shots are worth trying if they can be taken. In any event, having decided where the engineer will try and get his location the practice would be to put on an angle of elevation or depression (as the case may be) which gives about two-thirds of the maximum grade intended for the road, the rodman is then instructed to take up points from one to three hundred feet apart and at all prominent points encountered along the preliminary grade line, rough stakes are driven temporarily to mark the points above mentioned. Whilst engaged in this work careful notes should be taken as to the suitability of location, where the grades can be altered to advantage, location of springs, number of culverts required for proper and effective drainage, suitability of road for traffic at all seasons of the year, whether the road would be easy of construction or otherwise, and many other points of more or less importance. The author usually accomplished the reconnaissance work in from a few hours to one or two days, depending on the length of road and the difficulties to be overcome. In some cases, having run the preliminary grade and finding the outlet unsuitable, he would choose a suitable outlet, and starting there, run in a reverse direction, generally meeting the first grade at some point on the way up or down (as the case might be). Having decided upon the location by the above means, the author next had his men cut the necessary number of stakes. These were about 1½ inches in diameter and 18 inches long, and blazed on both sides (material usually easily obtainable at or near location of this kind). In the meantime he would probably walk over the location several times, taking notes as to final location. A little difficulty is encountered at first in setting up an instrument on hillside work and some care is required to avoid disturbing the adjustments of same after it is set up, but this is soon overcome by practice.

Method and Practice of Staking Final Location.—First have the rodman cut a rod about 1 inch in diameter, cut square across at both ends and peeled or blazed, the length of rod equal to the height of axis of telescope from the ground (the instrument being set at height suitable to the observer) usually from 4½ to 5 feet. The instrument is then set up at point of commencement and the height of same guaged by rod., i.e., rod on ground and top reaching axis of telescope, the instrument is levelled and angle of elevation (or as the case may be) to give the required grade set off on vertical circle and telescope clamped. About thirty-four and one-half minutes gives a one per cent. grade. The rodman then starts off with a bundle of stakes holding one crosswise on top of his rod and moves up or down the hill till the observer sees the stakes cut by the horizontal hair. Stakes are numbered consecutively and driven by another man following along the line. This man also keeps the rodman supplied with stakes. The interval between stakes is from 15 to 20 feet where hillside is uniform and at closer intervals where pronounced irregularities are encountered. So long as the line of sight is direct and grade uniform, the line can be staked for a considerable distance from one station, when the line begins to swing appreciably either towards the observer, or the reverse, or where it is desired to change the grade, the next station is taken up over the last stake set and instrument set up in the manner previously described; all sharp and short turns are run in either level, but in any case not exceeding a one per cent. grade. A slack grade is always put on at the outlet of the road, particularly if the bulk of heavy traffic is going up hill. Where a uniform grade could be obtained for any considerable distance, the author usually broke same in several places unless the ground admitted of a very slack grade in the first instance. At all runways or wherever he intended placing a culvert, a long stake would be placed about the centre of the proposed road, the rod was held on top of same and stake driven until the top became grade, the stake was then marked "culvert" and dimensions stated on one side, and on opposite side of stake was written "grade; fill to top of stake." It is often necessary to go back over portions of the staked line improving the grade wherever possible. The grade can easily be determined at any point where it is desired to commence a change by setting up over stake at this point and then directing the rodman to go backwards and forwards about five or six stakes. The telescope is then directed on cross stake on top of rod and clamped. Angle is then read on vertical circle, and as a further check the rodman then moves forward holding rod at foot of each stake set. If the horizontal wire cuts stake held on top of rod in each case you have the grade from angle given on vertical circle in the first instance. The changing of grade does not occupy much time once the line is established. Having staked the grade the writer would then engage a farmer and have him plough a furrow along the line of stakes where the hillside was open, using one of the men to either hold the plough or drive the horses, and going along with them would see that the line of stakes was closely adhered to and a suitable furrow made. This left an almost permanent grade line, even if the stakes were knocked down or fell out. The furrow was not necessarily through the bush, as a clear-cut line was always made which could be easily picked up for a considerable time afterwards, and stakes were not liable to be disturbed.

To ensure a satisfactory road being built, it is advisable (if possible) for the engineer to have the road foreman with him when he stakes the grade or before he leaves the ground, and by going over the line with him and pointing out how he will be able to strengthen the road and round out the bends, also how to work from the staked line or furrow (and if a practical man) he will in a few hours thoroughly understand what is required and how to carry out the work.

In making the survey of the road the writer usually ran the line so that the road foreman, in order to keep within the limits of roadway, practically had to follow, not only closely to grade, but also required to straighten road and round out bends. It is, of course, advisable for the engineer to be on the ground at least a portion of the time during construction. The author was seldom able to do this, but by taking the above precautions most of the roads he laid out were satisfactorily constructed.

The longest and most satisfactory side hill which he laid out by the methods above described is about 2¾ miles in length. Maximum grade 5½ per cent. with an average grade of about three per cent. or slightly under. All the curves are practically level and several of the shorter turns are level. There is one small timber bridge which eases out a very sharp bend and avoids a large spring, situate about one-quarter of the way down hill. The road was constructed under the supervision of a Mr. J. Bird, road foreman and contractor.

At the time, construction of this road was considered expensive. It did not, however, cost any more, if as much, per mile, as some of the roads constructed on the uplands where many ponds or sloughs were encountered.

It would be out of place in this paper to discuss the usual methods of staking out side hill roads beyond stating that in comparison, it is practical, economical, rapid and easily picked up at some future time as this location remains much longer defined on the ground, and if marked in the manner described it is apparent to anyone what the grade will be (i.e., easy or otherwise). Considerable time in the past often elapsed between location and construction. To somewhat support this statement, the following is an extract from the report, 1909-10, of the late Mr. E. W. Walker, District Surveyor and Engineer, Department of Public Works, Province of Saskatchewan. (Mr. Walker, in speaking of methods, means the usual method of staking centre line and putting in slope stakes).

"The shortcomings of these methods, as I see them now, are that this work is often done so long before the road foreman and grading crew begin operations, that the stakes with their markings, as planted by the engineer, have disappeared, and the engineer is called upon to replace and re-mark these before the work of grading can be commenced properly, and it therefore tempts the road foreman to go ahead with the grading, disregarding the stakes if he has to replace and re-mark them from the engineer's diagram which, in many cases, he doubtless does not fully understand or appreciate."

According to a recent statistical report laid before the aldermen of Montreal, within the last four years, the city of Montreal has spent approximately $100,000,000.

TOWN PLANNING.

In a paper entitled "Housing and Town Planning," read by Christopher J. Yorath, A. M. Inst. C.E., M. R. S. I., city commissioner of Saskatoon, at the Calgary convention of the Alberta Town Planning Association, June 16, 17 and 18, the two chief problems with which civic improvement organizations have to contend were severally dealt with. Concerning bad housing, the primary causes were given as follows:

(1) Lack of proper legislation;
(2) Lack of sympathy between landlord and tenant;
(3) Insufficient education; and
(4) Overcrowding due to want of proper transit facilities and the number of houses allowed to be built on an acre of land.

The author dealt at length with these evils and went on to show how the questions which usually face the problem of housing reform are dealt with in Great Britain. He summarized the position of housing as it is at the present day as follows:

1. Unhealthy areas and dwellings exist which can and must be dealt with by the local authority.

2. Houses unfit for human habitation must be made fit for human habitation at the cost of the landlord, if necessary the local authority carrying out the work.

3. The provision, where insufficient, of more dwellings for the working classes, either by the local authority or through building societies.

Town Planning.*—In the building of every city there should be some object in view, some aim towards which those who are responsible for its foundations and growth are consciously aiming. Unfortunately, in the majority of cases the aim has been an unconscious one with the result that cities have grown up in a haphazard manner and many a beautiful spot turned into an ugly accumulation of bricks and mortar. Until recent years, it was thought that the checkboard system of planning was all that could be desired, but anyone who has studied the subject of town planning will realize at once that it is a failure and has necessitated even in what are known as the New World Cities, large expenditure to rectify some of its many defects. How can a system be called a plan which does not take into consideration local characteristics such as the undulation of the ground, a winding river, thickly wooded spots and other amenities.

It invariably happens that town planning is not thought of or put into operation until a certain amount of development has taken place. In Great Britain this does not interfere to any great extent with the planning for the future, as the undeveloped land is not staked out into lots and held by numerous landholders, but is usually in possession of a few; whereas in Canada, owing to the checkboard system and the selling of outlying plots far in advance of the time when the land is ripe for development, the proper planning of the future is rendered far more difficult and in many cases the difficulties will be so great as likely to make a scheme impracticable without special legislation.

A city attractive by its beauty, by its artistic symmetry and design and by the amenities and conveniences which it offers, will gain a reputation and an individuality of which not only its council and its landowners but also its citizens may be proud.

The aim of every city should be the one implied by the term "Garden City," beautiful, well planted and finely

*[This section of Commissioner Yorath's paper is given practically in full.—EDITOR.]

laid out, known and characterized by the charm and amenities which it can accord to those who seek a residence or dwelling removed from the turmoil, stress, and discomforts of a manufacturing district.

The various systems of planning which have been adopted in the past are rectangular, radial, and circumferential and curvilineal, but the latest schemes for town planning are generally a combination of all three, which allows for the best fulfilment of town planning ideals.

Essentials in Making a Town Plan.—The most essential points for consideration in the drawing up of a town plan are:—

(1) A general survey of past growth, present conditions and future possibilities.

(2) The preparation of a map of the city and its environment showing the configuration and undulations of the site, etc.

(3) The entrances to the city by water and land.

(4) The direction of main, radial and circumferential avenues and boulevards.

(5) Transportation.

(6) The layout and construction of avenues, drives and boulevards.

(7) The appearance and furnishings of the streets.

(8) The provision of parks, open spaces and recreation grounds.

(9) The administrative or civic centre.

(10) The defining of areas from a residential, industrial and commercial standpoint.

(11) The architecture of buildings, the space about same, the limitation of houses per acre, and the height and character of same.

(12) The design of water, sewerage and tramway systems.

Survey of Past, Present and Future Growth of City.—Before commencing a town plan it is necessary that the town planner should make a complete survey of the site and make himself thoroughly acquainted with local conditions. He should consider the rate of development of the city in the past and whether conditions will be such that its rate of development will be as great or greater in the future and what the main factors governing its growth and expansion will be.

In framing the town plan for Saskatoon, the writer had consideration for the following:—

(*a*) That the population had increased from 113 in 1903 to 30,000 in 1913.

(*b*) That it is the geographical centre of the fertile portion of the province of Saskatchewan.

(*c*) That it is served by the three principal Canadian railways and has a distribution area of 48,000 square miles.

(*d*) That a large terminal elevator is being constructed by the Dominion Government, and the city is likely to be the large wheat collecting centre for the Hudson Bay route.

(*e*) That owing to its being in a position to obtain cheap power from the large gas fields in Western Saskatchewan, it is likely to increase in importance as a large manufacturing and distributing centre.

(*f*) That, having the University and Agricultural Experimental Farm, it will be the educational centre of the province.

Having regard to all these circumstances, it was decided to plan the future growth of the city for a population of 250,000, with facilities for further extension without impairing the general design.

Map of City and Its Environments.—Many of the once beautiful sites which some of our cities now occupy have been wantonly spoiled by the worst form of vandalism and the lack of a proper system of planning instead of providing a setting and vista by which the beauty of monumental and public buildings may be shown.

The second step preparatory to the drawing up of a town planning scheme is to make a contour map of the site with contours showing the rise or fall of the ground every five to ten feet. The map should be drawn to a scale of not less than 400 ft. to an inch, and in addition should show existing trees, places of historic or local interest, railways, existing residences, public and industrial buildings, waterways, etc. The map should also show any towns or villages in the vicinity of the city, which may possibly become in the future, part of the city, together with the most important main roads or trails leading to or from the city.

This map will enable the town planner to lay down the main radial and circumferential avenues so that the important transit routes are linked up one with the other in such a manner as will avoid traffic congestion in the centre of the city. It will also enable him to preserve places of beauty, the water front, and to establish the most important buildings in commanding positions; to design his storm and sanitary sewers so as to obtain the maximum amount of gravity flow and to arrange his water supply in the most suitable zones so that the whole system of public utilities can be built up in units, which will ultimately become parts of a completed whole.

In Canada the preparation of this plan is more costly and entails a far greater amount of work than the preparation of a similar plan in Great Britain, as in the latter country the Ordnance Survey, which is carried out by the government, is complete in every detail, even to the showing of lamp posts on the streets.

The Entrances to the City by Water and Land.—After having secured a plan of the town or city as it actually is, the town planner should become thoroughly acquainted with its approach by land and water, so that he can lay the foundation of his scheme from these points in such a way that the visitor as he approaches the city will be immediately impressed by its civic dignity and beauty.

The water entrance may be from the sea; by river; or by lake and gives innumerable opportunities (owing to its varied characteristics) of special treatment, and cannot be too carefully studied before finally settling upon the scheme which will for all time be the chief characteristic by which the city is known.

How often is the water front spoiled by being entirely occupied by quays, warehouses and railways, when with a little judicious planning the whole could have been so planned as to make a commanding entrance. Space can be provided for all without disfiguring the natural beauty of the site; the quays can be made to follow the graceful curves of the shore and spacious esplanades provided to break the monotony of continuous lines of warehouses. If the ground should slope towards the water front much can be done by terracing, boulevarding and parkways which will add dignity and beauty to the site. By grouping the principal buildings and providing spacious and well-planted boulevards leading to and from the main front, a facade will be provided which will at once impress upon the mind the civic splendor and harmony in style.

Again, the graceful winding river so often found running through the heart of a city should be jealously guarded as the most beautiful asset which a city can possess. Its banks can be made beautiful by the planting of trees, if they are not already wooded, and parks, terraces and boulevards provided which will be the most cherished belongings of the community. Sometimes the banks are flat, with large stretches of mud and the stream is very sluggish. This defect can often be remedied by formation of embankments and the land reclaimed formed into river-side parks.

Saskatoon has the South Saskatchewan River running through its centre with well-wooded and gradual sloped banks. In the town planning scheme which has been prepared by the writer, provision has been made along both sides of the river to form drives and boulevards, so that eventually when the scheme is completed a continuous drive of over 14 miles in length will be provided.

Again, the entrance to the city over the river by means of bridges should be considered from the architectural and scenic point of view. The whole beauty of the river may be spoiled by the construction of inartistic bridges, whereas they should be made to harmonize with their general surroundings. Every bridge over a river should be made a monument to the town.

Main, Radial, Circumferential Avenues and Boulevards.—The planning of the main, radial and circumferential avenues forms the skeleton upon which the town plan is built up, the minor and residential streets filling in the detail.

The main avenues, including the encircling boulevards and radial avenues bear the heavy traffic as they are usually the shortest means of transit between important points such as railway depots, quays, industrial and manufacturing districts. These avenues usually contain a street railway and should be made of sufficient width not only to take heavy traffic but also that they may be made attractive by means of boulevards.

In many of these avenues the street railway is laid in the centre of a boulevard with shaded walks on either side. By this method of construction a considerable sum of money is saved as compared with the system of paving the whole width of the track, and in addition a very much quicker means of transit is obtained as the railway is not hampered by the ordinary traffic of the street.

In planning out the widths of main roads it is difficult to estimate what the future will demand, but in any case it will be better to err on the wide side rather than the narrow.

The various types of streets usually required in a city are:—

(*a*) Main traffic avenues with tramways and boulevards (width from 100 to 200 feet).

(*b*) Secondary traffic avenues without provision for tramways (80 to 150 feet).

(*c*) Semi-residential avenues with provision for side and centre boulevards (width from 80 to 120 feet).

(*d*) Semi-residential avenues without provision for tramways but with side and centre boulevards (width from 80 to 100 feet).

(*e*) Residential avenues without provision for tramways but with side and centre boulevards (60 to 80 feet).

(*f*) Secondary residential avenues (width from 40 to 60 feet).

Transportation.—The most rapid and direct means of transport from and to important parts of the city is one of the chief considerations in the framing of a town plan, and emphasizes the necessity of developing the city's transportation facilities as a whole, and not as is often the case, the independent development of railway, water and interurban transportation. This latter method often entails very large expenditure in linking up the different systems in order to increase the efficiency of transportation. It is now realized in all large cities that enormous sums of money can be saved by commerce and industry if rapid means of transit are provided; and in many cities underground subways and elevated railways have been constructed in order to relieve congestion and provide this very essential requirement to aid the economic expansion of trade.

The Appearance and Furnishings of the Streets.—While it is essential and necessary in a town planning scheme to make provision for wide streets and to control the architecture of buildings, it is also important to remember that all objects in the streets, utilitarian or otherwise, are things to be seen, part of an organic whole, each having its respective part and place.

The furnishings of a street usually consist of street lighting posts, direction posts, telegraph and telephone poles, street railway poles and overhead wires, police patrol and fire alarm systems, letter boxes, public conveniences, advertisements, placards, etc.

It can easily be conceived and readily understood that if all these poles and erections on the street are neglected and allowed to be erected haphazard and without regard to artistic taste that no matter how much care may be taken in the upkeep of boulevards, and the control of architectural design that the general appearance and harmony will be spoiled.

