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Volume 27. Toronto, December 24 1914 Contents of this issue on page 3

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

METHODS OF TREATMENT OF SEWAGE SLUDGE

PROF. P. GILLESPIE, C.E., REVIEWS THE METHODS IN VOGUE IN AMERICA AND EUROPE—ABSTRACTS FROM A VALUABLE PAPER TO THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

A VALUABLE addition to literature on sludge disposal is contained in the paper presented on December 17th to the Canadian Society of Civil Engineers by Prof. P. Gillespie, of the University of Toronto. The formation of sludge is described, the paper confirming the frequently expressed generalization that American sewage contains up to one part per thousand of solid matter. It is with the treatment of this solid matter, partly in suspension, partly in solution, and partly in colloidal state, that Prof. Gillespie's paper deals, this treatment being such that the sludge ceases to possess properties in virtue of which it may prove a nuisance to the community or a menace to its health. The speaker calls attention to the fact that while the noted fifth report of the Royal Commission on Sewage Disposal devotes much space to detailed descriptions of various methods of sludge treatment, including conversion into fertilizer, depositing at sea, pressing, burning and trenching, and while in its recommendations every other matter is referred to, no specific recommendation is made with respect to the disposal of sludge.

The values of the fertilizing constituents (potash, nitrogen, phosphates, etc.) are dealt with, and the methods employed in this field outlined. The effect of decomposition on the fertilizing value of sludge is emphasized, it being due to dimunition of nitrogen content and of phospherous, a more porous non-fibrous constitution of nitrogenous material and a finely divided and more uniformly distributed condition of contained grease.

The paper divides methods of sludge treatment into (1) those which deal with crude sludge and (2) those which deal with decomposed sludge, owing to the radical differences and the methods of disposal best suited to each. These differences are described and explained.

The various methods of treating crude sludge are described. Disposal at sea, for cities fortunately located, is a method in quite general use, satisfactory and reasonably cheap. This method is practised in Providence, R.I.; Boston, Mass.; London, Salford, Manchester, Dublin, Belfast and Glasgow. The latter city reports a cost for this work equal to 3.1d. per long ton of sludge handled, including .9d. per ton for land charges. In London the cost is about 7 cents per ton of sludge, not including the cost of precipitation and pumping into barges.

The following costs per ton of 2,000 pounds of dry matter are reported: London, $1.03; Glasgow, 87 cents; Manchester, $1.26; Salford, 90 cents, and Dublin, 91 cents. Precaution must be taken to avoid pollution of shellfish layings and the deposition of solid matter where it can possibly be carried to any foreshore.

Methods of land disposal include air drying, trenching, and lagooning, none of which have been attended with anything better than partial success. The next method considered is that of treatment by use of the centrifugal machine, whose operation is described in detail. The process of pressing, whereby handling is facilitated, odor diminished, and capacity for putrefaction lessened, is explained. The sludge is here subjected, between plates, to a pressure of about 75 pounds per square inch. Its volume is about 1/5, after the treatment, and the water content is reduced 50 per cent. This method is in use in Hamilton, Ont.; Worcester, Mass.; Providence, R.I., and Bradford, England.

The writer claims the treatment of rotted sludge by filtering it on properly constructed beds, as being the only satisfactory method. The procedure in Great Britain (at Birmingham) and on the European continent (in the Emscher Valley) is described, it being strikingly similar in both cases, the main difference lying in the manner of sludge preparation.

At Birmingham plain sedimentation is employed. The sewage after passing through a grit chamber and being roughly screened is passed into sedimentation tanks, where the sludge is deposited. This sludge is removed from each tank weekly in summer, less frequently at other seasons, and deposited in one or more of a series of twenty tanks where septic action and digestion take place. Following this, the sludge is pumped to the drying beds which are each 150 feet square in area, consist of 6 inches of clinker and ashes, and are underdrained with 4-inch tiles laid in herring-bone fashion toward a main leader, which in turn takes the drainage to the well whence it is pumped to the filtering beds. Each bed gets two fillings per year

In the Emscher Valley the sludge is rotted in the lower compartment of two-story tanks, the upper compartment being the sedimentation chamber. It is periodically removed and dried on prepared beds, similar in construction to those at Birmingham. The drying period is considerably longer.

The writer deals to some length with plain sedimentation, the term denoting the subsiding of solids heavier than water, which takes place when conditions are favorable. The influences affecting it in the treatment of sewage are the velocity of flow, time of retention, specific gravity and size of settling solids. The observations of

Bock and Schwarz, Hanover, in 1899, were cited, where it was found that with a velocity between .014 and .027 feet per second, 55.7 per cent. of the suspended solids were settled out in 2¼ hours. When the period of retention was increased by 50%, this percentage of sedimented solids became 61.5. Steuernagel reported that complete quiesence for 12 hours removed 84%. Of American data the Columbia tests are noted.

The writer calls attention to the criticism which is attendant upon the method of expressing the sedimented solids as a percentage of the total solids in suspension, the latter having been determined by careful filtration of samples, in estimating the efficiency of sedimentation processes.

"Without doubt it leads to confusion in a comparison of results since it takes no account of the fact that there are always some solids which refuse to settle because their specific gravity is practically that of the water containing them or else through fine division they are in a state of semi-solution. A sedimentation plant has no more concern with non-settling solids than it has with matters in solution."

The paper goes on to describe the first attempt, by W. J. Dibden, London, at giving separated sludge a treatment independent of that given to the liquid sewage. Mr. H. W. Clark's observations (1899-90) were outlined, and followed by a full description of the Travis or Hampton hydrolytic tank, patented and put into service in 1903 and now in operation on a commercial scale at Hampton, Norwich and Luton, England. The circumstances surrounding the first German modification of this tank are also described in an interesting way.

Prof. Gillespie then traces the development of the septic tank, outlining the early experiments, particularly those of Doctors Guth and Spillner. The work of the Emschergenossenschaft was described,* and the typical Emscher plant outlined in detail. Each part, *viz.*, storm overflow weirs, screening chamber, detrieus tank or grit chamber, Imhoff sedimentation tank, and sludge beds, is taken up, carefully studied, and illustrated. An interesting parallel is drawn between what is commonly called the "British" and "German" methods, the former, as already described, embodying sludge digestion in separate tanks, and the latter, sludge decomposition in 2-story tanks. Both processes are termed satisfactory; both produce inoffensive and quick-drying sludge. Commenting upon them, the writer states that his observations have led him to believe that sludge which has been thoroughly digested in separate tanks does not differ materially as to character or quantity from that which has undergone digestion in Imhoff tanks, or indeed in ordinary septic tanks. "There are, however, certain objections to the method of decomposition in separate tanks which are significant. In the first place, where separate digestion tanks are employed, the overflowing excess liquid is very offensive and the escaping gases are likely to be very noxious also. Again, for the maintenance of bacterial life, it seems obvious that the food supply (fresh sludge) should enter the chamber continuously, and that the rotted sludge should be withdrawn as nearly as may be in the same way. The separate tank does not usually provide for this, while the two-story tank does. The proper environment seems to require time for its development, and after this environment is once created, it seems like taking a great risk to renew the entire contents of a tank at one operation instead of permitting the supply of food to come in gradually. Experience, moreover, has shown that the time required for complete digestion is likely to be longer in the separate tanks than in those with two stories. The body of water overlying the sludge in the decomposing room of two-story tanks, performs a function which it is not possible to duplicate in the ordinary tank for separate sludge digestion. This body of water is a medium in which the old sludge and the new, through the ebullition caused by the escaping gases, have an opportunity of becoming mixed, and one in which, as explained later, its soluble constituents may often exert an important influence in preventing acid decomposition.