The civic authorities and town planners should therefore give as much consideration to the details of street furnishings as to the development of the town plan if they wish to obtain the best results. The street lighting posts should be properly designed and appropriate in style; the street railway posts should also be artistically designed with ornamental base, etc. In many cities on the continent of Europe these posts, in the summer, are very much improved in appearance by flowers and drooping creepers hung from a basket fixed round the post.

Wherever possible, telephone and electric wires should be placed underground, as not only are the poles and wires a great disfigurement, but the poles occupy valuable space and they are a considerable source of danger to the public.

Parks, Open Spaces and Recreation Grounds.—In locating open spaces and parks, special consideration should be given to the preservation of places of natural beauty, such as wood, waterways, etc., and by the adoption of a town plan a young city can make provision for parks, etc., at very much less cost than would be the case in later years when building development has not only spoiled many beauty spots, but increased the value of land to a prohibitive price.

It is important that there should be ample reservations of open spaces, public parks and pleasure grounds, as without these "lungs" the health of a city must be very much impaired.

Although an endeavor has been made from time to time to fix a ratio of park area with population, up to the present there is no accepted ratio, as local conditions vary to such a large extent. In the United States it has been found that in cities with populations over 100,000 the number of persons per acre of park varies from 11,000 to 27,000.

With the checkboard system of planning, a large amount of valuable ground is often wasted in the unnecessary provision of paved streets and passages. By carefully planning the main and secondary avenues, through traffic can be avoided and residential districts can be laid out in a far less costly manner, part of the space occupied by paved streets being utilized for open spaces, tennis courts, and children's playgrounds.

People's parks are universally provided on the continent, which contain sufficient acreage to include a complete natural landscape, typical, as far as possible, of rural country.

It has become a very general rule in making arrangements for the development of land on modern lines in Great Britain to stipulate that one acre in ten shall be set aside as public, or semi-public open spaces—this in addition to limiting the number of houses per acre.

In addition to the large people's parks, open spaces should be provided in each locality where games and recreation can be enjoyed by the people without having to travel any great distance from their homes.

The enjoyment of parks and open spaces is very much enhanced if they are connected and linked up with a system of park drives or boulevards.

The Administrative or Civic Centre.—The administrative or civic centre, which is usually the heart of a town or city, should be the dominating feature of the city. It is not only necessary to secure a central location, but also, if possible, to select a site which will provide a vista from several points of vantage.

The civic centre should be dignified and impressive, whilst at the same time in harmony with the characteristics of the town itself, and in keeping with the resources of the public.

The buildings, if possible, should be grouped along the water front, or if a winding river runs through the city, a site can usually be selected which will not only be central but which can be viewed from several points in the city. By the grouping of the administrative centre along a water front stateliness of architectural treatment can be obtained which is impossible when grouping the same buildings along a street.

The Architecture of Buildings.—The architecture of buildings is an important factor in the success of a town planning scheme, and is a distinct phase of civic æsthetics. In order to obtain harmony in design, plans should be submitted to some central authority of all buildings intended to be erected, showing proposed elevations. It is essential that a maximum height of a building under certain conditions should be fixed. In London and many places in Great Britain it is now established that a building shall not exceed in height the width of the street upon which it fronts.

In order to obviate overcrowding, it is essential that a maximum number of houses per acre should be adopted for different grades of property.

In limiting the number per acre it should be sufficient, in the case of land that is not planned out in detail, if it be stated that the rule should be so many houses to the acre; but the requirements of the local authority would be satisfied if the average number was obtained over a certain area with due safeguards for the space about each house not being too small. There should also be a maximum number of houses stated, more than which should not be erected on any one acre.

Thus, if the number limited was 12 to the acre, the local authority might be satisfied if on any ten acres no more than 120 houses were built.

In residential areas the height should also be limited. Houses should not be built more than three stories or more than a maximum height, to be defined.

METHOD OF FIXING TIME FOR THE PERFORMANCE OF CITY CONTRACTS FOR STREET IMPROVEMENTS.*

By G. L. Bennett, M.M.E., New York.
Efficiency Engineer Board of Estimate and Apportionment.

THE determination of the number of working days which shall be allowed for the completion of a given contract is a problem upon which little data is at present available. Where the contract is very largely for work on one sort alone, such as paving, the problem is simple; but where as in the grading of streets, a number of really different sorts of work, often requiring equipments partly or wholly different for each sort, is covered by the one contract, the amount of time which is proper to allow, is really a quite complicated problem.

Contracts commonly arise from demands which in themselves are either urgent and set for a particular time of fulfilment or are more complaisant as to time, requiring only ultimate completion within rather wide time limits.

Contracts of the former type, for emergency work or for supplying necessary links in larger schemes, can, in proportion to their needs, afford to sacrifice economy for dispatch. Contracts of the latter type, which includes a majority of street improvement work, can properly afford to disregard time as such and to seek economy of total costs alone.

There are comparatively few pieces of work which can only be economically accomplished by the use of some one particular equipment and of some one particular method. In general, there are a number of equipments and of methods which, depending upon the genius of those in control for management under the conditions obtaining, will yield economical results, but will require somewhat different times for completion. Leaving out of account variations in required time, due to such causes, there is, for each sort of work, some number of working days, more than which could not economically be used by the contractor. Thus, on a pick and shovel job, the employment of less than a certain number of men would not be economical because of the cost of the foreman and superintendence and therefore, in this case, the use of more than a certain number of working days by a contractor would be uneconomical. The same thing applies to any job for which an equipment and force are provided sufficient to complete that job in one of the perhaps several most economical ways so far as contractor's costs are concerned; and to this somewhat varying time may be applied the term, "Contractor's Economical Time."

It is to be recognized that small total contract quantities, in general, only warrant the employment of light and easily moved equipments and that, somewhat progressively, as the quantities become larger, more and still more effective equipments are warranted.

But this may be modified considerably by the amounts of work of this same sort or sorts which have been done or are yet to be done, in the locality of the contract in question. Thus a rather small contract for rock excavation could properly be given a shorter contract time in the northern part of Greater New York where the rock excavation is constantly in progress than it could somewhere out on the shores of Long Island or southern New Jersey.

*Paper presented before the Municipal Engineers of the City of New York, February 25, 1914.

The amount of equipment to be employed is seriously effected by the costs of labor and the ease of procuring equipment. Where satisfactory labor is expensive or difficult to procure, contractors will, in general, employ machinery of a type which otherwise would only be used on much larger contracts, resulting, of course, in a shorter Contractor's Economical Time. Where machinery can be easily hired, equipment will often be used on small jobs such as could not otherwise be afforded. This affects also very large jobs for which, where no satisfactory disposal can be made of worn machinery, equipment is often provided only in such quantities that it shall all be practically worn out when the job is completed.

The total cost of the work rather than the cost to the contractor is the matter which interests the engineer in his capacity of manager for the party contracting for the work. And the total cost is, of course, the contract price plus the costs of surveys and designs, plus the costs of inspection, superintendence and interest on the moneys invested by partial payments or otherwise, all of which latter vary nearly directly with the time taken for the work.

The cost of interest, inspection, etc., will decrease, therefore, with a decrease in contract time, but because of the greater cost of equipment, etc., necessary to complete the work in less than the contractor's economical time, the contract price will tend to increase. That time which will give the minimum total costs for the work and which should accordingly on this sort of contract be used as the contract time, will therefore be somewhat shorter than the contractor's economical time.

Two methods of ascertaining the time to be allowed were open:

(1) By the balancing of inspection, superintendence, interest and similar time charges against the increased costs of obtaining and operating equipments of more capacity than are required to complete the contract in the contractor's economical time, using that point with reference to time which gives the least total cost, as the correct time to allow for the contract.

(2) By plotting the times allowed on previously completed contracts composed mainly of one kind of work and which had, in the judgment of the engineers in charge thereof, been prosecuted vigorously and with adequate equipment, a series of curves of quantity with reference to time can be drawn for each kind of work, each curve recognizing in its equation some particular controlling factor of variation. Having such curves and knowing the total quantity of work to be done, the proper contract time for this can be ascertained and the results can be combined to give the time for a contract including various kinds of work.

The operation of the first method for arriving at the contract time can be shown diagrammatically by Fig. 1.

In Fig. 1 the curve of contractor's costs shows the variation in cost with the contract time; the curve of interest, inspection and other time charges, the variation of these with contract time and the curve of total costs which has for its ordinate at each point the sum of the ordinates of the other two curves at that point, the variation of both with the contract time.

As these curves do not show variations with regard to quantity or other conditions governing any one sort of work, one such set of curves is necessary to determine the proper contract time for each total quantity of each kind of work. The contract times so obtained can later be plotted against the total quantities, even as has been done for Model 2, as shown in Figs. 2, 3, 4 and 5.

It is to be noted that this method depends upon a curve of contractor's costs, which can be determined, point by point, for the total quantity and the kind of work to which this curve applies, only by designing the most efficient plant or equipment to do this amount of this kind of work in each of the varying times assumed and from the use and costs of these plants or equipments, arriving at the contractor's costs.

That there is a very considerable difference in judgment as to the most economical plant for any given contract time and total quantity of work to be done and still more difference as to the delays and other items summed up in the contractor's costs must be apparent to those who are familiar with the variations in bid prices on those works of such magnitude as call for new and specially designed equipments.

And that the very considerable variation in bid prices between the various bids received for any contract is not all due to differences in the profits which the different

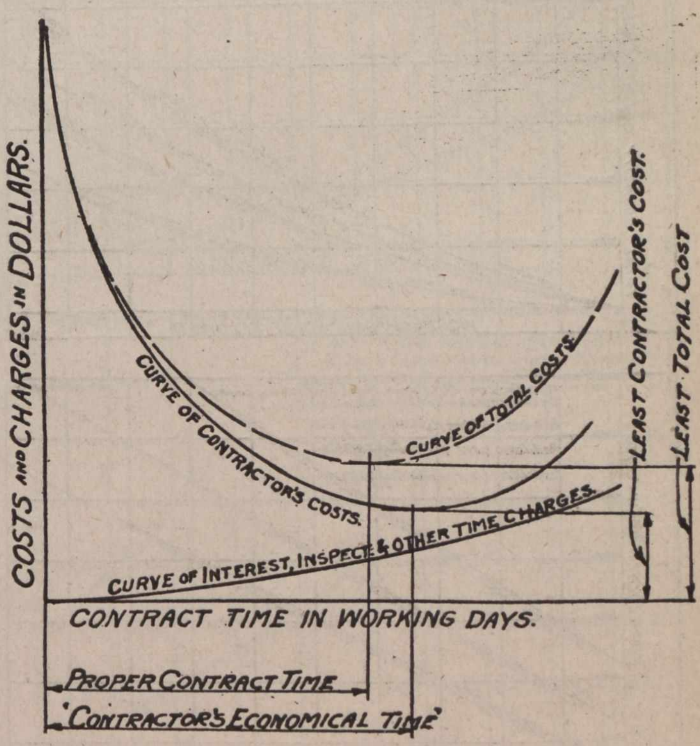


Fig. 1.

bidders desire, is quite clear to those who have studied prices bid when work was scarce and when therefore most, if not all, of the bidders were competing keenly for the job.

Also, that there is ample room for considerable differences between even the most carefully estimated contractor's costs and the actual contractor's costs is quite evident to those who have first planned and estimated and later built and operated contractor's plants.

In view, therefore, of the large number of assumptions which must be made and of the immense amount of work involved in creating such a "rope of sand" this seemingly more mathematical first method has been discarded in favor of the second method.

As an illustration of this method, the following set of rules, prepared by the author at the suggestion and under the direction of Mr. R. H. Gillespie, chief engineer of sewers and highways, for the use of the engineers of the Bureau of Highways in the Borough of The Bronx, New York City, in the determination of the contract time for regulating and grading are here introduced, the data for which was furnished by the records of this bureau and the judgments as to which contracts had been prosecuted properly by the engineers thereof.

The Determination of Contract Time.—To determine the number of days which shall be written into any contract for regulating and grading as the number of working days to be allowed under that contract the curves hereto attached are to be used in accordance with the rules herein given.

Explanation.—The work to be done will consist of items of rock or earth excavation or of filling or of both, of curb, of flagging, and of bridge-stones. These may or may not be accompanied by walls of dry rubble, rubble in mortar, or concrete; by pipe drains; by inlets; by receiving basins; by manholes; by piles; and by special constructions.

Items Which Govern.—Ordinarily, work on more than one of these items can be prosecuted at the same time. Care is therefore required to so use the information available of the special conditions surrounding a proposed work, as to eliminate from consideration all of those items and all parts of items which can properly be done during the progress of some other item. There will thus be left as the determining factor in the required time for such work, one, or more rarely, two main items which cannot be done simultaneously and some preliminary and subsequent parts of items.

The main items are liable to be earth and rock excavation or filling. The preliminary parts of items: The excavation of sufficient earth to permit earth and rock excavation to progress simultaneously; the building of sufficient of the pipe drains, inlets, manholes or basins to permit such building and the filling to progress simultaneously or the building of sufficient walls, in those few cases where such wall is necessary before any filling can be done, to permit such wall building and filling to progress simultaneously. The subsequent parts of items: Special structures which can not be completed until after the main item is completed; curb, flagging or bridgestone.

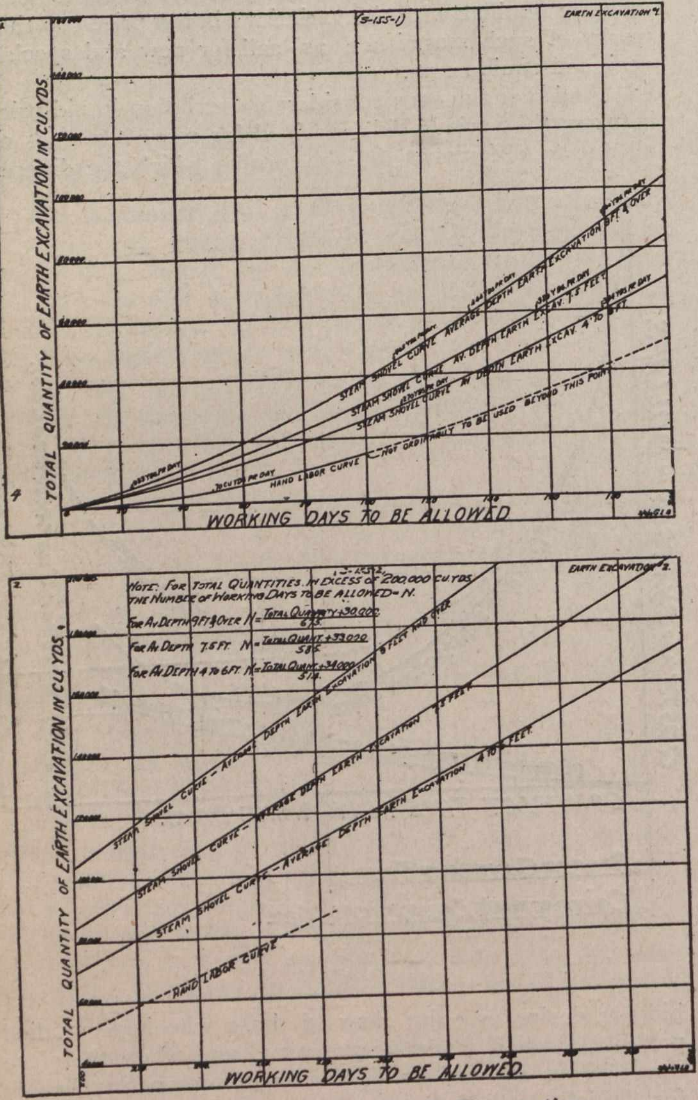


Fig. 2.—Curves for Earth Excavation.

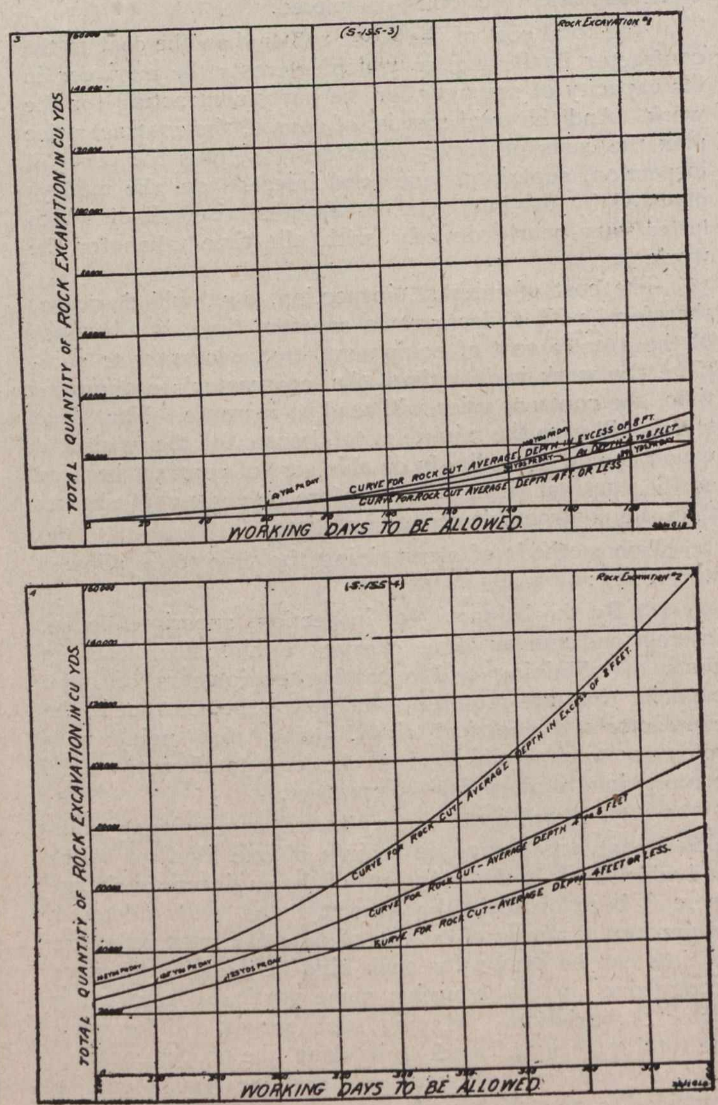


Fig. 3.—Curves for Rock Excavation.