"Fresh sludge separates from its water only with the greatest difficulty, the reason being the attraction of its contained colloid constituents for water. Structurally, the mass is supposed to be divided into cells by a network of amorphous membranes, which cells dilate as the liquid

*See *The Canadian Engineer*, June 25, 1914, for an article entitled "The Method and Work of the Emschergenossenschaft," by Prof. P. Gillespie, C.E.

Data Concerning Two-Story Sewage

	Date of Completion	Population for which designed	Number of Tanks	Radial or Longitudinal Flow	Open or Covered	Depth	Flowing through time	Mean Velocity in Sedimentation Chamber	Capacity of Sludge Room
Carleton Place, Ont.	1914	4,000	2	Longitudinal	Covered	26 ft.	3 hrs.	3 ins. per min.	6,000 cu. ft.
Edmonton, Alta.	Not Started	10,000	2	Longitudinal	Covered	24 ft.	2 hrs.	7.2 ins. per min.	22,000 cu. ft.
Hamilton, Ont.	1914	70,000	4	Longitudinal	Open	28 ft.	2½ hrs.	21 ins. per min.	6 mos. accumulation
Kelowna, B.C.	1913	3,000	1	Radial	....	23 ft.	2 hrs.	....	2,750 cu. ft.
Peterboro, Ont.	Not Started	....	8	Longitudinal	Covered	27 ft.	½ hr.	29 ins. per min.	42,700 cu. ft.
Stratford, Ont.	Under Construction	17,000	2	Longitudinal	Open	24⅜ ft.	1¾ hrs.	....	21,400 cu. ft.
Weston, Ont.	1913	3,000	2	Longitudinal	Covered	18 ft.	2 hrs.	4.8 ins. per min.	1,500 cu. ft.

is absorbed. When such sludge is applied to a bed, only the coarser particles remain on the surface. Owing to its fluidity, much of the finer material penetrates into the interstices in the medium, some of it indeed passing all the way through. The surface layer becomes more and more dense through the accumulation of particles of sludge which penetrate it successively with new applications until finally it becomes impervious.

"The rotting process, however, produces a radical change. The colloids are broken down. The sponge-like structure with amorphous cell walls referred to, disintegrates and loses in the act, its capacity for holding water. In the second place organic matter, such as fragments of animals and plants which are very common in household waste, is destroyed. These substances which have naturally a very large water content, are found in very small quantities if at all in decomposed sludge, so that the difference in the water content between fresh sludge and decomposed sludge must to some extent be regarded as a measure of the completeness of the decomposition.

"The most important element making for the separation of water from decomposed sludge is the contained gas. The gas in decomposed sludge under thirty feet of water sustains a pressure substantially twice that which acts upon it when it comes to the surface. Immediately on release of the water pressure, the confined gas swells and the sludge becomes frothy and foamy. The water being heavier, sinks to the bottom, passes down through the medium and drains away. This phenomenon may be illustrated in a very simple manner. If a glass beaker of decomposed sludge freshly drawn from an Emscher tank be permitted to stand for a few hours, it will be observed that the light and gas-containing portion will rise to the surface, incidentally increasing the depth. Meanwhile, the clarified water will have settled to the bottom. An examination of the floating matter shows the presence of many gas sacks or cells. In the course of time, a portion of the sludge, having lost its gas content, will sink to the bottom, thus indicating that this sludge, without the increased buoyancy given it by entrapped gases, is heavier than water. If, on the other hand, fresh sludge be placed in another beaker, its solid contents will settle to the bottom, and if it be examined later, it will be found that the separated water is at the top instead of at the bottom. In this lies a most important difference.

"Accompanying the destruction of the colloidal and organic matter, is a partial decomposition of the fats. In European sludges the fat content will average ordinarily 15% of the dried constituents."

The difference between good and bad sludge is defined; the effects of metallic salts upon sludge and of acid-forming ingredients are observed.

The paper goes on to enumerate the recommendations of Prof. Hyde and Mr. F. E. Daniels as essentials to be observed in the operation of a sewage treatment plant:—

1. If the velocity in the feeding channels be not sufficiently high to be self-cleansing, the deposits should be swabbed out semi-weekly in summer and less frequently in the colder season. If they become septic they are a source of disagreeable odors. Such deposits in feeding channels in which the flow is periodically reversed, are more likely to be found at the inlet end because of the diminished velocity there.

2. With equal frequency, too, should the sides and sloping floors of the sedimentation chamber be cleared of adhering matter. On floors of flat slope and rough finish the accumulation is most rapid; on others it is less so None are entirely immune. Instances have occurred in which the slots leading to the sludge digestion chamber have been completely choked by this matter. Ebullition of gas from the upper chamber is evidence that it has begun to septicize. A long-handled squeegee should be employed to clean the surfaces and to push with the least disturbance possible, the accumulations into the chamber below.

3. The tendency on the part of scum to collect in gas vents is well known. Since this scum must have been previously heavier than water, its later buoyancy is due in the main to the entrapped gases of decomposition. It will be seen that an existing scum tends generally to become thicker since particles that float up adhere to the mass of accumulations already floating and remain. Otherwise on losing their gas content, they would sink again. Scum formation tends to be greatest where evolution of gas is greatest. This state occurs usually in the comparatively early history of the life of plants when a mass

Sedimentation Tanks in Canada

Hydrostatic Head on Sludge Outlet	Sludge-Drying Area	SUPPLEMENTARY PLANT	Separate or Combined System	Capacity of Plant, Gallons per day	Cost of Plant exclusive of Sewers	DESIGNER	REMARKS
5 ft.	1,200 sq. ft.	Chlorination plant, sludge beds	Separate	1,080,000 (Imp.)	$8,800	T. Aird Murray and T. Lowes, Toronto	Sewage is chlorinated before entering tanks
6 ft.	4,680 sq. ft.	Grit chambers, sludge beds	Combined	1,500,000 (Imp.)	$35,000	Eng. Dept. City of Edmonton, A. J. Latornell, Chief	Filters to be added. Reversible flow
6 ft.	10,900 sq. ft.	Screens, grit chamber sludge pump, sludge beds, percolating filter (future).	Combined	5,880,000 (Imp.)	$70,000	A. F. Macallum and B. E. T. Ellis, Hamilton	Flow is reversible
12 ft.	625 sq. ft.	Grit chamber, pumping station, force main, sprinkling filters, sterilizer, secondary settling plant, sludge beds	Separate	270,000 (Imp.)	$15,000	A. K. Mitchell, Victoria	Vent is provided over central stack. Cost given is exclusive of pumping station
7 ft.	60,000 sq. ft.	Pumping plant, sprinkling filters, final settling plant, sludge beds	Separate	6,000,000 (Imp.) maximum	....	R. H. Parsons, Peterboro	Sterilizing plant may be added
7$\frac{3}{8}$ ft.	....	Screens, grit chamber, sprinkling filters, sludge beds	Both	1,350,000 (Imp.)	$15,500	A. B. Manson, Stratford	....
6 ft.	1,050 sq. ft.	Percolating filters, secondary settling tanks, with sub-irrigation sludge beds	Separate	540,000 (Imp.)	$19,000	Murray & Lowes, Toronto	....

of sludge has accumulated, most of which is in active decomposition and none of which, or practically none of which, is as yet decomposed and inert. Insufficient scum area or gas vent area will intensify the trouble.

Excessive depths should not be permitted, and need never occur if the scum is persistently broken up from time to time as it forms. A garden rake, or better still, a pressure hose will accomplish this satisfactorily, and since much of the entrapped gases are permitted thereby to escape, the bulk of the material will sink to the bottom. It has been observed also that the occasional discharge of water under pressure through the flushing pipes in the sludge digesting room will mitigate the scum evil. Materials which defy all attempts to settle should be skimmed off and buried or burnt. This last statement applies also to floating materials which are always observable near the baffles and along the walls of the sedimentation chamber. It should not be forgotten that if sewage fresh on its arrival at the works is to be found still fresh on its discharge from the sedimentation tank, its contained solids with their ready capacity for decay must not be permitted to lodge or remain in the upper chamber.

4. In tanks designed for the purpose, reversal of flow should be made monthly.

5. Determinations of the depth of sludge in the lower chamber should be made weekly. This is very conveniently done by lowering through the gas vents by a gradual cord, a disk of No. 20 B. & S. sheet steel, of diameter 15 inches, suspended at three points, so that its plane is horizontal. Its weight in air is about two pounds. The surface of the sludge can be rather closely ascertained through the support which it affords to the disk. The surface should not be permitted to rise higher than 18 inches below the slots at the bottom of the sedimentation chamber. It is observed that when this rule has been disregarded ebullition of gas is often observable in the upper chamber. This phenomenon is doubtless due to the fact that the stratum of mobile and gas-charged liquid overlying the sludge proper has been sufficiently thick to submerge the slots and thus permit some of the escaping gas to enter the settling chamber.

6. If the tank be supplied by pumps whose capacity exceeds the inflow of sewage and which in consequence must operate intermittently, the quantity pumped at each operation should not exceed, and preferably should be less than the volume of the sedimentation chamber.

7. Care must be exercised in the drawing off of sludge that neither fresh sludge nor the overlying sewage be permitted to escape. Thoroughly rotted sludge can always be detected by its color and smell, especially the latter. When a sludge gate is opened, there is always a tendency for the sludge in the immediate vicinity of the lower end of the discharge pipe and whatever overlies it, to be forced out by the weight of the water above. This results from the fact that the semi-liquid mass moves vertically in the centre of the sludge pit with less friction than it can move in the inclined direction along the sloping floor. In consequence, the sludge occupying the figure of an inverted cone lying over and above the lower extremity of the pipe is first forced out, and if care be not taken the liquid above this will soon follow. To avoid this, only small quantities of sludge should be drawn at a time. After the gate is closed the sludge mass will find its level again, especially if the flushing pipes previously referred to be brought into service. The water escaping from these has the effect of assisting and lubricating the movement of the rotted sludge down the slope of the chamber floor toward the extremity of the sludge outlet pipe. Sufficient of the contents of the sludge digestion chamber should be left to insure continuity of the rotting process.

8. To prevent the sludge pipe becoming filled with solidified sludge, after each drawing off, the pipe should be filled from its upper end with water. Similarly if all sludge chambers are cleansed after use with water under pressure or otherwise, both appearance and operation of the plant will be improved. Water under pressure is a great convenience for operating pressure rings in the sludge room, for backfilling sludge discharge pipes after use and for cleansing sludge channels. In cases where secondary sedimentation tank sludge is to be pumped back to the primary sedimentation tank, the pumping unit may be arranged to handle clarified effluent which may then be utilized for the various purposes for which water under pressure may not be available.

9. The depth of sludge run on to drying beds should not exceed 12 inches. After drying, its depth is reduced to about 6 inches. To facilitate the passage of water downward, care should be taken that the surface of these beds has not become clogged through too constant and continuous use.

A description of the Kremer apparatus, providing a method to remove the grease which the sewage to be treated contains, is also given.

Prof. Gillespie gives some very interesting descriptions of typical plants, including Bergedorf, near Hambourg; Essen-Nord; Atlanta, Ga.; Schenectady, and others. A section of the paper is devoted to a discussion of Dr. Imhoff's patents in the United States and Canada, and another to the reception in America of clarification tanks of the Emscher type. In concluding his remarks thereon, the writer states:—

"When it is considered that the Emscher tank has been tried out for seven years in Europe and for three years in America, it is safe to say that it is well past the experimental stage. The history of its operation on these two continents, and the testimony of engineers who have studied it at close range, constitute its vindication. The list of municipalities which have either installed or proprose to install it in America, furnishes additional evidence as to its reception on this side of the Atlantic. While it does not represent a method of disposal complete in itself except in special instances; while it is not easy to construct, is not fool-proof in its operation, and is not either initially or afterwards the least expensive of the appliances from which the engineer may choose, it offers, in the opinion of the writer, the most satisfactory solution for the troublesome sludge problem which up to the present has been proposed."

His paper closes with a list of places in America in which the 2-story sedimentation tank has been or is to be installed. From his list we extract the following as a list of installations in Ontario: Barry Tannery, Bowmanville, Carleton Place, Copper Cliff, Cornwall, Dundas, Guelph Prison Farm, Hamilton, Leaside, New Liskeard, North Toronto, Oakville, Peterborough, Port Arthur, Rockwood Asylum (Kingston), Simcoe, Stratford, Toronto, Vankleek Hill, Vineland Canning Co. (Vineland), Weston, Whitby, Whitby Hospital for the Insane.

The other Canadian installations are: in Saskatchewan, Battleford, Canora, Humboldt, Regina Jail, Saskatoon, Kamsack, Estevan and Battleford hospital; in Alberta, Calgary and Edmonton; in British Columbia, Kelowna and Vernon.

ECONOMICS OF ELECTRIC RAILWAY DISTRIBUTION.*

By Horace Field Parshall, D.Sc.

PRACTICALLY all modern traction systems of the larger class are referable to the same class of power house and transmission system, and these are not affected to any important extent by the sub-station arrangement, which is determined with reference to variations in the operating result occasioned by the spacing of the capacity of the individual sub-stations.