The curves have been drawn to recognize, in view of the total quantity of an item to be done, the equipment and force which should be used.

They show, accordingly each for its condition, the amount of time for any total quantity which should be consumed in completing that quantity.

Rule "A."—If the time for a part of an item has to be estimated, it is to be taken therefore at the same rate of accomplishment per day as is the total quantity.

Rule "B."—Where conditions are clearly intermediate between those shown by the curves, interpolation is permissible, but where doubt exists, it is preferable as making for lower costs to take that nearest diagrammed condition which gives the longer contract time.

Rule "C."—Where a part of an item comes clearly under one condition recognized in the curves and the remainder as clearly under another, unless the equipment and force which should properly be used for doing these two parts is widely different, the time for the two parts, each taken at the same rate of accomplishment as if the total quantity came under that part's condition, shall be summed to give the time for that item.

Rule "D."—If the equipment, etc., should properly be different, the time for each part of the item is to be taken as if the quantity for this part item were a total quantity and the times so obtained, summed to give the total time for the item.

NOTE.—It is to be remembered that the contract provides that allowances of time for delays occasioned by the weather, or by any act or omission on the city's part, are to be made in addition to the number of working days; and that, therefore, no consideration need be given in this determination to any conditions arising from such causes.

The curves represent average good practice as determined from the records of many contracts done under this office. They do not represent the greatest progress which can be made under good management, and if, therefore, conditions arise not provided for in these curves, such as inability to attack the work in more than a few points, unless the condition is very severe, no additional working days are to be allowed as a total.

Rule "E."—For time necessary to get the work started after being ordered ahead and for stopping, after completion, 10 working days are to be allowed as a total.

Example 1.—On a contract with a centre line length of 8,900 ft. and a street width of 100 ft., there are the following items and quantities:

Earth excavation	88,000	cu. yd.
Rock excavation	26,700	" "
Fill	151,100	" "
Dry rubble masonry	700	" "
Rubble in mortar	25	" "
12-in. pipe	100	lin. ft.
18-in. pipe	575	" "
Manholes	4	
Guard rail	5,800	" "
Lumber	7,500	ft. (B.M.)

No bluestone.

Of the above items, only the earth, and rock excavation and the filling need be considered.

Filling.—It is known that over a portion of the work where filling is required that the street is located on a swamp where settlement will, in all probability, take place. Assume that this settlement will amount to 30,000 cu. yd. Then the total filling required to complete the work would be 151,100 + 30,000 = 181,100 cu. yd.

The sum of the earth and rock excavation equals 114,700 cu. yd. It should be assumed that the entire excavation is to be applied to making the fill so that the material can at least be considered as easily available. The balance of the material required for filling 66,400 cu. yd. must be obtained from outside sources. It is further known that the swamp section of the street is near tide water where material can be obtained by scows. This material, so obtained, should be classed as material "easily available." Even though the dock or nearest obtainable landing may be at some distance from the street under consideration, and especially in view of the possibility of obtaining and placing this filling during the progress of the grading on other portions of the work, it should be classed as "easily available."

An examination of the filling diagram will therefore indicate that considering 181,100 cu. yd. as "easily available," 332 days should be allowed, and adding to this 10 days for starting and stopping, we have 342 days, or, say, 345 days for the contract time.

Excavation.—If, on the other hand, we consider the excavation and know that the earth cutting averages from 4 to 6 ft. in depth, and the rock 4 to 8 ft. in depth, and that 10,000 cu. yd. of earth must be excavated before rock excavation can begin, and that thereafter both will be

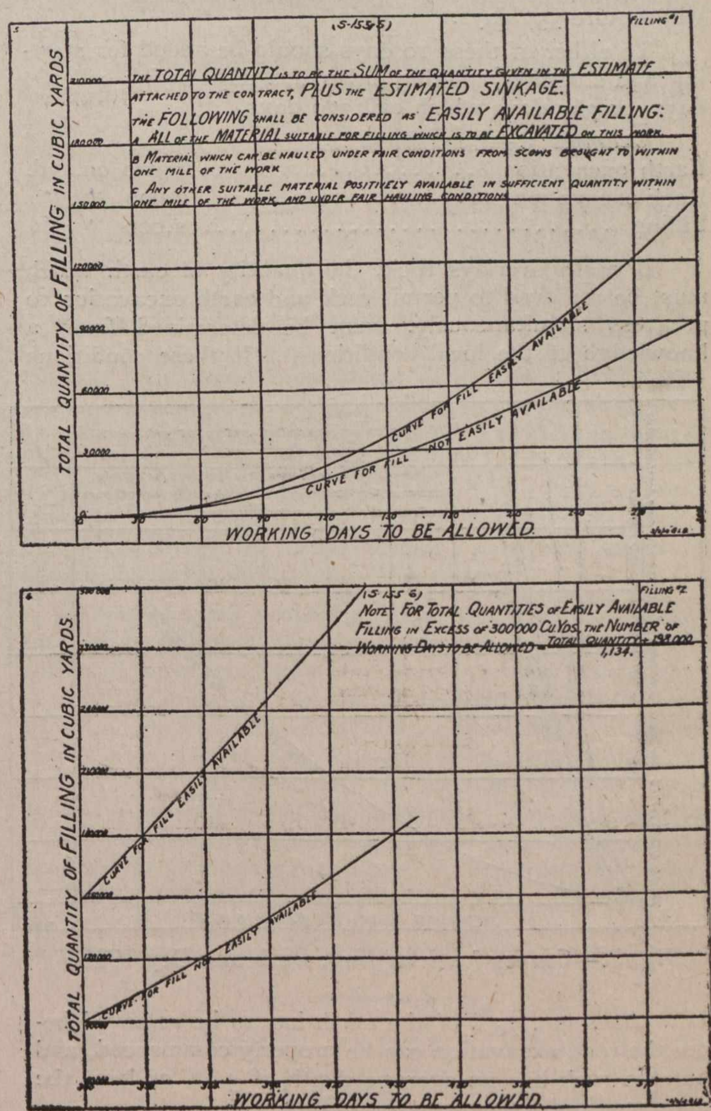


Fig. 4.—Curves for Filling.

carried on simultaneously, we will obtain from the curves the following:

10,000 cu. yd. earth excavation (at 88,000 rate)	27 days
26,700 cu. yd. rock excavation	212 "
	239 days
Starting and stopping	10 "
	249 days

If we consider only the earth excavation, and assume that while same is in progress the rock will be excavated, we have from curves the following:

88,000 cu. yd. earth excavation	235 days
Starting and stopping	10 "
	245 days

It is evident from the above that the filling required on the work controls and that the contract time should be fixed at 345 days.

Example 2.—

Earth excavation	1,000 cu. yd.
Rock excavation	500 " "
Filling	120,000 " "

In this example the excavation is plainly not to be considered. The filling, if easily available, will, by the curves, require 268 days. If not easily available, filling will require 357 days.

To either of these 10 days should be added for starting and stopping, making either 278 days which call 280 days, or 367 days which call 370 days.

Example 3.—

Earth excavation	6,000 cu. yd.
Rock excavation	6,000 " "
Filling	12,000 " "

If earth overlays rock, the quantity of earth which must be removed to permit rock and earth excavation to progress simultaneously, must be determined from a knowledge of the local conditions. If these conditions

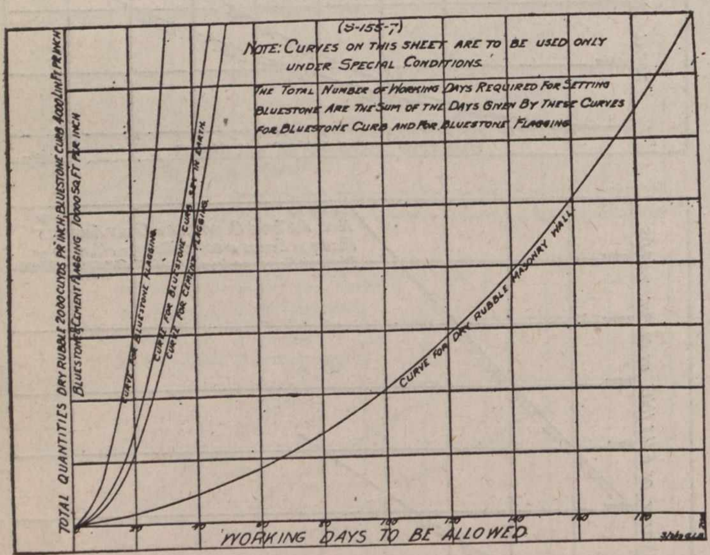


Fig. 5.—Curves for Flagging, Curb and Dry Wall.

show that, say, 35% of the earth has to be removed before the rock excavation can be properly commenced, and that the rock has an average depth of 4 ft. or less, the times required for excavation will be:

For earth 35% of the 64 days required by curve for hand labor for 6,000 yds.

For rock 114 days required by curve for 6,000 yd. of average depth 4 ft. or less.

The sum of these two, plus 10 days for starting and stopping, equals 146 days which call 150 days.

The filling, which is all easily available, would only require 90 days.

Therefore, the contract time for this job would be 150 days.

If earth and rock are in separate cuts and separately approachable so that the two sorts of excavation can properly progress simultaneously, the earth excavation need not be considered. The filling will, of course, not be the determining factor and the rock excavation will be. Under these conditions, the contract time should be for rock excavation, 114 days plus 10 days for starting and stopping equals 124 days, say, 125 days.

Example 4.—

Earth excavation	20,000 cu. yd.
Rock excavation	2,000 " "
Filling	3,000 " "

In this case, the earth overlies subgrade rock throughout most of the work.

The rock excavation remaining to be finished after the earth excavation is completed will amount to about 18% of the total rock excavation.

The filling will not determine the required time.

The earth excavation, being all in shallow cut, will be taken out by hand labor, thus requiring 118 days.

The 2,000 yd. rock, 4 ft. cut or less, would require 36 days, and 18% of this would require 6 days.

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The sum of the above plus 10 days start and stop equals 134 days which call 135 days.

Example 5.—

Earth excavation	1,000 cu. yd.
Rock excavation	6,000 " "
Filling	7,500 " "

Here, the 1,000 cu. yd. earth overlies the 6,000 cu. yd. rock and the conditions show that only a very little earth will be taken off, say, 200 yd., before the rock is commenced. Two hundred yards earth should require about one-fifth of the 24 days required by hand labor curve for the total 1,000 yd., say, 5 days.

Six thousand cubic yards rock, of a 4-ft. or less depth of cut, requires by the curve 114 days.

The sum of the above plus 10 days for start and stopping, equals 129 days which call 130 days, contract time.

Example 6.—

Earth excavation	30,000 cu. yd.
Rock excavation	45,000 " "
Filling (easily available)	120,000 " "

The filling will require by the curve 268 days.

The earth and rock excavation are such that they can be prosecuted quite simultaneously. The rock excavation will therefore control and has an average depth of 6 ft., requiring by the curve 270 days, so that 270 days is good for either.

Therefore, 270 plus 10 days stop and start gives 280 days as the contract time.

Example 7.—

Earth excavation	500 cu. yd.
Bluestone curb	15,000 lin. ft.
Cement flagging	60,000 sq. ft.

As cement flagging and bluestone work can progress simultaneously, the time required will be that for the longer of the two items.

The bluestone curb will, by the curve, require 32 days; the cement flagging 45 days.

Therefore, the cement flagging controls and the contract time should be 45 days plus 10 days start and stop = 55 days.

The application of this method to others of the more usual types of municipal work is obvious and in some cases is under way.

The confidence of contractors in general in the absolute fairness and in the knowledge of the engineer, will, perhaps as much as any other factor, tend to lower the costs of work to be done. And to this end a uniform method of figuring the contract time rather than guessing at it, will, it is believed, contribute in no small degree.

Editorial

ENGINEERING, A VEHICLE OF PRODUCTION.

Although there is no distinct mark of division, one is often led to believe that the relation between science and engineering should be better defined. At any rate, the engineer who recognizes that there exists a line of demarcation, however faint it may be, is less liable to enter upon schemes of an impracticable and therefore wasteful character.

It is perfectly true that the scientist and the engineer are engaged alike in a study of the forces of nature and of ways and means to properly guide and control these forces, so that they may be rendered more serviceable to mankind. But the work of the scientist precedes engineering. It leads him into new and unexplored fields and his investigation reveals the suitability of those fields for exploitation and development. Such is the work of the purely scientific man. It is a noble work; one that has rendered to the race the promotion of the new learning that has been behind the advancement of modern times. Nevertheless, it is perspective, in nature, and must, upon its conception, pass the muster of a combination of engineering and business ability before being presented to the world for assimilation and use. In other words, the purely scientific man must relinquish his conquest to the engineer and the financier in order that it may be judged productive and worthy of development. It is here that the engineer takes hold of the problem. Not previously, or he is encroaching upon the field of the scientist and hazarding his reputation as a reliable engineer.

The situation and its dangers were well protrayed editorially in a recent issue of Engineering (London), while on the subject of the business aspect of the profession. Here it was stated, "It cannot be denied that many engineers are inclined to become too much absorbed in the purely technical aspect of engineering, and to regard their profession a little too much from a standpoint which, though perfectly legitimate in the case of a physicist, is improper in the case of men whose labors are expected to contribute directly and immediately to the wealth of the world. An engineer—and examples are not uncommon—who interests himself solely in the scientific aspect of his profession undoubtedly greatly reduces his opportunities of benefiting his kind, and often is indirectly responsible for much wasteful expenditure. The complaint, for instance, is often made that funds appear to be easily found for the financing of engineering schemes of the most impossible and impracticable character, whilst really reasonable schemes go begging. Were those responsible for the latter better acquainted with the ways of business men, there would be a fair chance of diverting into productive channels resources which are now just as absolutely wasted as if they were invested in a timber yard and immediately fired."

THE TORONTO-HAMILTON HIGHWAY.

Ontario has now entered upon an excellent movement for better roads—one that seems to have the approval of the various classes of road users throughout the province. The appointment last July of the Good Roads and Public Highways Commission was followed by prompt activity resulting in the publication a few months ago of a comprehensive and valuable report. It is most encouraging that the government has seen fit to follow up the suggestions of the Commission, and to adopt its important proposals.

An important line of investigation recommended by the Commission, and one that has already been entered upon, is a motor survey of the main travelled roads in order to acquire an estimate of their present state and of the nature and amount of work necessary to bring them up to the required standard. Chief among the roads now being subjected to the motor survey and traffic census is the Lake Shore road between Toronto and Hamilton. Fourteen men were detailed for this work last week. It is perhaps the most important road falling in the interurban class, and it is one most in need of immediate attention. There are three roads under the travel of the Toronto-Hamilton traffic (including that to and from a number of intervening points) and none of them is in anything like a satisfactory condition. It is the desire of the Commission to construct a permanent road, with concrete base, 20 feet in width. The expense will be borne jointly by the province, the urban termini, the towns en route and the counties through which it passes.

There is every probability that the present investigation will be followed by early construction. The materialization of a thoroughfare commensurate with the importance of the route, its commercial and pleasure traffic, and its scenic possibilities will be a most praiseworthy achievement on the part of the Commission, and a work that will render easier the conception of similar highway enterprises in other parts of the province. Undoubtedly the successful carrying out of this 35-mile piece of permanent road by the Commission will have a farther reaching effect on the good roads movement that has swept the Dominion than one is led to believe from a mere consideration of the benefits that will accrue to the local municipalities.

NOVEL METHOD OF ADJUSTING CROSS-HAIRS.

A novel method of adjusting cross-hairs is described by a recent contributor to a mining contemporary, and shows one of the ways in which tedious and costly delays may sometimes be avoided in survey work. Breakages of cross-hairs in a transit are not common in instruments fitted with finely drawn metalic cross-hairs, but there are sets in use made of spider webs which are apt to give trouble with the slightest provocation. While new webs may conveniently be found, a means of cementing them in position is not always available. The writer found himself with a broken set of cross-hairs when far from headquarters and without any suitable means of adjusting new ones. The circumstances necessitated emergency measures and as an experiment new webs were fastened in place with the membrane next to the shell of a bird's egg, the desired tension being given to the web with the fingers, a pair of dividers being unavailable.

After six weeks of hard service the transit was sent to the repair factory for general repairs and the spider webs were found in good shape.

STEAM TRACTOR vs. TEAM LABOR IN THE HAULAGE OF ROAD MATERIAL.