In the book by Mr. Hobart and the author on "Electric Railway Engineering," most of the problems entering into the design of electric railway installations have been dealt with. The question of the economic arrangement of sub-stations and the distribution conductors was not dealt with at length, because at the time the book was written sufficient operating data were not available to furnish a basis for different calculations. Such a wide difference of opinion existed between different engineers as to the cost of operating and maintaining a system of sub-stations that it did not appear advisable to treat the subject except on general lines. Since the publication of that book a great deal of experience has been gained, as a result of which engineers have come into more general agreement as regards sub-station practice. The present paper is written with a view to assist towards the standardization of electric railway sub-station practice. Many years ago Lord Kelvin formulated a law as to the economic use of conductors in transmission systems. The number of independent variables when a complete system with sub-stations has to be dealt with is so great that the mathematical expression, from which might be deduced the minimum cost, would in practice be open to some suspicion. In this paper a complete balance-sheet embodying every item has been worked out for each case, and the tabulated result is included as a part of the paper; hence, for different conditions it would be possible for an engineer to make the necessary corrections, so that, without any great amount of labor, the methods and results of the paper may be applied to practically any class of electric railway installation. The paper has not been extended to include the electric traction installation as a whole, since the process of standardization in respect of motor equipments is still proceeding, and conclusions that might be drawn under present conditions would in another short time be incorrect. So far as the distribution is concerned, the conclusions are likely to be lasting, since the operating conditions on which the general results are founded are likely to obtain for a considerable time to come.

With the given energy-consumption per unit of length of line that follows from a given train-movement, the capacity of the substances increases indirectly with the distance between them. The energy-loss in distribution-conductors of a given section varies with the cube of the distance between sub-stations. The cost of attendance is within wide limits independent of the size of the sub-station. The cost of the plant per kilowatt falls off with the size of the units, but the maintenance and renewals per kilowatt are more or less constant. The paper embodies a series of curves showing graphically the arrangements of substations that will operate different train services on different electrical systems and at various voltages with a minimum total operating cost. With rotary-converter sub-stations and a working voltage of 600 volts, and for certain assumed average conditions of train-weight, speed, and energy-consumption, the most economical sub-station spacings are 8½, 5½ and 3¼ miles for train services of 6, 12 and 24 trains per hour respectively. For a working voltage of 1,200 volts the sub-station spacings are 11, 7½ and 5 miles respectively, while when 2,400 volts is adopted the most economical sub-station spacings are 16, 12 and 8½ miles for the three train services respectively. Curves are also given illustrating the advantage gained by working at higher voltages, and these confirm the author's view that with the present arrangement of rotary-converter sub-stations, there is little advantage in a higher voltage than 2,400 volts for the track conductor. The economy of higher voltages is shown to be approximately the same whatever the train service. As between 600 and 1,200 there is a saving of 14 per cent. in the total annual costs of the distribution system; as between 1,200 and 2,400 volts there is a further saving of 7 per cent., or 21 per cent. as between 600 and 2,400 volts. If the working voltage is further increased to 3,600 volts, there is a decrease in total annual expenditure on sub-station and overhead conductor equipment of only 3 per cent., which will be less than the additional cost of the rolling stock.

For single-phase distribution at 5,000 volts the most economical sub-station spacings are 31, 24 and 16 miles for train services of two, three and six trains per hour respectively. At 10,000 volts single-phase, the most economical sub-station spacings are 45, 34 and 26 miles for the same three train services respectively. With three-phase distribution at 5,000 volts the most economical distances between sub-stations are 38, 31 and 18 miles for the same respective train services. In most of these last cases, however, the economical distance between sub-stations thus determined is greater than would be permissible in practice from considerations of both traffic operation and voltage drop. Further, in the case of single-phase operation, the lower pressure of 5,000 volts is found to be the most economical for certain services and the higher pressures of 10,000, 12,000 and 15,000 volts in vogue on the continent are explained by considerations of voltage drop.

*Abstract of a paper read at a meeting of the Institution of Civil Engineers of Great Britain, Nov. 17, 1914.

POWER SURVEY OF CANADA.

The Commission of Conservation is compiling data respecting power used in the Dominion. A circular has been issued to power users and manufacturers requesting information regarding the consumption of power. The questions asked cover the field fully, embracing water power, electric power, steam power, gas engines, and oil engines, and each division solicits answers which, if given with any degree of enthusiastic co-operation, should place the Commission in the position of being able to compile information that will be found of great value by Canadian engineers and manufacturers. It is to be hoped that those to whom blanks have been sent will furnish the fullest possible information and that any of our readers who may not have been approached by the Commission, will apply for a blank to the Assistant to Chairman, Commission of Conservation, Ottawa. The compilation entitled "Waterworks of Canada," published in December, 1912, has proved of signal value, and it is to be expected that the data which the Commission has now set itself the task of collecting, will have an even greater field of usefulness throughout the country.

CONCRETE CONSTRUCTION AT CEDARS RAPIDS, QUEBEC.

On December 17th the Canadian Society of Civil Engineers will have under discussion at its general meeting the paper read at a former meeting (October 22nd, 1914) by Mr. John E. Conzelman, chief engineer of the Unit Construction Co., Montreal. This paper had to do with the system of unit concrete construction employed in the erection of the power house and transformer stations of the newly completed hydro-electric plant of the Cedar's Rapids Manufacturing and Power Co. *The Canadian Engineer* has presented, in previous articles, the general details of design and construction of this development, and we abstract herewith some notes on the above method of construction, from Mr. Conzelman's paper, believing it to be one conducive to some very interesting and valuable discussion.

For the essentials of the layout our readers are referred to issues of this journal for January 1st, 1914, and July 9th, 1914. It will be remembered that the superstructure of the power house is built over the dam and that it is of structural steel frame construction with reinforced concrete floors, walls and roof. It was originally intended to construct the walls of brick, but unfavorable transportation facilities, etc., effected a change in the plan, the result being a decision to use concrete throughout.

The power house is about 643 ft. long x 125 ft. wide, with 35 bays 16 ft. 8 in. long and 3 special bays 18 ft. 4 in. long. Fig. 1 shows the typical section. The exterior walls are 12 in. thick, consisting of two independent 4-in. concrete slabs with a 4-in. air space between. The steel columns were provided with slots to receive the slabs (which were lowered down from the tops of the columns) and after two opposite slabs had been set, they were held apart by a piece of one-inch plank which fitted into notches in the slabs. This board also served as a form for the grout which was poured into the space between the column and the slabs. The purpose of this grout is

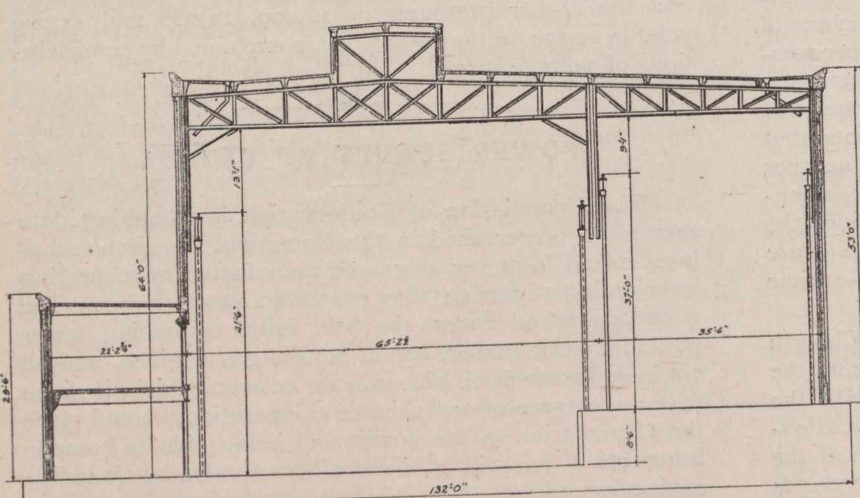

Fig. 1.—Section Through Power House, Cedars Rapids, Quebec.

to hold the slabs in place and also to protect the columns against corrosion. The construction is shown in Fig. 2.

Fig. 1 shows the form of roof construction. The roof units consist of a reinforced concrete plate 3 in. thick cast integral with the beams, which are carried around the four sides. The units are 16 ft. 6½ in. long and 16 in. deep over all. The entire unit acts as a beam between trusses; the reinforcement in the beams acting as the tension flange and the entire slab providing compressive strength. A uniform distribution of load on the trusses is assured by the stiff end beams of the units, and the mortar bed upon which the units are set. The roof units are so dimensioned that a space one and a half inches wide is left between the ends and over the centre line of the trusses. These spaces, as well as the spaces between the slabs themselves, are filled with grout. Reinforcing

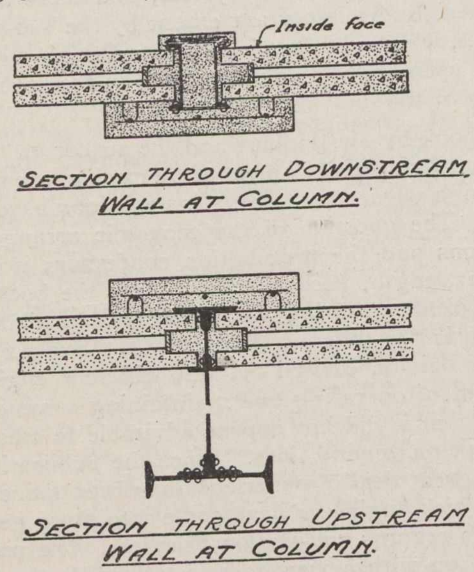

Fig. 2.

bars 3 ft. long are placed in the space between the units and extending over the trusses. These fars form an effective tie after the grout has hardened. Concrete saddles were formed on the roof for the purpose of directing the water to the downspouts. The roof covering is 4-ply Barrett specification material mopped directly to the concrete.

The steel work was erected by the Phœnix Bridge and Iron Works Co., Montreal. The roof trusses are designed to carry a load of 100 lbs. per sq. ft., and the crane girders and main aisle columns are designed to carry two electrically operated travelling cranes of 150 tons capacity. The high columns were spliced at the level of the crane girders. All connections, except the butt joint between the ends of the crane girders, were riveted. One expansion joint was provided.

Erection of structural steel and concrete units was done by means of a structural steel stiff-leg derrick mounted on a triangular steel tower 60 ft. in height with an 80-ft. boom. The weight of the heaviest steel member was about 5¾ tons and of the heaviest concrete unit, 8 tons. Each unit was provided with lifting hooks or bent steel bars for the purpose.

The reinforced concrete transformer house is a 4-story building with basement, and is supported on spread footings with concrete curtain walls. The foundations rest on hard clay about 7 ft. below grade, and each footing carries a load of approximately 4,000 lbs. per sq. ft. Fig. 3 is a typical section. The building is 228 ft. long and 88 ft. wide. It comprises 10 bays 20 ft. long and 4 bays 7 ft. long. A special column spacing was necessary as the transformers are arranged in groups of three. Instead of the typical spacing of 20 ft. and 7 ft., as noted above, a length of 47 ft. was divided into three equal spaces of 15 ft. 8 in. Above the third floor typical spacing was used.

Heavy construction was used in the ground floor to support transformers estimated to weigh 75 tons, together with handling equipment necessary for their installation. The upper floors were designed for a live load of 250 lbs. per sq. ft., except where special loadings occur. The roof is designed for a load of 100 lbs. per sq. ft.

In this building the exterior walls are of concrete slabs 10 in. thick with a 2-in. air space, formed by means of a sand-core which was washed out before the unit was set. The basement walls are 12 in. thick and of reinforced concrete.

The concrete units were brought to the building on flat cars from the unit yard located some distance from the site. The casting yard was provided with a track about 400 ft. long down the centre from which a locomotive crane with a 50-ft. boom handled distributing buckets of controllable discharge type to forms disposed on each side of the track for a width of 50 ft. The effective area of the casting yard was 36,000 square feet.

There are 3,916 units in the power house and 1,602 in the transformer house, the total amount of concrete being 6,111 cu. yd.

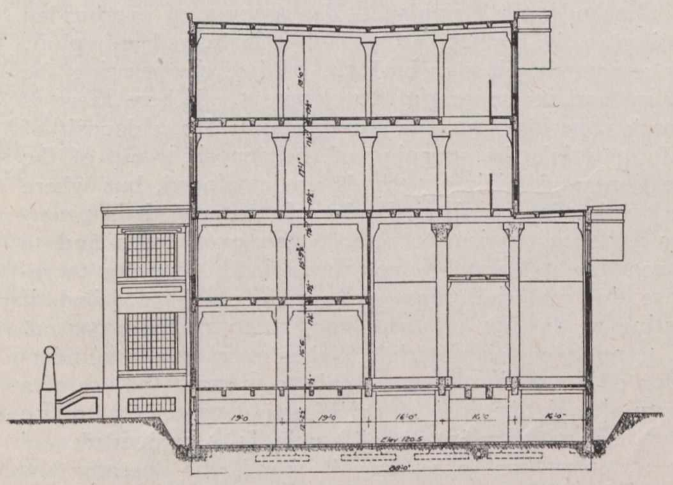

Fig. 3.—Section Through Transformer House.

In his paper Mr. Conzelman presents some very interesting information respecting details of unit construction and laboratory tests covering them. In closing he claims as a chief advantage for the method the fact that the units may be made under what may be called factory conditions. The forms can be strongly built and carefully bedded. The system provides for easy inspection and test, if desired, before incorporation into the intended structure. The reinforcement is easily held into proper position. There is also more certainty, according to the writer, in a unit design as the loads are carried by a definite system of units, and the joints occur exactly where a designer wants them. Although unit methods are not advisable for all reinforced concrete structures, they were recommended by Mr. Conzelman for those consisting of a series of similar bays involving considerable duplication of parts. Again, as in the case of the Cedars Rapids power house, it is often advantageous to cast the units sometimes before foundation is ready to receive the superstructure.

At the recent convention in Jacksonville, Fla., of the American Public Health Association, the convention city for 1915 was chosen to be Rochester, N.Y.

ENGINEERS FROM THE CONTRACTOR'S VIEWPOINT.

In an address delivered to the Albany Society of Civil Engineers, Mr. Richard W. Sherman, chief engineer of the New York State Conservation Commission, notes the impossibility of complete harmony existing always between engineers and contractors, and attributes this to the fact that they represent opposing interests in a considerable degree. The engineering graduate starts with an educated prejudice against contractors, whom he believes to be, in the main, determined to get the best of engineers, and therefore he is on his guard and purposes not only to take care of himself but to get the best of the contractors.

Contractors dread the "boy engineer" just from college. These young engineers are extremely technical. They expect a literal compliance with every iota of the contract obligations by the contractor.