THE advantages of steam tractor haulage over team labor in road work is the subject of a useful paper that was read on June 6th, 1914, at a meeting of the Institution of Municipal and County Engineers by Mr. W. L. Gibson, one of the road surveyors of Perthshire County. The paper presented some detailed statements of working expenses of tractors, and comparisons of cost of team labor. Several are given as examples of a year's work, and the method of keeping the cost, while others show abstracts and analyses of the whole time during which the tractors had been at work. A portion of Mr. Gibson's paper is given below:—

No small debt is due to the efforts of the makers of road plant in having contributed to the great advance made in modern times in the methods of road-making and maintenance, and not least in the manufacture and transportation of all kinds of material necessary for road work. The ratepayers, no less than road surveyors, owe them a debt for carrying out the great work at the minimum of cost.

Within the last thirty years the methods of road construction and maintenance have been revolutionized. For generations, we may say, no advance was made on the methods taught by the Romans. Insufficient attention was paid to the importance of good roads, and up to a generation ago the work was carried out by rule-of-thumb methods by the local blacksmith, who supplied the plant, consisting chiefly of tools, and the farmer and the local carting contractor who did the haulage.

Under this primitive system of haulage most of the material had to be distributed into depots along the roadside, entailing extra expenditure in relifting while road-surfacing, and often there was difficulty in securing the necessary amount of team labor when required in isolated districts. But now road-making has been elevated from the position of mere empiric practice to the dignity of a science. The local blacksmith, the farmer, and the local carting contractor are being replaced by engineering experts, who undertake the supply of all kinds of plant necessary for the most improved methods of road-making and maintenance and haulage of material.

In no department is the advance more notable than in the substitution of mechanically propelled vehicles for team labor. It is the purpose of this paper to consider some of the advantages possessed by tractor haulage as compared with team labor, and to present observations which may be useful to road engineers and surveyors who contemplate the adoption of the more modern method. The writer was the first county road surveyor in Scotland to adopt tractor haulage, and having now had ten years' experience of this method of transportation is in a position to submit some observations on the subject, accompanied by detailed statements of actual cost and comparative analyses of tractor haulage as compared with team labor.

It has been said that "the bigger the load the cheaper the cost per ton-mile." If this be true, haulage by heavy traction engines is still the cheapest known method of road transport, so far as cost per ton-mile is concerned. Nevertheless, road surveyors must consider the question of damage to road by such haulage, and it is, therefore, necessary for them to keep the axle weights within reasonable limits. If heavy plant is used surveyors must make and maintain their roads to meet this class of traffic, which means that a large initial expenditure as well as a large annual cost would be required to meet the expense of road maintenance for their own traffic. If, on the other hand, light tractor haulage be employed there is a marked saving in the wear and tear to the road surface as contrasted with the heavier plant. We must, therefore, qualify our axiom that "the bigger the load the cheaper the cost per ton-mile" by this rider, "The heavier the axle weight the greater the damage to roads," with its corollary of increased cost for maintenance.

To secure at one and the same time cheapness of transport and minimum damage to roads must be the aim and ideal of the skilful road engineer, and it is my opinion that the two aims are irreconcilable so long as heavy traction haulage is employed. On other grounds the use of heavy traction haulage is to be deprecated.

The question of easy working—i.e., turning and shunting on narrow roads, and in quarries and loading banks of railway sidings—is an important consideration, for it must be remembered that in haulage of road material the primary object is to ply between the quarry or the railway siding and the scene of steam road-rolling operations without the intervention of roadside storing depots, and the inevitable and unnecessary cost of depositing and relifting the material.

Let us consider briefly team labor as regards cheapness of transport and damage to roads.

As far as the first is concerned, team labor cannot compete with tractor haulage. But the difference in wear and tear between light tractor haulage and team labor is a more problematical question, though my own experience goes to confirm me in the view that in some cases —if not in most—there is a difference here also in favor of the former. Indeed, I would go further and affirm that in some cases where the effect of the use of team labor was to cut through the surface and cause deep ruts, the substitution of tractors resulted merely in a depression, which was more easily remedied by making up with metal, and that continued use of the tractor and wagon over the metal in the course of haulage actually producing a much stronger road than before. It is naturally to the advantage of the carting contractor when hauling under contract, to load to the full, but the greater the profit the greater the damage to the road. Here, again, though, of course, in a much less degree, the two aims of the road surveyor cannot be fully secured by the employment of team labor.

In considering as to the adoption of mechanical haulage for West Perthshire, the author recognized that many of the roads were lightly constructed and narrow, and the quarries restricted in area and not easy of access. To adopt heavy traction engines would be almost impracticable for the work contemplated. Under the heavy motor-car regulations the use of self-contained vehicles, such as steam and petrol wagons is permitted; but from the author's point of view they have the disadvantage of the great axle weight on the hind wheels, which are, as a rule, in the case of the steam wagon, only about 3 ft. 6 in. diameter by 10 in. wide, carrying a legal weight—often, unfortunately, exceeded—of 8 tons.

This is quite an extravagant load for an ordinary country road. This type of vehicle has also another disadvantage to road authorities, in that the whole plant must remain idle while being loaded, whereas the tractor, using two tipping wagons, can be hauling the one while the other is loading. The output of this plant, therefore, is greater than that of a steam or petrol wagon, and the produce of the breaker, or tar-macadam mixer, or material from the railway siding, is delivered on the road in a more regular manner. While the higher speed of motor wagons on rubber tires may be considered an advantage for this type, in the present state of development of mechanical haulage, it appears that the cost of rubber tires alone, which could be calculated at not less than 4 cents per vehicle mile, and the cost of petrol where motor engines are used, make it impossible for this type to be compared with tractor haulage for the conveyance of road material, irrespective of the disadvantages already mentioned of the self-contained unit.

Notwithstanding rubber tires, the axle weight of this self-contained vehicle has proved to be very damaging to road surfaces where regular services of motor buses, heavy vans, etc., are in operation. It must, of course, be understood that where the roads are strong and smooth, and where facilities are provided for quick and cheap loading, the use of the fast-running motor wagon—either steam or petrol—may be seriously considered; but the author has yet to learn of instances in any way similar to his own work where this type of vehicle has been used at a cost which can be compared with his own experience.

The following points may be suggested for the consideration of road engineers and surveyors who may be contemplating the adoption of mechanical haulage:—

(1) Whether capable of carrying the maximum axle weight of the type of vehicle it is proposed to use.

(2) If the tonnage is small, or the distances unduly short, hire may be cheaper than purchase.

(3) There are still some districts where the prices of cartage are so cheap that purchase of plant may not at present be justified.

(4) Whether the work of the district suits the use of convertible tractor and roller. (The author finds the convertible tractor the most useful plant he has.)

(5) Whether the engine can be utilized for driving small stone-breaker for tar-macadam mixer, supplying steam for rock-drilling, pumping water out of quarries, removing accumulations of road scrapings, hauling tar-sprayers and boilers, or any of the many operations for which a surveyor requires power of any kind.

An analysis of Mr. Gibson's statement of expense for one of the tractors (3 tons) is given in Table I.

Table I.

No. of days hauling	239
Material hauled	5,357 tons
Material hauled per day	22.4 tons
Total distance travelled in 239 days	4,873 miles
Average distance travelled per day	20.4 miles
*Average cost per day	$6.25
Average cost per ton per mile	11.8 cents
Fuel consumed per day	3 cwts.

* This includes filling wagons, time of driver washing out boiler, cleaning, and repairs, with depreciation, etc., estimated at the rate of 22 per cent.

		In percentages.
Cost of carting by team labor	$3,191.13	100
Cost of steam tractor haulage	1,470.07	46
Total saving†	$1,721.06	54

† In addition, the tractor (after 8½ years' work) was sold for $720.00.

Another statement, covering a period of 8½ years, gives, as actual cost of this steam tractor haulage, $10,048.65, with an estimated cost of team labor, amounting to $21,495.00. Concerning another 5-ton tractor, convertible to a 7-ton roller, the figures given in Table II. apply.

Table II.

No. of days' hauling	142
Quantity of material hauled	3,158 tons
Average quantity hauled per day	22.23 tons
Average distance travelled per day	21.95 miles
Total distance travelled in 142 days	3,118 miles
Average cost per day, including filling into wagons and time of driver, washing out boiler, cleaning and repairing	$5.80
(Depreciation and tear and wear included at the rate of 15 per cent.)	
Average cost per ton mile	10.28 cents
Fuel consumed per day	3 cwt.

		In percentages.
Cost of carting by old contract system	$1,978.04	100.0
Cost of motor haulage	821.86	40.8
Total saving	$1,156.18	59.2

Note.—This tractor, being convertible to a 7-ton road roller, was engaged at rolling operations for 141 days at an average cost of $4.58 per day.

This tractor, during a period of six years, effected a saving of over $4,644.00, allowing for depreciation at the rate of 15 per cent. per annum, when compared with the estimated cost of team labor over that period.

ONTARIO ROAD SURVEY.

Motor surveys of the 18 Ontario counties where highway systems have not yet been organized, have been commenced under the auspices of the Good Roads Commission and directed by W. A. Maclean, Provincial Highways Engineer. Three parties will go north, east and west; and the fourth will cover the central district. The work is to be handled by trained engineers and surveyors. The first group will cover Ontario, Victoria, Peterboro, Northumberland and Durham; the second, Essex, Kent, Elgin and Lambton; the third, Bruce, Huron, Grey and Dufferin; the fourth, Dundas, Stormont, Glengarry, Prescott and Russell. A report will be made to the Government as to the best method of making the various township routes co-ordinate with the county market roads. The market and shipping points in all the counties will be ascertained as well as the population, the volume of traffic on the roads, the location of building materials, and the estimated cost of construction.

The department has plans of every township in the province in preparation, and these will be used in an effort to systematize the roadway system throughout Ontario.

The report of the chief of the Vancouver, B.C., fire department shows that its equipment consists of 18 pieces of automobile apparatus—two ladder trucks, eight hose wagons, one combination hose and chemical wagon, five chemical engines, one chief's car, and one assistant-chief's car; one self-propelled steam fire engine, 14 horse-drawn apparatus—four steam engines, two ladder trucks, five hose wagons, one combination hose and chemical wagon, and two chemical engines; and 31 horses. Owing to the city's recent rapid growth, it has been enabled in purchasing to secure apparatus of the latest improved makes, and in consequence has an excellent equipment for a city of its size and population. The first automobile apparatus was purchased in 1908, and since that time whenever old apparatus was replaced or the demands of the city required increased equipment, this class of apparatus has been added.

DESIGN OF STEEL TURNTABLE.

It is only when one attempts to find some data on the subject of turntables and their design that he discovers the lack of material on this phase of structural engineering. Text books practically ignore the subject, and data in the engineering periodicals is correspondingly scarce.

In *The Canadian Engineer* for November 21st, 1912, an article appeared dealing with the design of turntables for heavy locomotives. Some years previous the "American Engineer and Railway Review" published an article, written by a Mr. Greenleaf, a designer and builder of bridges. Later the "Engineering Record" contained in its columns an article chiefly commentary on the lack of knowledge on the subject. The latest information to appear respecting the design of turntables in that contributed by E. C. White, C.E., to the "Cornell Civil Engineer." Mr. White is an instructor of civil engineering at Cornell University. The following is from his treatment of the subject:

The early turntables were made of wood, and in general were quite unsatisfactory. Cast iron was later substituted for wood. The cast iron turntables were made in two pieces which were tied together by strips of iron set into the top. These were in turn replaced by the modern steel structure, thus keeping pace with the development on structural design. It is in the treatment of the modern steel turntable that data is so scarce. Practically the only data on the subject that was of any use to the author in making his design, outside of ordinary mechanics, was a stress diagram shown in "American Engineering and Railway Review."

The size and length of turntable to be used is governed by the maximum weight and length of the engines now used, with proper allowance for probable future increase. An ample length at the present time is 75 feet to 100 feet; but few of the longer types are now in use. The tendency, however, is toward gradual increase in size and length of locomotive, necessitating longer and heavier turntables.

The locomotive turntable may be said to be a swing bridge on a centre bearing. The bearing may be a nest of rollers, ball bearings, or a bronze disc. The design here shown is of the latter type, with Cooper's Class E 55 live loading. The design is quite similar to that of a plate girder with somewhat varying kinds of stresses depending on the position of the live load upon the structure. Under dead load and under balanced live load stresses the girders act as two cantilevers joined at the centre. When the load is moving onto the structure it may be treated as a continuous beam on two supports, or to produce the greatest stresses, as a simple beam from end to centre supports. In a full determination of the stresses the effect of the engine coming onto the structure must be considered. As an example, if an engine with trucks is considered, the stress will be found to be less than that produced by a switching engine as it comes on. Thus the stresses under this condition of loading, i.e., to produce the worst possible conditions, should be taken under wheel two. The results of these investigations are shown on the stress diagram in Fig. 1. The position of the wheels in the plate apply to the moment or stress diagram under the balanced condition, and also to the shear diagram under the same condition of loading. It will be noticed that under a balanced load for this type of loading the

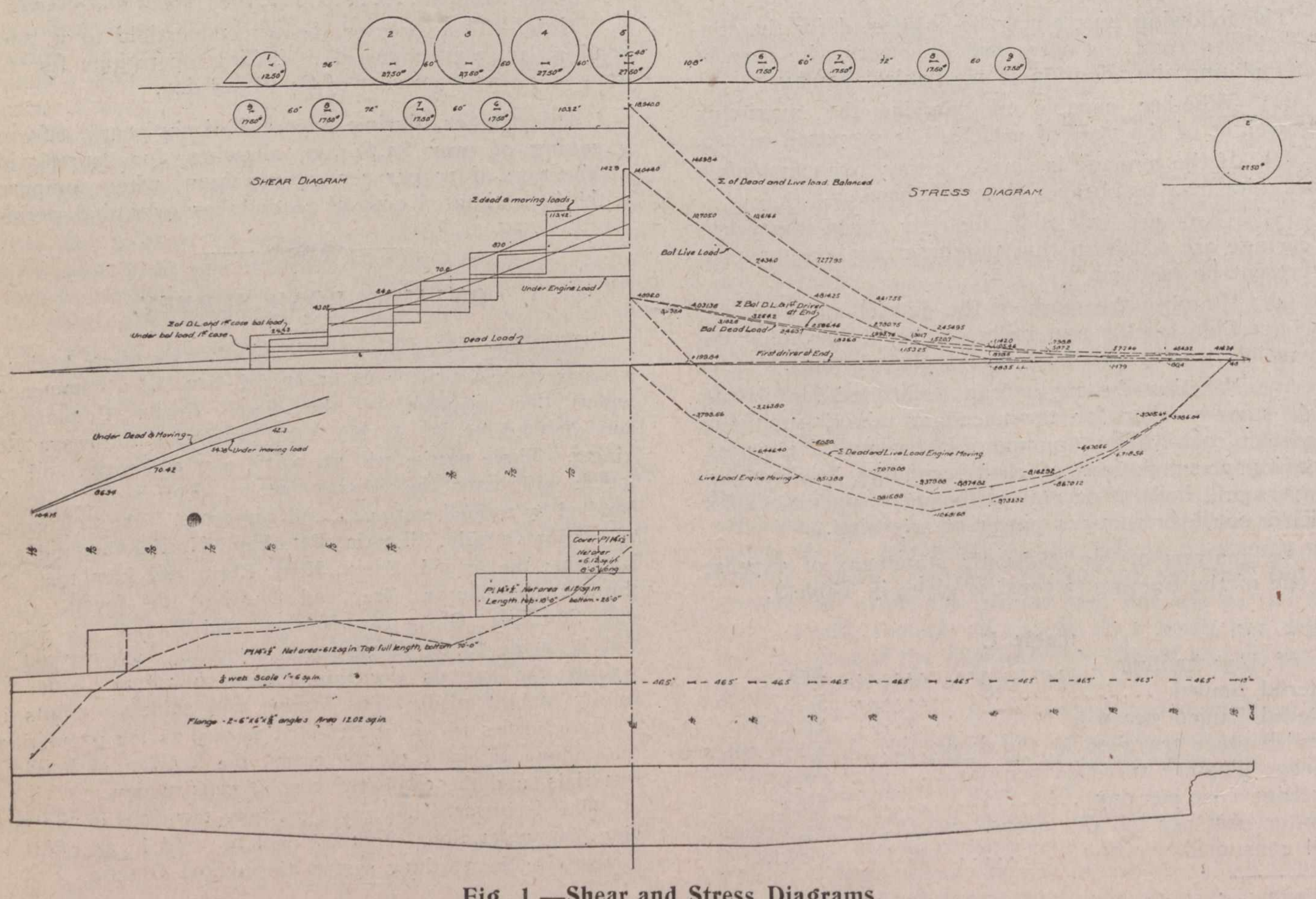

Fig. 1.—Shear and Stress Diagrams.

tender produces maximum stress. Also maximum stress is caused by both engine and tender, and in places, by moving load. The lower part of this plate shows flange joints or plates. The details of the lateral system, are shown in Fig. 3. Fig. 4 shows a section through the bronze disc centre bearing.

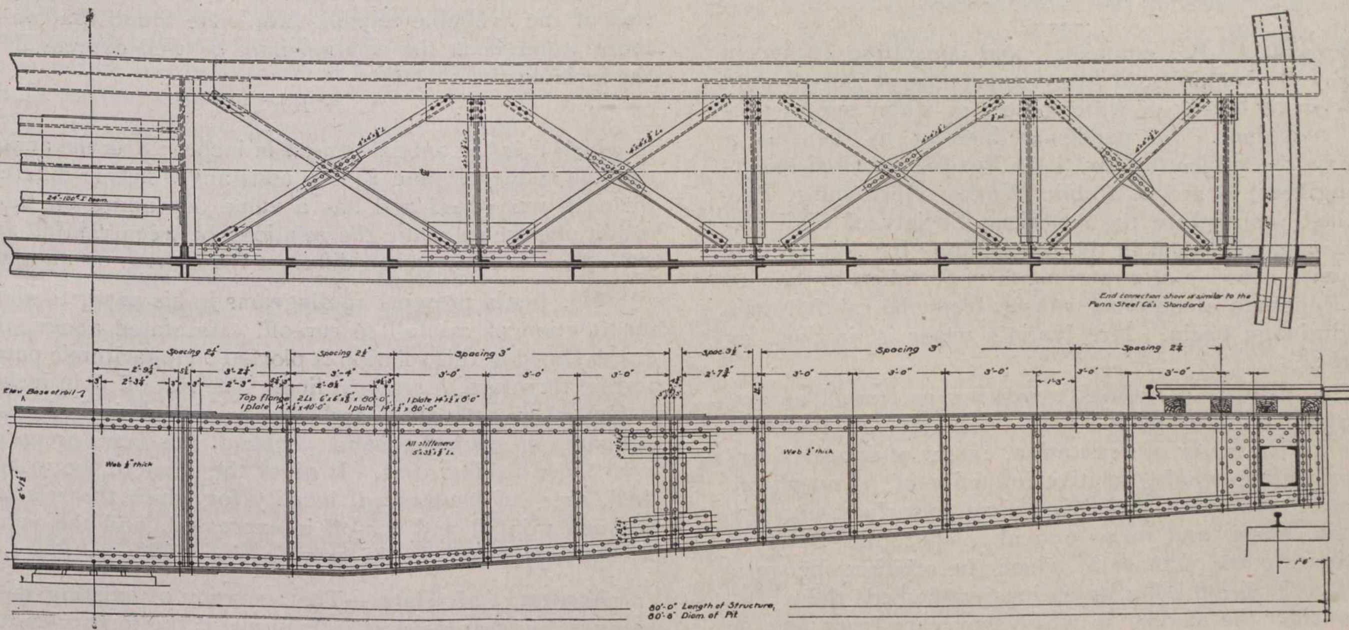

Fig. 2.—Details of Steel Turntable.

area required from point to point, and the make-up of the section used.

Having found the stresses and shear values, the next step in the design is the same as for a plate girder. As no impact is allowed except at the ends (where it was taken as 100%) the unit shearing stress used was 6,000 pounds per square inch, and a unit tension and compression of 10,000 pounds per square inch. The details are

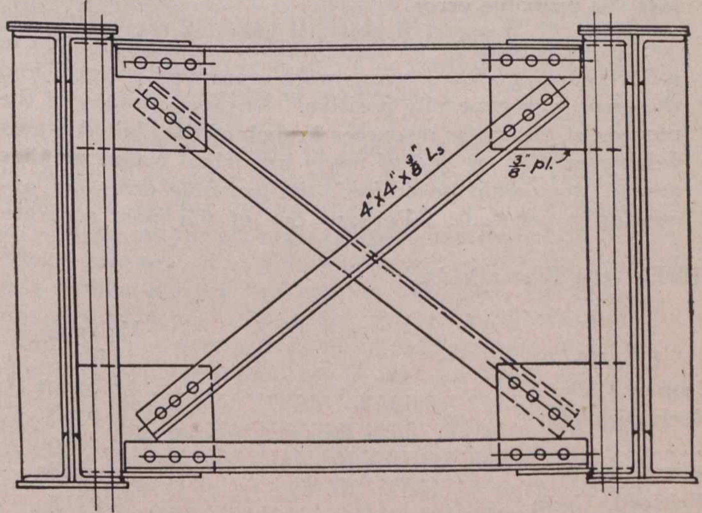

Fig. 3.—Lateral System.

shown in Fig. 2. The lateral stresses are indeterminate and angles are used according to standard practice, in plate girder design, with full section developed at all

The assumed dead load was taken as that given by the formula ($w = 10\ l + 100$) for a deck plate girder, using one-half the length of turntable as l. This value

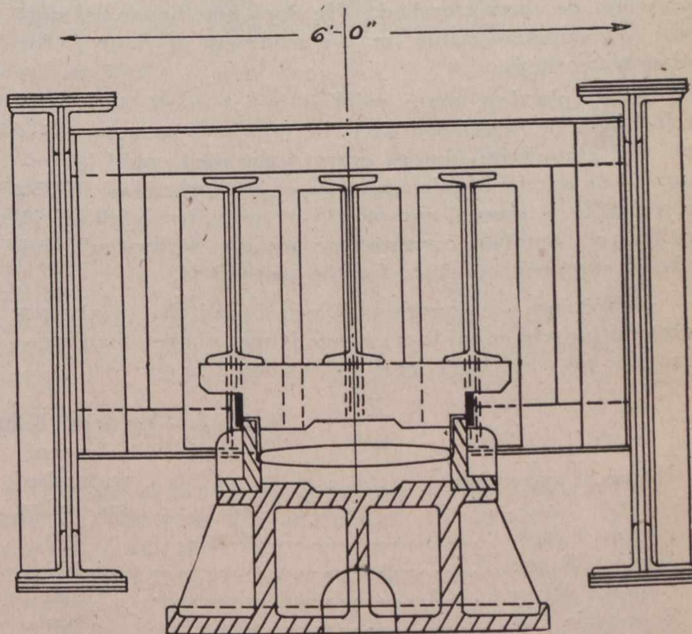

Fig. 4.—Section Through Bronze Disc, Centre Bearing.

checked slightly over the actual computed weight of the completed design, the difference being insufficient to affect the design.

Recently the City Council of Toronto unanimously adopted a minimum rate of wages of 25 cents per hour, for all organizations engaged upon civic contracts. The recommendation involves the recognition of a higher standard of wage for workmen engaged by the city. The present minimum rate of 18 cents per hour was established many years ago, since which time the cost of living has increased continuously from year to year.

Within a range of 10 miles of Lethbridge, a discovery of mica, which is stated to be almost pure, has been made by L. P. Tuff, a prospector, formerly of Montana. In some instances, the samples shown are several inches thick, and are perfect in cleavage. Specimens have been sent to the Ottawa Government for examination. Mr. Tuff is also of the opinion that silica sand also exists in the neighborhood of the mica formation.

DERIVATION OF RUN-OFF FROM RAINFALL DATA IN WATER SUPPLY AND WATER POWER PROJECTS.

HYDRAULIC, municipal, and consulting engineers fully comprehend the importance of run-off data in the study of water power or water supply propositions. Of particular interest to them is a paper on the subject by Mr. J. D. Justin, principal assistant engineer, Board of Public Works, Harrisburg, Pa., read last year before the American Society of Civil Engineers and published in the proceedings for August. It deals with a series of experiments undertaken by him to solve a method of deriving run-off from the rainfall data of a drainage basin. Mr. Justin's paper is, in part, as follows:

The quantity of rainfall appearing as run-off on any watershed is governed by many conditions, chief among which are character of vegetation, extent of forest covering, prevailing winds, relative humidity of atmosphere, barometric pressure, percentage of water surface, geology of basin, slope, and mean annual temperature. Before investigating the manner in which the relations between rainfall and run-off differ on various watersheds the writer will consider the manner in which they vary from year to year on any one watershed.

George W. Rafter showed that the relation of rainfall to run-off on a watershed could often be expressed as an exponential equation. For the upper Hudson he gives the two equations $P^2 = 84.5\ R$ and $P^{1.77} = 34.3\ R$; P being the annual precipitation and R the annual run-off, in inches, on the watershed. He does not, however, suggest any constant value for the exponent of P or R for other watersheds.

After plotting many rainfall and run-off data, the writer became convinced that the relations between rainfall and run-off on almost every watershed could be expressed by a logarithmic equation, of the form, $C = K\ R^n$, in which C = annual run-off, R = annual rainfall, K is an abstract number, constant for any one watershed, and n is an exponent constant for the watershed.

In solving the equations it was found that n always came out nearly equal to 2; hence it was chosen as a constant for all watersheds and always equal to 2.

The writer then plotted, on logarithmic cross-section paper, using annual run-off in inches as ordinates and annual rainfall in inches as abscissas, a considerable portion of the available reliable data. He found that on all these watersheds the relation may be well expressed by the formula:

$$C = KR^2,$$

in which C is the annual run-off in inches; R is the annual rainfall in inches, and K is a constant which is different for each watershed and has a value depending on those conditions which make the relations between rainfall and run-off on one watershed different from those on another.

Mr. Justin presents 19 diagrams in his paper to show the relation of rainfall to run-off. As stated above, the graph showing this relation is plotted on logarithmic paper and is, therefore, a straight line. The run-off C in inches is plotted as ordinates, and the rainfall R in inches as ordinates on each diagram. Table I. has been prepared from these 19 diagrams. It gives the name of the watershed, area of watershed, locality for which the relation between rainfall and run-off is expressed, and the value of the coefficient K in the formula $C = KR^2$.

Accuracy of Data.—The accuracy of existing data does not justify precision. On some of the territories for which diagrams were prepared there is one rainfall station per 1,000 sq. miles of watershed. In the computation of run-off a discrepancy of 1 or 2 ins. is not worthy of discussion. In most cases one can safely assume a probable error of 10 per cent. in the observed rainfall for any one year for most watersheds. The error in any individual record at a certain station is undoubtedly less than this in most cases, but when several rainfall stations are combined to give the rainfall for an entire watershed the probable error is increased. In general, the larger the number of rainfall stations on a watershed the less the probable error.

Run-off records are usually more accurate, but up to a few years ago few streams were accurately gauged, and the error was generally positive. At present many of the records of the water resources branch of the United States Geological Survey and of many municipal water supplies are all that could be desired, the probable error not exceeding 5 per cent. Perhaps one of the most accurate

Table I.—Value of K for 19 Eastern Watersheds.

Name of watershed.	Area of watershed, sq. miles.	Locality.	Value of K.
Esopus Creek	239	Esopus Weir	0.01292
Hudson River	4,500	Mechanicsville	0.0118
Genesee River	1,070	....	0.00890
Schoharie	240	Prattsville, N.Y.	0.01485
Connecticut River	10,234	Hartford, Conn.	0.0117
Sudbury River	75.2	....	0.0109
Connecticut River	3,300	above Orford, N.H.	0.016
Ohio River	23,820	above Wheeling, W. Va.	0.0131
Susquehanna River	9,810	above Wilkesbarre, Pa.	0.0149
Tohickon Creek	102.2	....	0.0115
Perkiomen Creek	152	....	0.0105
Croton River	338.8	above New Croton Dam	0.0094
Rondout Creek	105	Honk Falls and Lackawack	0.0130
Susquehanna River	28,030	above Harrisburg, Pa.	0.0135
Potomac River	11,043	....	0.0119
Lake Cochituate	18.9	....	0.0092
Nashua River	118	Clinton, Mass.	0.0116
Passaic River	822	Dundee Dam	0.0115
Neshaminy Creek	139.3	....	0.0099

records for purposes of comparison between rainfall and run-off is that on the Esopus watershed (area 239 sq. miles) of the Catskill water supply system of New York City. On this watershed there have been maintained from 8 to 13 well-distributed rainfall stations. The measurement of run-off has been made at a concrete weir especially built for the purpose.

The relation between rainfall and run-off on this watershed is shown in Table I. All the points in the diagram fell almost precisely on the curve, $C = 0.01292R^2$.

When rainfall and run-off data are plotted on diagrams the probable error in using the resulting curves in mass curve storage studies is much reduced.

Effect of Proportion of Water Surface.—The writer believes that many hydrologists have exaggerated the importance of the effect of water surfaces on a watershed in decreasing the quantity of run-off. Aside from regulating the distribution of the run-off throughout the year, the effect of any ordinary proportion of water surface is so small as to be negligible.

This is well shown by Mr. Rafter. In discussing the percentage of water surface on the Croton watershed (3.56 per cent.) he says:

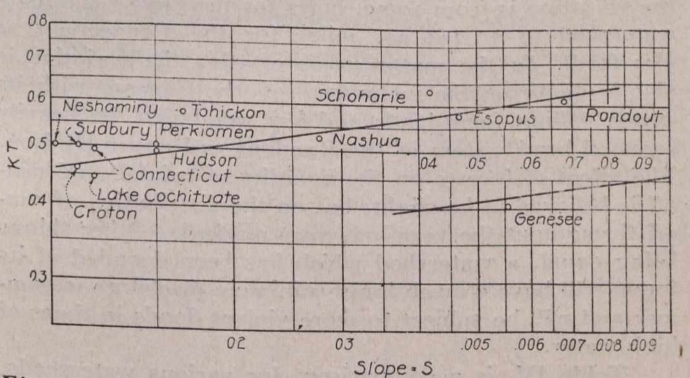

Fig. 1.—Diagram Showing Relation Between K, T and S. (K = Const. in Eq.; $C = KR^2$; T = mean annual temp.; S = slope of watershed.)

"It may at first thought be imagined that these large water surfaces exposed to evaporation have considerably increased the ground evaporation over the entire catchment. When, however, one considers that it is only the difference between what a water-surface evaporation and what a ground-surface evaporation would be, the difference is seen to be not very much. For instance, assuming the water-surface evaporation at 36 ins. per year and the ground-surface evaporation at 27 ins. per year, the difference becomes 9 ins. With 12 square miles of water surface in 1900, giving 3.56 per cent. of the whole, the excess of water-surface evaporation over ground-surface evaporation is 0.32 in., a quantity which is so far within the limit of possible error in other directions as to be negligible.

Grouping of Data by Water Years.—In the comparison of rainfall and run-off grouped by water years, beginning October 1, December 1, or some other date, it is frequently observed that on any watershed certain years, having the same recorded rainfall, have recorded run-off differing by from 1 to 4 ins.

In the 19 diagrams, although most of the points fall on or near the curves represented by the equation, $C = KR^2$, there are some which are at some distance from the curves. Noting this condition, many claim it as proof that there is no definite relation between rainfall and run-off. In reality, the apparent discrepancy is due merely to variation from year to year in ground-water conditions on the date arbitrarily assumed for beginning the water year. The fact that a point does not fall on the curves does not necessarily show that the observations are at fault, but in most cases it does indicate that the date of beginning the water year assumed for the watershed is not the true one for that particular year.

It is an error to consider the water year as a hard and fast division of time. Many of the points which in the diagrams plot some distance from that curve would fall directly on or very near it, had the first of the preceding or succeeding month been used for beginning the water year.

The true water year does not begin or end at any particular date, but should be regulated so that ground-water conditions are nearly constant on the dates selected for the beginning of such years. It is believed that if this could be done all points for which the data are accurate would fall on or near the curve represented by the equation, $C = KR^2$.

Owing, however, to the almost utter lack of data on ground-water levels, it is impracticable to adopt this method of division. Especially in the study of large storage propositions the apparent discrepancies will balance each other and will not affect the conclusions.

Table II.—Values of K, T, S, and KT, for Various Watersheds.

Watershed	K—in the formula, $C=KR^2$	T—Mean annual temperature.	S—Slope of watershed.	KT=K×T.
Lake Cochituate	0.0092	48.5	0.0116	0.446
Sudbury	0.0109	46.0	0.0119	0.501
Hudson	0.0118	41.9	0.0149	0.494
Rondout	0.0130	47.0	0.0664	0.611
Croton	0.0094	49.0	0.0110	0.460
Esopus	0.01292	44.5	0.0468	0.575
Passaic	0.0115	48.4	0.00977	0.555
Genesee	0.0089	45.5	0.00554	0.405
Neshaminy	0.0099	50.6	0.0101	0.500
Perkiomen	0.0105	48.6	0.0148	0.511
Tohickon	0.0115	49.6	0.0166	0.571
Nashua	0.0116	45.0	0.0278	0.522
Connecticut	0.0117	42.0	0.0117	0.490
Schoharie	0.01485	42.3	0.0367	0.630

Manner in Which the Relations Between Rainfall and Run-off Vary from One Watershed to Another.—It has frequently been observed that, other things being equal, a steep watershed will have a greater run-off for the same rainfall than a flat one. The water, staying on the watershed a shorter length of time, has less chance to evaporate. Mr. Vermeule has shown successfully the great influence which the mean annual temperature of a watershed has on the relation of rainfall to run-off.

These two elements, slope and mean annual temperature, the writer believes are, in general, the chief factors determining the manner in which the relation between rainfall and run-off vary from one watershed to another. Hence he will use them in determining the value of *K*.

The slope of a watershed may be defined as the difference in elevation between the highest and lowest points divided by the square root of the area.