With rare exceptions, men greatly improve in learning, wisdom and disposition as they grow older. After 20 or 30 years, a man is surprised to find how little he knew when he started his professional or business career. He has grown in riper judgment, and has developed greater caution, discretion and justice toward others. He grows considerate, amiable and kind.

Contractors are largely influenced by their opinions of engineers. The engineer who has a reputation for ability, honesty, fairness and good disposition will attract bidders for any work of which he has charge and the desire to do work under him would be an incentive to reasonably low prices. It is a feature of contracting to "size-up" the engineer with as much accuracy as possible.

In bidding for work, contractors are almost as sensitive as weathervanes. It may be possible to make a profit at a given bid under one engineer and impossible to avoid a loss under some other engineer, with all other conditions similar and the quality and the merits of the work constructed being equally good at the same cost to the owner in each case.

A majority of bids are too high. The highest bid is often twice as much as the lowest even when the lowest is sufficient. Over-anxiety to secure the contract is the commonest cause of low bidding. Low bids are often made to keep a contractor's organization together for future work on which he hopes for better prices.

Contractors who do not care for the contract often bid fairly high up, without any expectation of securing the contract but merely to avoid a reputation among contractors of being low bidders, and with the bare chance of getting the work at good prices. Excessively high bids are usually the result of lack of knowledge of the value of the work and lack of time to become familiar with it.

If an engineer's preliminary estimate is believed to be too low, it drives away bidders and tends to indifferent, high bidding. Some over-anxious contractors may be influenced thereby to bid too low. They may secure the work, in which event the engineer has an unpleasant task during construction. There is almost sure to be a disposition on the part of the contractor to save himself from loss and he is thus tempted to slight the quality of the work. Both contractor and engineer are in some degree injured by the work having been done at less than cost.

An engineer who can make reliable preliminary estimates will find his services in demand by municipalities, corporations and other owners, or if he chooses to practice as a contractor's engineer, he will find his services of great value in that field. Some prominent engineers of my acquaintance would not under any circumstances do engineering work for contractors, confining their services entirely to the owners. I know of other engineers who confine themselves wholly to engineering for contractors and who do a large business as engineering experts for contractors, in litigations.

These two fields of engineering are becoming more and more distinct and it is my opinion that an engineer is wise who makes his choice and adheres strictly either to the one line of practice or to the other.

The contracts and specifications on very large and important works usually are models of perfection. In smaller works, such as may amount to, say, not over $200,000, contractors are often confronted with bidding papers, contracts, specifications, plans, etc., which are a disgrace to the engineer who drew them.

There are a few engineers who are sometimes called "specification fiends." They write to many places, where work is advertised, for specifications, etc. They read them eagerly and often clip such paragraphs as catch their fancy—usually those which are harsh, severe and unreasonable from a contractor's standpoint. With these clippings to aid them, they draw up specifications, etc., which often deserve the name of "crazy-quilt" specifications.

Such papers are full of contradictions, useless paragraphs and ambiguities which are almost sure to cause contention and trouble during construction and in the final settlement, or lead to litigation. Such engineers are apt to insert severe conditions such as excessive cash deposits with the bids, unreasonably short time in which to construct the work, excessive per diem liquidated damages for overtime, excessive bonds and sometimes excessive retained percentage where monthly payments are provided. About all they can think of is to make the work undesirable and objectionable to contractors. Such engineers and their work are often avoided by the best class of bidders and the contracts are apt to go to rather undesirable contractors.

PROGRESS ON QUEBEC BRIDGE.

At the annual meeting of the Dominion Bridge Co. held last week it was stated that on December 1st about 42 per cent. of the steel for the superstructure of the new Quebec bridge had been fabricated, and about 18 per cent. erected. It is anticipated that the work will be finished in good season, and within the original estimates of cost.

INVESTIGATIONS OF EXPLOSIVES USED IN COAL MINING.

The United States Bureau of Mines have carried on a number of investigations into the nature of the explosives used in mining operations, with a view to changing the character of explosives so as to meet the needs of the various branches of mining, and especially to increase safety in coal mines. Both the improper use of explosives and the use of improper explosives have resulted in coal-mine disasters. The investigation of explosives is also important to metal miners, whose health and efficiency are seriously affected by the use of improper explosives, but the bureau has not yet had the facilities for taking up a thorough investigation into this latter phase of the subject.

THE STRIPPING, QUARRYING AND MINING OF GYPSUM.*

THE methods employed in the exploitation of gypsum deposits are generally of the simplest. The operations consist of stripping, quarrying or mining, and transportation. There are, however, several important points that have to be taken into consideration when opening up a quarry, which, if not considered, would be liable to seriously handicap an operator in competition with his neighbor. A deposit of gypsum may be everything that is desired in the way of quality and extent, but still may not be capable of being worked economically on account of its distance from shipping facilities, ready market, and also its heavy overburden. Its location also with respect to the drainage of the surrounding country may necessitate a heavy expense in keeping a quarry free from water, so that this factor has in some cases to be taken into account. Another factor that influences the operation of a quarry is the availability of a steady supply of labor. When steady labor is obtainable, better work can naturally be accomplished, and new and improved methods can more readily be taught the quarrymen when they are working continuously instead of spasmodically.

Methods of Stripping.—The amount of overburden resting on the gypsum beds which it is desired to exploit, has a great bearing on both the method of operating the quarry and its successful development. Where there is a rock covering over the gypsum and also a deposit of drift material, the stripping of the deposit is out of the question, and mining methods are employed, but where the overburden consists of only soft material, it is generally more economical to remove this overburden and to extract the gypsum by open quarrying. In order to remove this material, great expense has to be entailed, it costing at the present time from 20 to 25 cents per cu. yd. to remove such material. When operations are undertaken on a sufficiently large scale to warrant the use of a steam shovel, the cost of stripping is between 15 and 20 cents, but where only a small quarry is to be opened, and the stripping has to be done by hand, the operator has to consider very carefully what depth of an overburden he can reasonably afford to remove, as in many cases the cost would be so excessive that a quarry could not possibly be worked at a profit.

The methods of stripping usually employed in gypsum practice are: Hand, horse scrapers, and steam shovel.

It is only in very small quarries, or where the material to be stripped is very light, that the work is done by hand. The work has naturally to be carried on during the summer months, as the frost would make the price during the winter months prohibitive. When the dirt is removed by hand, it is shovelled into carts and hauled to the nearest dumping ground, or else it is allowed to cave into the quarry and then sorted from the gypsum and carted away. This latter practice is greatly to be condemned, as the loose waste cannot help getting mixed with some of the white rock, impairing its value for plaster manufacture. It is a practice that is, however, very prevalent, even among some of the larger operators, and is only due to the fact that the Canadian gypsum is of such a high grade that no notice has so far been taken of it.

*From "Gypsum in Canada," prepared by L. H Cole for the Department of Mines.

The horse scraper method has been employed successfully in the deposits in northern Manitoba to remove overburden. These horse scrapers are similar to those used by railway contractors in railway construction work. The nature of the deposits there lends itself admirably to this mode of operation. The surface covering in these northern deposits consists of about 3 feet of clay and loam, loosely cemented together by gypsum, and this material readily breaks up before the scraper, and can then be hauled and dumped into any of the numerous sinkholes which are scattered through all the deposits. This has proved a very satisfactory method for the removal and disposal of the waste material.