The proper value for the mean annual temperature of a watershed can generally be determined by a study of the data published by the United States Weather Bureau in the "Summary of Climatological Data for the United States by Sections." In using these data it sometimes happens, especially on mountainous watersheds, that all the observations are at stations in the valleys. On such a watershed the mean annual temperature frequently varies directly with the elevation. In such a case a practical method of determining the mean annual temperature would be as follows: (1) Take the average temperature at the stations. (2) The average elevation for the same stations. (3) The average elevation of the watershed = the elevation of the highest point plus the elevation of the lowest, divided by 2. (4) Take the difference between the average elevation of the stations and the average elevation of the watershed. (5) Multiply this by the mean difference in temperature per foot of increase in elevation. (6) Finally, subtracting this from the average temperature at the stations will give the mean annual temperature of the watershed.

In Fig. 1 T is the mean annual temperature; S is the slope of the watershed, determined as previously described, and K is the constant in the equation, $C = K R^2$.

It was found that for several watersheds having about the same value of S, K varied very nearly as the first power of T. In Fig. 1 the values of KT (the product of K and T) have been plotted as ordinates and the values of S as abscissas.

Table II. gives the values of K, T, S, and KT for various watersheds.

Picking values off the logarithmic curve in Fig. 1 and solving the equation,

$$K T = P S^x,$$

P being the unknown coefficient and x the unknown exponent, we have, for the equation of the curve, $K T = 0.934\ S^{0.155}$

$$\text{but } C = K R^2,$$

$$\text{whence } C = 0.934\ S^{0.155} \frac{R^2}{T}$$

which is the general formula for the relation of run-off to rainfall.

C = Annual run-off, in inches, on the watershed;

R = Annual rainfall, in inches, on the watershed;

S = Slope of the watershed, equals the elevation of the highest point minus the elevation of the lowest point, divided by the square root of the area;

T = Mean annual temperature of the watershed, in degrees, Fahrenheit.

For convenience in using the formula, Table III., giving values of $S^{0.155}$ was computed. By using this table the formula is easily solved. Thus, for the Rondout watershed, $T = 47$, mean $R = 46.6$, and $S = 0.0664$. From Table III. for $S = 0.0664$, we have $S^{0.155} = 0.658$. Hence the expression for the mean annual run-off of the Rondout becomes

$$C = 0.934\ S^{0.155} \frac{R^2}{T} = 0.934 \times \frac{0.658 \times 2180}{47} = 28.5 \text{ ins.}$$

In this case the computed mean annual run-off is just equal to the actual.

The character of the various watersheds considered in the derivation of the formula varies widely. By reference to Table II. it is seen that the slope and the mean annual temperature vary between wide limits. The slope of the Genesee is 0.0054, and that of the Rondout is 0.0664. The mean annual temperature of the Hudson is 41.9 and that of the Neshaminy is 50.6 degrees. In area the variation is from 19 sq. miles for the Lake Cochituate watershed to 10,234 sq. miles for the Connecticut at Hartford. In the matter of forestation the variation is also large, from the watershed of the Genesee with its gently rolling farm lands and few woods, to the heavily forested head waters of the Rondout and upper Hudson. The effect of forests on the quantity of rainfall and run-off is believed to be slight, but on the distribution of run-off throughout the year it is very marked. Other things being equal, a watershed which has been denuded of its forest will have a much lower minimum discharge in summer and will be subject to more violent floods in times of high water.

Table IV. is a comparison, for various watersheds, of the run-off computed by the formula and the recorded observed run-off.

It will be noticed that the closest agreement between the computed and the observed run-off is for the water-

Table III.—Values of $S^{0.155}$ for Various Values of S. To be Used in Solving the Formula, $C = 0.934\ S^{0.155} \frac{R^2}{T}$.

S.	$S^{0.155}$.	S.	$S^{0.155}$.	S.	$S^{0.155}$.	S.	$S^{0.155}$.	S.	$S^{0.155}$.
0.002	0.382	0.0070	0.464	0.0093	0.484	0.026	0.567	0.049	0.628
0.003	0.406	0.0071	0.465	0.0094	0.484	0.027	0.570	0.050	0.630
0.004	0.425	0.0072	0.466	0.0095	0.485	0.028	0.574	0.051	0.632
0.005	0.440	0.0073	0.467	0.0096	0.486	0.029	0.578	0.052	0.634
0.0051	0.442	0.0074	0.468	0.0097	0.487	0.030	0.582	0.053	0.636
0.0052	0.443	0.0075	0.469	0.0098	0.488	0.031	0.584	0.054	0.638
0.0053	0.444	0.0076	0.470	0.0099	0.489	0.032	0.587	0.055	0.640
0.0054	0.445	0.0077	0.471	0.010	0.490	0.033	0.590	0.056	0.641
0.0055	0.446	0.0078	0.472	0.011	0.496	0.034	0.592	0.057	0.642
0.0056	0.447	0.0079	0.473	0.012	0.502	0.035	0.595	0.058	0.644
0.0057	0.448	0.0080	0.474	0.013	0.509	0.036	0.597	0.059	0.646
0.0058	0.449	0.0081	0.475	0.014	0.514	0.037	0.600	0.060	0.648
0.0059	0.450	0.0082	0.476	0.015	0.520	0.038	0.602	0.061	0.650
0.0060	0.451	0.0083	0.477	0.016	0.526	0.039	0.604	0.062	0.652
0.0061	0.453	0.0084	0.477	0.017	0.531	0.040	0.606	0.063	0.653
0.0062	0.454	0.0085	0.478	0.018	0.536	0.041	0.609	0.064	0.654
0.0063	0.456	0.0086	0.479	0.019	0.541	0.042	0.612	0.065	0.656
0.0064	0.458	0.0087	0.479	0.020	0.545	0.043	0.614	0.066	0.658
0.0065	0.459	0.0088	0.480	0.021	0.549	0.044	0.616	0.067	0.659
0.0066	0.460	0.0089	0.481	0.022	0.552	0.045	0.619	0.068	0.660
0.0067	0.461	0.0090	0.482	0.023	0.556	0.046	0.621	0.069	0.661
0.0068	0.462	0.0091	0.482	0.024	0.560	0.047	0.624	0.070	0.662
0.0069	0.463	0.0092	0.483	0.025	0.563	0.048	0.626		

sheds where the data are the most reliable—for instance, the Hudson, Genesee, Esopus and Croton. Furthermore, where there is any material variation the computed quantities are generally less than the observed. Accordingly, the use of the formula for estimates of flow will be likely to give quantities which are less than the actual, rather than those that are more; that is, the error is on the side of safety.

The formula is also applicable for the computation of run-off for individual years. For illustration, take two watersheds—the Hudson and the Esopus. In the case of the Hudson, $S = 0.0149$ and $T = 41.9$, and the formula becomes

$$C = 0.934 \frac{0.520\ R^2}{41.9},$$

$$\text{or } C = 0.0116\ R^2.$$

In the case of the Esopus, $S = 0.0468$ and $T = 44.5$, and the formula becomes

$$C = 0.934 \frac{0.623\ R^2}{44.5} = 0.0130\ R^2.$$

These two illustrations serve to show the degree of accuracy that may be expected in the use of the formula when the rainfall and temperature data are fairly accurate.

The Supply of Missing Records.—It sometimes happens that only two or three years of good run-off records have been kept on a watershed, and that the rainfall records are available for a number of years. In such a case the record may be extended in the following manner:

Table IV.—Comparison Between Observed Run-off and Run-off Computed by the Formula, $C=0.934\ S^{0.155} \frac{R^2}{T}$.

Watershed.	Mean annual rainfall observed, in inches.	Mean annual run-off observed, in inches.	Mean annual run-off computed, in inches.	Difference, in inches.
Rondout	46.7	28.5	28.5	0
Sudbury	45.7	23.6	21.3	2.3
Connecticut	43.5	23.8	21.1	2.7
Lake Cochituate	47.3	20.4	21.5	1.1
Esopus	48.3	30.1	30.4	0.3
Nashua	48.7	25.4	28.2	2.8
Tohickon	48.4	26.7	23.5	3.2
Croton	49.3	22.6	23.0	0.4
Perkiomen	47.6	23.6	22.6	1.0
Passaic	46.8	25.3	20.7	4.6
Neshaminy	47.8	22.8	20.7	2.1
Genesee	40.4	14.3	14.9	0.6
Muskingum	42.4	15.1	13.3	1.8
Hudson	44.5	23.5	22.9	0.6

Plot on logarithmic cross-section paper points for the two or three years of known run-off, using rainfall abscissas and run-off as ordinates. Compute the run-off for several other years, using the formula

$$C = 0.934\ S^{0.155} \frac{R^2}{T}.$$

Plot the corresponding points. Then draw a straight line parallel to the line $Y = X^2$, among these points giving greater weight to the observed data. This line will be represented by the equation $C = K\ R^2$. Having this curve, the run-off for any year may be read off, using the rainfall as argument.

Application to the Mass-Curve.—Engineers are frequently called on to construct reservoirs of considerable capacity on watersheds where accurate run-off data are lacking. For the determination of the necessary capacity of a proposed reservoir the mass-curve is the accepted method. Having given a watershed without run-off data, but with rainfall records available, a satisfactory mass-curve may be constructed by using the formula

$$C = 0.934\ S^{0.155} \frac{R^2}{T}.$$

The values of S and T are generally easy of determination for any particular watershed.

In using this formula for the construction of a mass-curve it is applied to the rainfall for each month consecutively, and the resulting monthly run-off is used in constructing the mass-curve in the usual manner. Of course, using the formula in this way, the resulting computed run-off for individual months will often be very different from the actual; but in the study of large water power or water supply projects, where water must be stored for several months, this will not affect the conclusions as to the necessary size of the reservoir for a given draft.

The most expeditious method of applying the formula for this purpose is as follows:

Compute several values of C for given monthly values of R. Plot these computed values of C, with the corresponding values of R, on logarithmic cross-section paper. The points will lie in a straight line. This logarithmic curve may then be used for picking off values of C for given values of R.

Two mass-curves for the Croton watershed were plotted by the author. The upper curve was obtained from the recorded run-off data, and the points on the lower curve were computed by the formula, $C = 0.934\ S^{0.155} \frac{R^2}{T}$. It was noticed that the cumulative totals of the observed run-off for 37 years differs from the computed by about 3 per cent., the computed being less than the observed. A draft on the watershed of 1.65 ins. per month, or 320,000,000 gals. per day, was assumed and applied to the curves. The greatest depletion shown on the curve of observed run-off was 14.2 ins., and the mass-curve of computed run-off showed a depletion of 18 ins., a difference of 21 per cent. This difference, however, is on the safe side. It is customary to build reservoirs with a capacity of from 20 to 30 per cent. in excess of the depletion shown by the mass-curve. Had there been no run-off data in existence on the Croton watershed, a reservoir of sufficient capacity could have been decided on from a study of the computed mass-curve.

In a similar manner, two mass-curves were plotted for the Nashua watershed, one from the observed run-off data and the other from computed run-off data obtained by using the formula. A draft of 1.852 ins. per month, or 125,000,000 gals. per day, was assumed. The greatest depletion on the curve of observed run-off was 10 ins., and on the curve of computed run-off, 12 ins., an error which is again on the safe side.

The mass-curves of observed run-off and of computed run-off were plotted for the Esopus watershed. A draft of 1.825 ins., or 250,000,000 gals. per day, was assumed. For the curve of observed run-off, the greatest depletion was 8.2 ins., and, for the curve of computed run-off, the greatest depletion was 7.5 ins. The difference, 0.7 ins., though not on the safe side, is so small that it could not affect materially the size of the reservoir decided on.

Conclusions.—The writer is not of the opinion that the gauging of streams and the accumulation of run-off data should be abandoned, and the method herein described established in their place. Accurate run-off data are scarce, and engineers need far more. These methods and formulas are applicable to watersheds where run-off data are meager or lacking, and it is believed that they will give more reliable results than those now generally in use.

The formula, $C = 0.934\ S^{0.155} \frac{R^2}{T}$, is, the writer believes, applicable to the Eastern United States, and, in general, should give results within 10 per cent. of the true run-off. In applying the formula to other watersheds, the writer would advise caution. Although the formula is believed to be general, it is possible that, if more data were at hand on the relation of run-off to rainfall, the value of the constant (here 0.934) and of the exponent of S (0.155) might vary somewhat in other sections of the country, where there is a marked difference in climatic conditions.

Table V.—Comparison Between Observed and Computed Run-off for Various Years, for the Upper Hudson.

Year ending December 1st.	Rainfall observed, in inches.	Run-off observed, in inches.	Run-off computed by formula, in inches.	Difference, in inches.
1888	43.9	23.6	22.3	1.3
1889	43.0	21.7	21.5	0.2
1890	50.4	28.9	29.5	0.6
1891	43.0	20.6	21.5	0.9
1892	53.9	33.1	33.5	0.4
1893	42.2	21.9	20.8	1.1
1894	42.0	19.4	20.4	1.0
1895	36 7	17.5	15.6	1.9
1896	45.2	23.6	23.7	0.1
1897	46.5	26.2	25.0	1.2
1898	48.5	27.1	27.3	0.2
1899	35.8	19.5	14.9	4.6
1900	45.4	20.7	23.8	3.1
1901	42.6	21.9	21.0	0.9

Of course, if this formula is applied to the rainfall for some particular month it will not give the true run-off. It has been shown, however, that it may be used for obtaining monthly run-off, and that the mass-curve when plotted gives depletions which do not differ materially from those obtained when the observed monthly run-off is used in constructing it.

At first sight, the application of the formula may appear to be complicated, but, by using Table III., which gives the values of $S^{0.155}$, it is simple; and if logarithmic plotting is utilized, as suggested, it becomes merely a matter of reading off the curve.

A recent report from Montreal states that a method of converting titanium ore into high grade steel has been discovered by Dr. G. D. Condle, of Montreal, who has been working on the solution of this process for 5 years. It is stated that a new industrial corporation is being formed with a nominal capital of $25,000,000 to take over the rights and all the interests of the new steel process; and a plant is to be set in operation where high grade steel will be produced and sold at about $100 per ton.

A NOTABLE GATHERING OF ENGINEERING EDUCATORS.

On June 23rd there assembled at Princeton, N.J., a group of some two hundred men upon whom largely depends the character of the engineers of this continent for many years to come. Here, for four days, enjoying the freedom of Princeton University, the Society for the Promotion of Engineering Education conducted its twenty-second annual convention.

The choice of meeting place was most happy. In historic Nassau Hall, named in honor of King William the Third, "a branch of the illustrious House of Nassau," and which opened its doors to students in 1756, the executive offices of the convention were located. Regular sessions were held in the Palmer Physical Laboratory, while the annual dinner took place in the magnificent new Graduate College, situated among green fields, three-quarters of a mile to the south of the main group of buildings.

It was a gathering at once representative and diverse. Engineering professors from Boston to Seattle, from Toronto to Mississippi, participated in the deliberations. Veterans like William Kent and Mansfield Merriman rubbed shoulders with vigorous young enthusiasts like Henry H. Norris, of Cornell; Dugald C. Jackson, of "Tech." and F. L. Bishop, the "Boy Dean" of Pittsburgh. Here, from day to day, was witnessed the graciousness and tact of President Anthony, the versatility and precision of Karapetoff and the power and picturesqueness of Franklin, of Lehigh. Silent, but contributive of weight to the deliberations, were Turneaure, of Wisconsin; Talbot, of Illinois, and Ketchum, of Colorado.

On Tuesday at 2.30 the meeting was formally opened with an address of welcome by John Grier Hibben, president of Princeton University. In a few earnest words he indicated the necessity of engineers being scientific, rather than technical, being searchers for the causes of the facts and not merely for the facts themselves. The engineer cannot afford to be a pragmatist—a judger of things in accordance with the way they turn out—but must know beforehand what the result will be and must be able to satisfy his client that he does know.

The receipt and consideration of reports of committees and a meeting of the delegates of the institutional members constituted the formal business of the first day.

At five o'clock a reception to the delegates was tendered by President and Mrs. Hibben at "Prospect," the official residence of the president.

In the evening an informal "get-together" smoker was held at the Nassau Club, facetiously described by one member as a club for gentlemen and members of the Faculty of Princeton University.

The formal welcome of the State of New Jersey was extended on Wednesday morning by the Hon. Jas. F. Fielder, Governor of the State.

With the exception of the few minutes thus occupied, the forenoon was devoted to a session on College Administration. Two admirable papers were presented on the subject, one on "The Financial Department of a School or University," by Mr. T. H. B. McKnight, treasurer of the Pennsylvania lines west of Pittsburgh, and the other on "The Relation of the Administrative Department to the Teacher," by Dr. C. R. Mann, of the University of Chicago, who has been commissioned by the Carnegie Foundation for the Advancement of Teaching to investigate the courses in engineering colleges for the Joint Committee on Engineering Education. From the character of Dr. Mann's address, some severe strictures on over-administration may be expected in his report to the Joint Committee. In the report of the Committee on Statistics, the surprising fact was brought out that in thirty-two representative engineering colleges of the United States, the attendance for the session 1913-14 was 8.3 per cent. greater than for 1912-13.

Special attention was given on Wednesday afternoon to the relation of scientific management to education. Professor Hugo Diemer, author of "Factory Organization," presented a paper on "Education in Scientific Management," in which the course instituted by him at the Pennsylvania State College was outlined. A paper by Professor L. M. Passano, of the Massachusetts Institute of Technology severely criticizing certain claims of the advocates of scientific management in the matter of promoting "academic efficiency" was read in abstract. The "scientific manager" would, in Professor Passano's opinion, "like the suburbanite, make two blades of grass grow where only one ought to."