In the larger quarries, the steam shovel is gradually coming into use for the removal of the waste material which lies on top of the gypsum. Only in late years, however, have these appliances been employed to any extent. Where the overburden is of any great thickness, the waste material is removed in benches by the steam shovel working on the top of the deposit. In that case a track is generally laid alongside the shovel, and the shovel loads directly into cars, which can then be hauled to wherever the best dumping ground is available. This method proves satisfactory to a certain extent, but considerable material is allowed to fall into the quarry, there to be removed by hand, or else by a second shovel. A second method, sometimes employed, is to remove the overburden over a bench of gypsum, to operate the shovel on top of this bench, and then clean off this bench by hand and carts. This method leaves the greater portion of the gypsum free from danger of being mixed with the waste material.

Hydraulic Stripping.—In many of the gypsum deposits of Nova Scotia and New Brunswick the overburden which rests on the gypsum is of considerable thickness. The present method of removing this waste material is, as already stated, by hand labor, horse scraper, or steam shovels, and this entails a great expense, and in many cases materially reduces the small margin of profit upon which the quarries are operated, or actually causes their shutting down. As this overburden is in all cases composed of loose material, it would seem that stripping of the gypsum beds by the hydraulic method would not only, in many of the quarries, be feasible, but would also greatly reduce the time required and the cost in handling. In order to bring this matter to the attention of the gypsum operators throughout the country, Mr. Cole inserts the following notes on hydraulic methods in his report:

Conditions Required.—Unlike the methods required and employed by most of the large hydraulicking companies of the west, hydraulic methods, when used for the purpose of removing the surface coverings to enable the rock underneath to be mined or excavated, have to be greatly modified to meet the altered conditions. In the first place, the wash from the monitors does not have to be saved, and hence the material can be conveyed in sluices greatly simplified from those which have to be prepared for the gold-bearing gravels. The shortest and most convenient form of sluice leading directly to the dumping ground will answer the purpose, regardless of slope (or grade) or curves.

Then, again, in most cases, when used for the stripping of gypsum, the nozzle pressure of the water would have to be obtained by means of a high pressure pump of large horse-power, and although this would be the greatest expense of the whole installation, it would do away with an extensive and expensive flume or pipe line, as the contour of the country is not such as to enable a high head of water being obtained except by this means.

The supply of water required would be one of the greatest factors in the installation, but this, in most cases, could be overcome by using the water over and over again.

The matter of a dumping ground for the waste material would be one of considerable difficulty, especially where the material was to be sluiced directly to it, but if no convenient place were available for direct sluicing, the waste material could be readily handled by a pipe line and a relay of centrifugal pumps, which would place it in any of the old abandoned quarries nearby.

In phosphate mining in Florida, hydraulic stripping is being employed to great advantage, at a cost of from 5 to 8 cents per cu. yd. of material moved. In the same district, where steam shovels are employed, the cost is 20 cents per cu. yd.

A modified form of hydraulic stripping is being made use of by the Nipissing Mining Co., of Cobalt, Ont. There it is employed to wash the surface covering of drift from the rock, in order to examine the rock closely for the small veins which sometimes would be overlooked by ordinary trenching. A turbine pump is employed, guaranteed to throw 4,800 gallons of water per minute, under a head of 415 ft., through a 3½-in. nozzle. The pumping plant consists of a 675-h.p. turbine pump connected directly to a motor. The water is piped to the point required, and is there forced through a 3½-in. nozzle at high pressure. A space is first cleared by this means, after which the ground is sluiced down in benches, thus, as soon as a certain section has been examined, it is covered over again with the tailings from the section above. The ground slopes gradually towards Cobalt Lake and the water drains back again into the lake from which it is pumped in the first place.

The application of hydraulic stripping to gypsum overburdens is very simple. The water is obtained from the nearest and most constant source of supply and is forced through a pipe line by an approved form of pump, so that a pressure of from 90 to 150 lbs. per sq. in. is obtained at the nozzle of the monitor. A nozzle which delivers a stream of water at the required pressure is placed conveniently near the overburden to be removed, and the stream playing on the soft drift soon disintegrates it and it is then sluiced away by the running water to the dumping ground. If no dumping area is available near at hand, the sump method can be employed, where a sump is made in the floor of the quarry at a convenient spot and the waste material all washed into it. A series of centrifugal pumps and a pipe line are easily installed to keep the sump empty and remove its contents to the nearest permanent refuse pump.

Installation Required.—The following list will cover practically all the machinery and material required for stripping by the hydraulic method: (1) Pumps (*a*) high pressure pump, (*b*) centrifugal relay pumps; (2) pipe lines (*a*) mainpipe line, (*b*) discharge pipe line; (3) monitor (nozzle); (4) sluices; (5) special ball and socket joint, etc.; (6) operating motors and power.

In Mr. J. A. Barr's article on Florida phosphate practice (M. and M., Dec., 1912, p. 265) he gives the following paragraph descriptive of the present practice in pumping machinery in Florida for this type of work:

"The earlier and present universal practice is to use direct acting compound or triple expansion pumps for furnishing water to the hydraulic nozzles at the mines and to the washer. The Florida Mining Co. has a triple expansion pump capable of furnishing 4,000 gallons of water per minute, which it delivers at a pressure of 150 pounds per square inch. The Prairie Pebble Co. uses a somewhat similar pump made by the Worthington Co. Their pumping plant consists of three triple expansion, duplex, direct acting pumps, size 12 in. x 19 in. and 30 in. x 17 in. x 24 in. These pumps have a capacity of 2,800 gallons per minute each.

"The only centrifugal pumping plant that supplies water to the pipe nozzles is installed by the new French company. This company uses a three-stage turbine pump, direct connected to a 250 horse-power induction motor, and it delivers water to the nozzles at a pressure of 140 pounds per square inch. The experience with this pump in the field has been that when new, it was very satisfactory, but when pumping gritty water, such as must be the case in most of the mines, the pump lining soon wears, and the pump has a low efficiency.

"The newest pumping stations being built contain the Corliss flywheel condenser pump. The principal advantage of this pump for this kind of work over the direct acting pump is principally its high duty, which often is at least one-third more. The duty of the direct acting pump seldom goes over 90,000,000 gallons, while that of the Corliss flywheel pump approximates 120,000,000 gallons in 24 hours. The flywheel pump is less liable to become broken by the failure of the governor to act, or by bursting of the pipe line."

Where the waste has to be transferred from a sump to a dumping ground at a distance, the pumps employed are generally centrifugal pumps of an approved type. To obviate the trouble always encountered when two or three of these pumps are operated in tandem, the best practice is now to make each pump in the relay act independently by delivering into a series of sumps from which the following pump draws its supply.

Pipe Lines.—For the pipe line for the delivery of the water to the nozzles, a 10-in. steel spiral pipe is being employed, and this has been found to work very satisfactorily. There is, however, no reason why other styles of piping could not be used. For the last few hundred feet of piping before the nozzle is reached, a 6-in. flanged, spiral riveted, galvanized water pipe is employed.