In the evening, an interesting lecture was given on "The Meteor Crater in Arizona," by Dean W. F. Magie, of Princeton University.

Thursday morning opened with fireworks: it was the mathematicians' field day. First, a paper by Professors W. S. Franklin, Barry MacNutt and R. L. Charles on "Practical Mathematics" was presented in characteristic style by Professor Franklin. Professor E. V. Huntington, of Harvard, followed with one on "The Use of the Differential in Calculus." Professor E. R. Hedrick, of the University of Missouri, completed the triology with one on "The Calculus Without Symbols." Correct statements of meaning formed the burden of the discussion—a most animated and entertaining one.

Methods of study next came under consideration and papers were read by Professor W. L. Upson, of Union College, on "The Preceptorial System and Electrical Engineering at Union College," by Professor George L. Sullivan, of the University of Santa Clara, on "Teaching Engineers How to Study," and by Professor W. H. Kennerson, Brown University, on "Giving Instruction in Methods of Study."

The afternoon opened with two papers on courses of instruction—one by Professor A. B. McDaniel, of the University of Illinois, on "Co-ordination in Engineering Instruction," and the other by Professor H. S. Jacoby, of Cornell University, on "A Study of Technical College Catalogues with Respect to Descriptions of Courses of Study and of Instruction." Fundamental pedagogical topics received consideration in papers by Professor C. F. Harding, of Purdue University, on "Grading of Students by Universities vs. Grading of Technical Graduates by Employers," and by Professor A. M. Wilson, University of Cincinnati, on "A Report of Progress in Co-operative Education."

At the annual dinner on Thursday evening, Dean Gardner C. Anthony, president of the society, delivered his presidential address—an eloquent plea for a training of more cultural content and for greater co-ordination between liberal arts and technical studies.

On Friday, the 26th, papers were presented by Professor L. F. Rondinella on "Constructive Drawing in High Schools and Engineering Colleges"; by Professor J. B. Whitehead on "A Department of Engineering at the Johns Hopkins University"; by Professor W. M. Wilson, University of Illinois, on "Proposed Courses in Structural Engineering for Civil Engineering Students," and by Professor Chas. E. Lucke, on "The New Mechanical Engineering Course at Columbia University."

At the final session Dean Anson Marston, of the University of Iowa, was elected president of the society, and Dean F. L. Bishop, of Pittsburgh, secretary for the ensuing year.

In the opinion of those present, the Princeton meeting was the best in the history of the society, and if future conventions keep pace with it, a powerful constructive force in engineering education will thereby be maintained from year to year.

ENGINEERING ACTIVITIES IN HALIFAX, N.S.

FROM an engineering standpoint, the city of Halifax is experiencing considerable activity this season compared with other centres of population throughout the Dominion. The Halifax ocean terminals, the construction and organization of which is under the supervision of Mr. Jas. McGregor, C.E., have exhibited marked progress of late, a large quantity of excavation and filling having been completed. Work has progressed on the bulkhead, which is to extend into the harbor for approximately ¼ of a mile and as far south as the proposed breakwater. The plans, together with the construction work as it is at present, indicate that the completed terminal will be one of the finest in North America.

The city engineer's staff has under construction, or supervision, many new sidewalks, sewers and water extensions. The new terminals create further activity in this department owing to the establishment of grades, street lines, building sites, etc.

The city has just completed a pavement on Cogswell Street, the principal artery leading north from the central portion of the town. Granite block pavement was used. It is the intention of the department to use this material for the construction of pavements on a number of hilly streets at an early date. Of these, Argyle Street, the next street of importance outside of the already paved business streets, will be paved this year. There are nearly 50 concrete sidewalks of varying lengths to be under construction at an early date. A considerable length of sewers, chiefly in the outlying districts, is being laid, and it is expected that the question of a large intercepting trunk sewer with an outlet near the mouth of the north-west arm will be up for consideration at an early date.

The high service reservoir, commenced last year, is nearing completion. It will be a great addition to the water system, especially to the north and higher sections of the city. It is built of reinforced concrete, and is located at an elevation of 247 ft. above mean low tide. Mr. H. W. Johnston, C.E., assistant city engineer, was designing engineer and is superintending its construction.

Building operations are decidedly brisk, the largest building being the new market, Dalhousie University science building, St. Mary's College and St. Matthias' Church.

PROGRESS ON ROADS IN NORTHERN ONTARIO.

Mr. J. F. Whitson, Provincial Road Commissioner of Ontario, states in connection with the work on roads in Northern Ontario now in progress, that new roads are being opened up, and many others completed. The trunk road along the Timiskaming and Northern Ontario Railway is being opened up in sections; and this road is now available for almost all of the distance between the swamp outside of Cochrane on the north to the rocky ridge crossing the country near Sesikinika on the south. The trunk road between Charlton and Englehart, and between Charlton and Long Lake is being graded; while road work is also in progress around Matheson.

AMERICAN SOCIETY FOR TESTING MATERIALS.

The American Society for Testing Materials in holding its 17th annual meeting this week at Atlantic City. The convention is divided into nine sessions terminating on Friday, July 3rd. Among the reports of committees which are being presented are the following:—Standard Specifications for Steel. This report is an exhaustive one and bespeaks an extremely active year for the committee. The recommendations occupy 106 pages and cover the proposed revisions in present standard specifications for steel and steel products; factor table and curve for values of elongation and reduction of area; proof tests of finished forgings; permissible variations in weight and gauge of sheared plates; proposed revised standard specifications for carbon-steel rails, for carbon-steel and alloy-steel forgings, for quenched and tempered carbon-steel axles, shafts and other forgings for locomotives and cars, for structural steel for cars, and for carbon-steel bars for springs. In connection with the proposed new standard methods of chemical analysis for plain carbon steel the report deals with the direct combustion and colorimetric method of determination of carbon and other methods for the determination of manganese, phosphorous, sulphur, silicon, copper, nickel and chromium.

The report upon standard specifications for wrought iron includes the consideration of the activities of sub-committees upon tubes and pipe; staybolt and engine bolt iron, chain iron, and iron chain.

The committee on the heat treatment of iron and steel presents a report on proposed recommended practices of (1) annealing of carbon-steel castings; (2) heat treatment of case-hardened carbon-steel objects.

Proposed standard specifications for coal-drawn steel are presented, together with tentative specifications.

The committee on magnetic testing of iron and steel submits a report which contained a number of recommendations in the existing specifications.

The committee on standard specifications for quicklime and hydrated lime is presenting specifications to cover each.

The most extensive committee report is that on preservative coatings for structural materials. The committee presents proposed standard definitions of terms used in paint specifications besides the reports of the various sub-committees, including those on paints, oils, turpentines and also on steel plates.

The committee on lubricants has a report outlining proposed provisional tests for lubricants. A minority report is being brought in with respect to viscosity.

The committee on standard testing for road materials recommends provisional tests and methods for: (1) determination of apparent specific gravity of rock; (2) determination of the absorption of water per cubic foot of rock; (3) making a mechanical analysis of broken stone or broken slag; (4) making a mechanical analysis of mixtures of other fine material with broken stone or broken slag. The report also contains proposed definitions of non-bituminous and bituminous road materials. A report is also brought in respecting regulations governing the form of specifications, in which a number of revisions are made.

Proposed standard specifications are brought in for strength tests, quality, design and construction of drain tiles.

The committee for the methods of sampling and analysis of coal is bringing in its second preliminary report.

Other reports being presented are on standard methods of tests, fire proof materials, non-ferrous metals and alloys, and standard specifications for copper wire, cement, brick, timber, rubber products and locomotive cylinders.

The annual report of the executive committee shows a membership of 1687.

The following are the papers being read at the various sessions:—"Magnetic Habits of Alloy Steels," by J. A. Mathews; "An Efficiency Testing Machine for Testing Drills, Caps and Dies," by T. Y. Olsen; "Are the Effects of Simple Overstrain Monotropic?" by Henry M. Howe; "Rubber Belting and Methods of Testing," by W. E. Campbell; "Report on Proceedings of Turin Meeting of the Council of the International Association for Testing Materials," by Henry M. Howe, Life Member of Council; "A New Vibratory Testing Machine and Results Obtained by its Use," by S. V. Hunnings; "Testing Concrete Aggregates," by Lloyd M. Chapman; "Some Considerations Affecting Specifications for Wrought Non-Ferrous Materials: Examination of Concrete Failures for their Determining Causes," by R. S. Greenman; "Specifications and Tests of Glue," by Oscar Linder and E. C. Frost.

CANADIAN ELECTRICAL ASSOCIATION.

The 24th annual convention of the Canadian Electrical Association was held in Montreal, June 24th, 25th and 26th, with the Ritz-Carlton as head-quarters. The president, Col. D. R. Street, of Ottawa, conducted the proceedings. Over 200 members and guests were in attendance. The convention was divided into morning and afternoon sessions and many instructive and valuable addresses were given. The entertainment of the delegates throughout the convention was very efficiently carried out. The entertainment committee, with Mr. Lawford Grant as chairman, made it a very pleasant occasion, particularly for the out-of-town members and visitors.

Among the papers presented at the technical sessions were the following:—"Modern Switching Equipment," by L. B. Chubbuck, Canadian Westinghouse Co.; "Maximum Demand Determination and its Relation to the Cost of Supply of Electrical Energy," by P. T. Davies, Montreal Light, Heat and Power Co.; "Legal Points in Connection with Central Station Matters," by G. H. Montgomery, K.C.; "Grounding of Distribution Circuits," by S. Bingham Hood, Toronto Electric Light Co.; "The Value of Electrical Heating Devices to the Central Station," by Harold S. Brown, Canadian General Electric Co.; "Some Notes on Steam Railway Electrification," by J. A. Shaw, Canadian Pacific Railway Co.; "Interruptions on Long Distance Transmission Lines," by P. Ackerman, Toronto Power Co. Numerous other papers and discussions were presented, together with reports on the work of various International Electric Light Association Committees. The election of officers for the coming year resulted as follows:—

President, Col. D. R. Street, sec.-treas. Ottawa Electric Co.; first vice-president, D. H. McDougall, sec.-treas. Toronto Power Company; second vice-president, R. M. Wilson, Montreal Light, Heat and Power Co.; third vice-president, Wills MacLachlan, Electric Power Company, Toronto; honorary secretary, T. S. Young, Hugh C. MacLean Co., Toronto; secretary-treasurer, Alan Sullivan, Toronto. Managing committee—J. S. Gould, Smith's Falls; G. W. Magalhaes, Toronto; P. T. Davies, Montreal; H. G. Matthews, Quebec; A. E. Dunlop, Pembroke; J. S. Norris, Montreal; George Kidd, Vancouver; Robin Boyle, Niagara Falls; W. G. Angus, Hamilton; W. S. Robertson, Toronto; E. L. Milliken, Sydney, N.S.; L. W. Pratt, Hamilton; H. R. Mallison, Montreal; H. Hulme, Montreal.

The next place of meeting was left to be decided by the managing committee.

Coast to Coast

Toronto, Ont.—The bridge at Sunnyside, Toronto, has been completed, and is now open for traffic.

St. Catharines, Ont.—Hydro-Electric was turned on in St. Catharines for the first time officially on June 27.

Vance, Sask.—Another gas and oil strike has been made at Vance, Sask., at a depth of 47 feet. Vance is located on the Winnipeg-Edmonton line of the C.P.R.

Calgary, Alta.—The latest report from the Street Railway Department of Calgary shows a gross deficit of approximately $70,000; and it is expected that this will be greatly augmented before the end of the year.

West Vancouver, B.C.—On property, known as George Mars' property, which is located half a mile due north of Dundarave station on the P.G.E. railway, oil has been discovered. It is proposed to form a company and to place stock upon the market almost immediately.

Winnipeg, Man.—The new elevated track at the C.P.R. depot, Winnipeg, is in operation. This track is about 6 feet higher than the present level of the station. The improvements at the depot are reported as proceeding rapidly. The track adjacent to the finished elevated track is being torn up preparatory to laying the foundations for the steel girders which will carry the tracks.

Montreal, Que.—While the big concrete conduit, which supplies Montreal with water from the St. Lawrence river, is being inspected in August by the New York experts, Messrs. Hering and Fuller, the emergency conduit from the Lachine canal will be used by the city. Contamination of the canal water will be prevented during the period of inspection and repairs—if any are found necessary—to as great a degree as possible.

Montreal, Que.—The section of the C.N.R. tunnel which extends from the upper end of the McGill University grounds to Cathcart street is now being lined with cement blocks, which are blocks weighing about one ton each. Some 40 or 50 feet of this lining has been put in position, and the work will be completed during the summer. The other sections of the tunnel have been bored practically through the solid rock and will not require this lining.

Vancouver, B.C.—The first section of the second new 18-inch water main, a 750-foot length of pipe, has been hauled across the First Narrows and has been placed in position. Some time ago, the work of hauling was commenced, but had to be stopped on account of ledges being encountered beneath the surface; and these had to be blasted away. Two other sections must be hauled across the Narrows, and will be connected under water.

Brantford, Ont.—Preparatory work for the raising of Lorne Bridge at Brantford is being advanced rapidly by the contractors for the work, P. H. Secord and Sons. The big abutment stones are being undermined and removed to make way for the new inner wall now under construction on both sides; and just as soon as these walls are completed, the bridge will be raised. This work is being carried on with very little interruption of traffic to and from West Brantford.

Lethbridge, Alta.—It is reported that work on the Thirteenth Street subway is progressing rapidly. The grading on the south side is practically finished; while, to the north of the regular main track of the C.P.R., piles have been driven, and a temporary trestle constructed. When grading on the north side is completed, trains will be run over the trestle while the work of excavation proceeds. The structure is to be completed by August 1.

Edmonton, Alta.—Mr. McArthur reports in connection with railroad construction on the E.D. and B.C. and on the A. and G.W. Railway, that 2,000 men are engaged on the former railway and 1,500 on the latter; that the big bridge over the Athabasca River at Smith will be completed in about one month's time; that the ballasting of the track between Edmonton and Smith will be completed in from 6 to 8 weeks; while, on the A. and G.W. Railway, the laying of steel is to be commenced at once.

Toronto, Ont.—First among the roads on the program of the provincial highways commission which will be surveyed and constructed, will be the road extending along the lake shore from Toronto to Hamilton. It has been decided to construct a substantially paved highway 20 feet in width, and to have it ready for traffic in the fall of 1915. A staff of 14 men are now engaged in a motor survey of the intervening district between the two cities; and following their report, legislation will be introduced to allow the letting of contracts and the immediate procedure with building.

Cranbrook, B.C.—Already the Cranbrook city council has commenced action in connection with the work covered by new money by-laws which have received the favorable vote of Cranbrook ratepayers. The water system which will be constructed will cost about $110,000, and will be one of the best in Western Canada. Mannesman steel pipe, the contract for the supply of which is now held by J. B. Turney and Co., Limited, of Lethbridge, Alta., will replace all of the old wooden pipe now in use. A supply of 110 cars of pipe, or over 5,000 tons, will be necessary.

Vancouver, B.C.—The G.N.R. bridge on Broadway avenue, Vancouver, has reached the stage of practical completion, and is being used for vehicular and pedestrian traffic. The bridge is 288 feet in length and 70 feet wide. The sidewalks are of cement, and the roadway is paved with wood blocks; while tracks have been installed on the bridge to provide for the possibility of a future extension of the street railway along Broadway. The G.N.R. company is now proceeding with the construction of abutments on the viaduct which passes over the Grandview cutting at Victoria drive.

Red Deer, Alta.—A press to manufacture pressed cement brick and building blocks is being started in Woodlands to the north of Red Deer, Alta. It is stated that in the manufacture of these brick, they are subjected to a pressure of 40 tons, and will stand a pressure test of 2,742 lbs. A brick was tested by placing it upon two blades 7 inches apart; and it took 850 pounds of pressure on a blade in the middle to break it. The press has a capacity of 5,000 bricks or 500 building blocks a day. The faced brick is manufactured plain, rock-faced, or ornamental, and of any color.

Winnipeg, Man.—Arrangements are now under way in connection with the erection of the big power plant which is to be built by the Winnipeg Electric Railway Company at Big Bonnet Falls, and which is to serve for the development of power not only for consumption by the street railway but for manufacturing purposes as well. The location at Big Bonnet Falls is about 70 miles north of Winnipeg. The plant will have a final capacity of about 150,000 h.p., and will cost close to $6,000,000. Only from 50,000 to 60,000 h.p. will be developed at first, or sufficient for immediate need.

London, Ont.—The engineers of the Hydro-Electric Commission who have been investigating the power possibilities of the northern peninsula, have sent in a report to the effect that over 22,000 h.p. of electric energy is available, and that the approximate cost of development would be $2,000,000. The Big Shute, purchased by the Commission for $400,000, is capable of delivering 6,000 h.p.; Port Severn, 1,200 h.p.; Eugenia Falls, 8,000; Wadsdell's Falls, 1,200; the Saugeen River, in Bruce, 4,000; and Swift Rapids, 6,000. The counties to be supplied from these sources are Simcoe, Ontario, Dufferin, Grey, Wellington, Bruce, and a portion of Huron.

Victoria, B.C.—It is given as an assured fact that towards the end of July, a service between Victoria and Courtenay over the new East Coast extension of the E. and N. Railway, will be opened. Steel-laying has now reached the Trent River, where the Dominion Bridge Co. is installing the last bridge which must be erected before entering Courtenay. This bridge is about 5 miles from the town; and since the viaduct will be sufficiently advanced for use in a week or so, rails will soon be carried into the temporary terminal and permanent divisional centre of this section of the Island railway. Arrangements are under way for the official inauguration of the service.

Port Nelson, Ont.—This year, early in July, the Dominion Government purposes despatching from Halifax to Port Nelson 5 steamers of materials and supplies necessary for the construction of the railway terminals, elevators, and harbor work at that port. Up to date, over $6,000,000 has been expended on the railway and terminals; and, at the session just closed, further appropriations were voted to the extent of $4,500,000 for the terminals and elevators. The Hudson Bay Railway has now been completed over half the distance from Le Pas. And, this year, the Government will undertake the construction of lighthouses and wireless stations on the Hudson Straits along the northern route to Port Nelson.

Hamilton, Ont.—Of the $620,000 which has been granted by the Dominion government for works at Hamilton, $250,000 is to be expended at Stipe's inlet on part of the harbor improvement scheme mapped out at Hamilton. The inlet will be deepened and widened, and large docks will be built, so as to afford good shipping facilities in the very heart of the industrial annex. $165,000 has been secured for the purchase of property and the commencement of work on the new customs house and post-office extension. $100,000 is the grant obtained for completing the work at the revetment wall; $50,000, for a wharf at the foot of Wentworth street; $40,000, for a new east end post-office; and $15,000 for improving the central post-office.

Edmonton, Alta.—In July, 1913, the Ulen Contracting Company, Chicago, commenced work on the contract of laying sewers in Edmonton. Since September 13 to the week ending May 30, over 1,000 feet of trunk sewers has been laid each week, while in one week, 1,142 feet were laid. In all 39,215 lineal feet have been laid, the sewers varying from 4.4½ inches to 6 inches in diameter. The sewers which have been laid by the company are those provided for in what is known as the Potter report, which was designed to prepare for a population of 200,000 people. Only about 1,900 feet remain to be laid, and the contract will have been completed, though the company has until the end of March, 1915, to fulfil its contract. The total value of the work is about $1,500,000; and it is the largest contract ever awarded by Edmonton officials.

North Vancouver, B.C.—On June 17, actual work commenced at North Vancouver upon the construction of the great dry docks and engineering works, including foundries, shipbuilding yards and graving docks, of the Dominion Shipbuilding, Engineering and Dry Dock Company. The incident was made the occasion of a ceremony, the nature and magnitude of the proposed works being pointed out to over 500 citizens of Vancouver. Already a large amount of money has been expended in clearing lands, in making roadways, and in planning and surveying the site, as well as in laying the water mains. According to the expressed intention of officers of the company, work will be vigorously pressed, and orders will be taken, as early as January of next year, when the first unit of the plant will have been completed.

Red Deer, Alta.—Seymour and Dawe, city engineers of Red Deer, have submitted to the city council a plan of the present and proposed sewerage system and a detailed estimate of the cost of the extensions, amounting, in all, to $101,394.60. The engineers were instructed in 1912 to proceed with a topographical survey for the purpose of preparing plans for extensions to the present sewer system. The plans presented indicate the rates of grade, elevations at intersections, location of manholes and depth of fill at all the principal points. The general idea is to construct a fairly large concrete or vitrified pipe trunk sewer with a storm outlet for the total sewage until such time as the city will be expected by the Provincial Board of Health to construct a sewage disposal plant, after which this storm outlet will only be used for storm water. The sewage disposal works are designed to be located some distance down the river.

Fort George, B.C.—The construction of the new winter road, which is to be built between Fort George and the Peace River district, is being urged upon the British Columbia authorities by the Fort George board of trade and the trade organizations of Vancouver and other coast cities. The road as at present planned will make use of all lakes, rivers and streams, cuttings being made so as to connect these natural winter highways, thus practically eliminating all grades, and providing the most convenient means of reaching the Peace River country before the institution of railway service. The road will follow the Giscombe Trail from Fort George to Giscombe Portage, along the Crooked River, with cut-offs in convenient places to shorten the mileage, across McLeod Lake, along the Missinchinka River to the Pine Pass, across the pass and down the Pine River to the Pouce Coupe country, with cuttings at various places to enable settlers to get down to the river easily.

Mount Dennis, Ont.—Work is now in progress at Kodak Heights, in Mount Dennis, on the plant of the Canadian Kodak Company, Limited, which is being erected at a cost of about $1,500,000. In the new plant, there will be seven buildings, with a floor area of more than 480,000 square feet, or about 11 acres. The largest building will be 460 feet long by 80 feet in width and 5 storys high. The plans call for reinforced concrete construction, with metal sashes and wire glass. In the seven structures, there will be used 2,500 tons of steel bars, 600 tons of fabricated structural steel, 80,000 square feet of metal sash, with 25,000 cubic yards of concrete requiring 45,000 barrels of cement. There will be a complete system of fire protection, consisting of outside hydrants, hose-houses and sprinkling systems for each building; and water for manufacturing purposes will be drawn from two concrete reservoirs with a capacity of 1,000,000 gallons. As Kodak Heights is about a mile beyond the limits of the city of Toronto, the water supply will be taken from 150-foot wells located on the company's property. The combined flow of these wells will be about 175,000 gallons per day. The manufacturing buildings proper will be located on a plateau, at the foot of which the power plant will be set. The contractors for the general construction of the plant are C. E. Deakin, Limited, of Montreal.

Vancouver, B.C.—The Vancouver and District Joint Sewerage Board is now advertising for tenders for the construction of what is officially known as Contract No. 2 of trunk sewer mains, which will cost at least $350,000. The work under this contract means the extension of a branch of the China Creek sewer to Central Park, with tributary mains to Gladstone, Collingwood and Earls road districts and a separate trunk sewer to Trout Lake. Contract No. 1, which is now under way, will probably be completed by November next. It covers the China Creek and Canoe Creek mains in wards Five and Eight and a portion of South Vancouver; and represents a cost of about $250,000. It is expected to commence work on Contract No. 2 in August, and to have this completed within a year. The Joint Sewerage Board also proposes to proceed this year with the levelling of Burnaby Lake. When the water is at its lowest in July and August, it is intended to clean out the Brunette River from North road to the lake, and thus to increase the flow of water out of the lake, dropping the level several feet. This will have the effect also of increasing the flow from Still Creek, west of Burnaby Lake. The board will probably straighten Still Creek and endeavor to make it a better carrier of drainage water from this district. There is also a possibility that the sewerage board may take steps this season to extend the Balaclava main trunk in Kitsilano south to the city boundary line.

Fraser River, B.C.—The boring at the mouth of the North Arm of the Fraser river for the location of the best course for the channel in connection with the proposed harbor works, has proven satisfactory. The contract for this work was awarded to K. S. Robinson, of Vancouver. One hole sunk on the south of McMillan's Island, between that island and Sea Island, went down 45 feet and found nothing but sand and clay. Another off the Indian reserve was sunk 75 feet and down to 63 feet only sand and clay were encountered, when hard pan was struck. Several other holes have been bored at the mouth of the stream, and all have been equally satisfactory. Surveyors, also, are making current and water observations in the river, as well as surveying the foreshore and locating suitable places for test-boring. Also, good progress is reported on the construction of the long jetty at the mouth of the North Arm at the point of McMillan's Island. This, which will be 4 miles in length, will run parallel with and about 1,500 to 2,000 feet from the shore, and is being built by the Federal authorities for the protection of the channel, so as to prevent the sand from the sand heads silting up the channel, by the action of the tides. About a mile of bulkheading is already done, and work is now proceeding a mile further out towards the gulf, from the end of McMillan's Island, and directed landwards. Mattressing will be commenced when the jetty has progressed somewhat further.

PERSONAL.

J. C. NELSON, of Fort Rouge, Man., has been appointed traffic superintendent on the new railway in connection with the Greater Winnipeg Water District. Mr. Nelson has been in railway work for 23 years. In 1907 he joined the staff of the Northern Pacific Ry., at Winnipeg.

R. W. LEONARD, C.E., is resigning his position as commissioner of the National Transcontinental Railway, and the Department of Railways and Canals, Ottawa, will assume charge of his duties. It is reported that F. P. Gutelius, general manager of the Intercolonial Railway will be given charge for the Government of its whole system of railways —i.e., the I.C.R., the N.T.R. and the Hudson Bay Ry.

OBITUARY.

From Brandon, Man., comes the report of the death of Arch. M. Leitch, for many years a prominent contractor on the western lines of the Canadian Pacific Railway Company. Mr. Leitch was born in Argyle, Scotland, 66 years ago, and at the age of 36, became engaged in railway building in Canada.

An extremely sad fatality occurred at Copper Cliff, Ont., on the morning of June 25th, when Fred. J. Bedford, a '08 graduate in mining of the University of Toronto, was instantly killed while examining the mechanical operation of a skip in Mine No. 2 of the Canadian Copper Company.

Mr. Bedford had proceeded to the 10th level and was stationed at the side of the shaft when, owing to a mistaken signal, the skip descended upon him from the 9th level, causing instant death.

Mr. Bedford entered the employ of the company in 1908. Shortly afterward he proceeded to Porcupine and took charge of the Dome Mine at its opening. Later he entered into private practice in a consulting capacity and in assessment work. In November, 1913, he returned to Copper Cliff where he had since occupied the position of shift boss of No. 2 mine.

COMING MEETINGS.

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

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.—Summer convention to be held at Brighton Beach, N.Y., July 3rd and 4th, 1914. Secretary, J. R. Wemlinger, 11 Broadway, New York.

UNION OF CANADIAN MUNICIPALITIES.—Annual Convention to be held in Sherbrooke, Que., August 3rd, 4th and 5th, 1914. Hon. Secretary, W. D. Lighthall, Westmount, Que. Assistant-Secretary, G. S. Wilson, 402 Coristine Building, Montreal.

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

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

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

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

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

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

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

The Ottawa branch of the Canadian Society of Civil Engineers announces the date of its annual meeting as the first Wednesday in October. During the summer months the rooms at 177 Sparks Street will be closed.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

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

22011—June 13—Amending Order No. 21751, dated April 29th, 1914, by striking out paragraphs 4, 5 and 6 of operative part of Order.

22012—June 16—Relieving G.T.R. from providing further protection at crossing of Waterloo St., town of New Hamburg, Ont.

22013—June 17—Approving proposed Supplement No. 3 to Canadian Freight Classification No. 16, as finally revised and submitted for approval by G. C. Ransom, Chairman, Canadian Freight Association, by letter dated at Montreal, June 10th, 1914, and with which is consolidated Supplement No. 2 approved by Order No. 20967, Dec. 10th, 1913, to become effective with the least delay necessary, subject to certain provisions.

22014—June 17—Authorizing G.T.R. to construct siding into premises of John R. Booth, on Lot 29, Con. 2, Tp. Dickens, District Nipissing, Ont., near Opeongo.

22015—June 17—Authorizing G.T.R. to construct siding and spur therefrom, into premises occupied by Ross, Church Road Co., Limited, Lot 260, 6th Range, Tp. Godmanchester, Co. Huntingdon, Que.

22016—June 17—Approving city of Montreal plans No. B-1-1342-1 and No. B-1-1342-2, showing diagram of material and general details of steelwork and details of sidewalk brackets, of subway proposed to be constructed under C.P.R. at Park Ave., Montreal.

22017—June 17—Authorizing G.T.R. to construct siding into premises of Interprovincial Brick Company of Canada, Limited, on Lot 29, Con. 5, Tp. Chinguacousy, Co. Peel, Ont., near Cheltenham.

22018—June 15—Authorizing Dominion Stock and Bond Corporation to construct subways at Corporation and Government Streets, under G.T.P. Ry., town of Fort Fraser, B.C.

22019—June 16—Authorizing C.N.R. to operate trains over railway between Saskatoon and Harris, 49.4 miles, at speed not exceeding 25 miles an hour, instead of 20 miles. And relieving company of speed limitation of 15 and 20 miles an hour over portion from Harris to Kindersley, 76.7 miles.

22020—June 18—Approving plan showing alterations and additions to C.N.R. Co.'s station building at Alsask, Sask.

22021—June 16—Approving and authorizing clearances, as shown on G.T.R. plan, of bridge over siding to premises of Dominion Tire Co., Limited, Berlin, Ont., subject to certain conditions.

22022—June 17—Authorizing G.T.R. to construct siding into premises of Dominion Glass Co., Limited, Toronto, Ont.

22023—June 18—Authorizing G.T.R. to construct siding into premises of Kirkfield Portland Cement Co., Limited, Lot 18, Con. 2, Tp. Somerville, Co. Victoria, Ontario.

22024—June 16—Authorizing C.P.R. to construct Bassano-Easterly Branch Line across fifty-eight (58) highways, mileages 0.82 to 50.95, with some diversions.

22025—June 17—Extending, until August 1st, 1914, time within which C.P.R. install electric bell at crossing of highway at Port Haney, B.C.

22026—June 18—Relieving Michigan Central R.R. from maintaining day and night flagman at crossing of highway about 2 miles west of Mull, Tp. Harwich, Ontario.

22027—June 18—Authorizing C.L.O. & W. Ry. (C.P.R.) to include within limits of right-of-way shown in plans approved under Order Nos. 17024 and 17105, lands edged in red on plan referred to in book of reference dated June 8th, 1914.

22028—June 10—Authorizing City of Vancouver, B.C., at own expense, to construct highway over V.V. and E. Ry. and Nav. Co., at Venables St.

22029—June 8—Directing that Esquimalt and Nanaimo Ry. file plans showing culvert sufficient to properly drain lands of Adam Gordon, Hillbank, B.C., for approval of Engineer of Board; work be completed to satisfaction of Engineer of Board within 2 months from date of approval of plans; and be done at expense of Ry. Co. Upon completion of work Adam Gordon pay to Ry. Co. sum of $50.00 towards expense of said work.

22030—June 22—Authorizing C.P.R. to open for traffic double track from Herbert to Notman, mileage 91.9 to 95.1, Sask.

22031—June 22—Granting leave to Government of Sask., at own expense, to construct highway over C.P.R. blind line north of Sec. 15-30-22, W. 2 M., Sask.

22032—June 22—Authorizing G.T.R. to construct siding into premises of Welch Grape Juice Co., Lot 21, Con. 6, Tp. Grantham, Ont.

22033—June 22—Approving location C.N.O.R. station grounds at Vaughan, Tp. Deacon, Dist. Nipissing, Ont., mileage 151.1 from Ottawa.

22034—June 23—Authorizing C.N.R. to construct across 37 highways, mileage 44.84 to 93.85, Sask.

22035—June 22—Granting leave to Winnipeg, Selkirk and Lake Winnipeg Ry. to cross, for construction purposes only, until September 1st, 1914, Selkirk Branch of C.P.R. Applicant operate its trains over crossing between hours of 6 a.m. and 11 p.m.; during these hours crossing be protected by watchmen, appointed by C.P.R., at expense of applicant—watchman be supplied with C.P.R. train time table, and if possible be notified by it of any extra train requiring to make the crossing during the hours of operation by Applicant.

22036—June 17—Approving agreement between Bell Telephone Company and Caradoc-Ekfrid Telephone Company, Limited, dated June 9th, 1914.

22037—June 22—Authorizing Shale Products, Limited, to construct aerial tramway over Hamilton and Allandale Branch of G.T.R. near Inglewood Jct., Ont., subject to certain conditions.

22038—June 18—Authorizing Department Railways and Canals to construct Welland Ship Canal Construction Ry. across N. St. C. & T. Ry. at Lake Shore Road, Port Weller, Ont., subject to and upon certain conditions. Department to bear and pay whole cost of providing, maintaining interlocking plant.

22039—June 19—Amending Order No. 20240, Sept. 2nd, 1913, by adding clause,—"The Ry. Co. bear and pay cost of filling side ditches and installing crossing planks, cattle guards, and culverts."

22040—June 20—Authorizing G.T.P. Ry. to construct across Government Road Diversion, N.W. ¼ Sec. 24-53-7, W. 5 M., mileage 60.2, Dist. North Alberta, Alta.

22041—June 19—Authorizing G.T.R. to construct siding into premises of Pilkington Bros., Limited, Lot 5, Con. 2, Tp. Wainfleet, Co. Welland, Ont., and west of Port Colborne.

22042—June 22—Amending Order No. 19199, dated May 6th, 1913, in so far as diversions on plan covered by said Order are concerned.

22043—June 19—Authorizing C.P.R. to construct siding for G. A. MacIver, Sherbrooke, Que., from point on southerly limit of main, mileage 19.66, Megantic Sub. Div., Lot 544, R. 1, Victoria North, Tp. Hampton, Co. Compton, Que.

22044—June 20—Authorizing Lake Erie and Northern Ry. to connect with T.H. & B. between station 866-92.5, equal to 00-00, in village of Waterford, and station 58-95.4, Tp. of Townsend, Ontario.

22045—June 11—Dismissing application B. C. Express Co. for Order directing G.T.P. Ry. to remove temporary bridge built across Fraser River below confluence with Nechaco River, and make openings in permanent steel bridge across Fraser River, at Ry. Mile No. 142; also Mile No. 189, etc.