When the pipe line is used for removing the waste material from the sump, any approved kind of piping that will stand the wear and tear of gravel, etc., passing through it, can be employed.

Nozzles.—Any of the smaller types of hydraulic monitors that are in use in gold hydraulicking methods can be employed in stripping. From 3½ in. to 4½ in. in size would suit.

Sluices.—The sluices for hydraulic stripping can be of the simplest type, and in many cases no sluice is required at all, as the natural gullies in the rock will be sufficient to carry the waste material to the required dumping ground. Generally small trenches are dug, or else temporary sluices are built which very well answer the purpose.

Special Ball and Socket Joints, etc.—In order to facilitate the easy moving and handling of the monitor from place to place, a special form of ball and socket joint is generally employed in the 6-in. pipe. Several of these are placed in a length of from 400 to 500 ft., and this gives the nozzle sufficient play so as to cover a large territory. Several other special attachments are required, such as a joint to keep the pump from being broken by water hammer, and special suction pipes, etc.

Power and Motors.—The question of power for operating the pumps is a matter of considerable interest. In many of the properties electric power could readily be generated, and current delivered to the motors, which are directly connected to the pumps. Where coal is cheap, steam could be used for generating this power. In some localities, water power could be obtained.

Quarrying or Mining.—The consideration of the best means of the exploitation of gypsum is a matter which up to the present time has not been a serious factor in the development of a deposit. In the maritime provinces, and also in the west, the largest deposits of gypsum are all comparatively near the surface, with only a covering of loose material which can easily be removed, but which would not hold up if undermined. Consequently the only method in most cases is to remove the gypsum by open quarries. This method has a number of advantages over underground mining, which have been greatly to the benefit of the gypsum operators. These advantages may be stated as follows:

(1) Easier supervision. A better idea can be obtained of the class of material that is being quarried.

(2) Better ventilation, as the men are always working in the open air.

(3) Easier handling of the gypsum.

(4) No timbering is necessary, and all the material can be extracted, as no pillars have to be left.

Its disadvantages are few, the principal one being the exposure to all the different kinds of weather, thus hindering the work, and the danger of exposure of the men to heavy rain, snow, or extreme cold.

Quarry Work.—As a rule most of the quarries operating in gypsum have no regular shape, and nowhere does any systematic method seem to have been employed. It has generally been a case of taking the gypsum from wherever it occurred, without any regard to future economy in working. In consequence many of the quarries are just a series of pot holes, with no two parts of the quarries alike. Thus much time is lost by the repeated handling of the gypsum, when in many cases one handling would be sufficient.

The present practice is to obtain as high a face as possible of clean gypsum, and to break it down by caving. This is accomplished by drilling the lower part of the face with auger and hand-power drills, and then blasting the holes with a low-power dynamite, generally about 40 per cent. strength. This brings down a large tonnage of gypsum, which is then broken up by hand sledgehammers to a convenient size for handling. The broken material is hand picked, so as to remove any pieces of anhydrite or foreign matter, and is loaded into small cars or dump carts and hauled either to the mill or wharf direct, or else where there is a railway line, to the nearest siding, where it is dumped into the railway cars.

In the gypsum deposits of northern Manitoba, a steam shovel is being employed successfully to handle the gypsum, thus doing away with the excessive handling which is so frequently met with in gypsum practice throughout the country. After the surface is stripped, the gypsum, which is of a soft variety, is drilled by a series of vertical holes placed regularly at 8-ft. intervals across the working face of the deposit. These holes, when blasted, shatter the gypsum sufficiently so that it can be handled by the steam shovel directly into the standard railway cars, standing on a siding beside the shovel. This method is found to be cheap and economical, and enables a large tonnage to be got out in a very short time.

In all of the gypsum quarries in Canada, the drilling is accomplished by hand power, one-man auger drills, similar to those employed in coal mining practice. They are found to work very successfully, as the gypsum is soft and drills easily. No attempt seems to have been made to install power drills of any sort.

Mining Methods.—Where the overburden is excessive, and consists of a rock capping over the gypsum beds, the deposits are generally operated by underground methods. On account of the small price obtainable for the gypsum, the simplest and cheapest methods have to be employed. The present practice in Canada in gypsum mines seems to be to open up the deposit by an incline tunnel, generally at a slope of 15° to 20°. Why this special method of entrance has been adopted in preference to a vertical shaft is not clear. In the earliest gypsum operations in the country, the deposits were opened up in this manner, and the custom has been to follow the example of these first attempts.

When the bed of gypsum has been reached, main haulage ways are laid out, and the gypsum is recovered by a room and pillar system similar to that employed in coal mines. Tracks are laid to the face in these chambers, and the broken gypsum is loaded directly into cars, which are then taken by hand, or horses, to the main haulage way, where they are made up into trains preparatory to being hauled up the incline by a small hoist. Considerable loss is caused by the fact that the pillars in most cases are composed of good gypsum, which would otherwise be recovered.

Transportation. — Transportation facilities in the quarries are of the simplest nature. In most of the operating quarries in the east, the broken gypsum is loaded by hand into single horse Scotch carts, and taken by them either to the shipping pier, or to the nearest railway siding. This necessitates a great deal of extra and useless handling of the rock before it reaches its final destination. Much time and labor might be saved if a system of radiating tracks were laid through the quarry, and the cars loaded directly at the face.

The method of transporting the loaded material from the quarry to the mill or shipping pier, is, in most cases, by narrow gauge railways, and this affords easy and cheap handling.

Drainage.—Gypsum quarries, as a rule, are seldom troubled with water, but in some places, especially where the level of the floor of the quarry is near the level of the water table of the surrounding country, the problem of handling the water has to be taken into consideration. In this case a sump is located in the lowest part of the quarry, into which all the water collects, and a small duplex pump, generally stationed somewhere well protected from the blasting, is sufficient, being operated only a few hours each day, to handle all the drainage from the whole quarry. In cases where the quarry is below the drainage level of the surrounding country a larger pumping plant has to be installed.

DRILLING HARD STEEL.

To drill a hard piece of steel without having clearance wear off the lip of the drill, which necessitates repeated grindings, hold the drill firmly in a vise and with a light hammer strike the face or cutting edge at the outer corners, raising a light burr. This makes the drill cut enough over size for easy clearance, and it is surprising how much wear it stands. It is much better than grinding off centre, and is especially handy in drilling small dies.

THE MECHANICAL ELIMINATION OF SEAMS IN STEEL RAILS.*

By Robert W. Hunt,
President, Robert W. Hunt & Co., Chicago, Ill.

THE increased weight of rolling stock and speed of traffic has necessitated increasing the size of the rail sections, and hence their weight; as many of the details of rail manufacture have been changed with such alterations, it is not surprising that new and unexpected physical weaknesses have developed in the heavier rails. One of the most notable has been the failure through crescent-shaped pieces breaking out of the rail flanges, followed by at least one, and in many cases several, ruptures across the whole section of the rail. Investigation has showed that in practically every instance of such failure there was a more or less pronounced seam running longitudinally in the bottom of the rail near its centre, and thus immediately under its web. This seam occurs at the top of the curve of the crescent-shaped break and is undoubtedly the point at which the fracture starts.

Those familiar with steel rail making have known that it was practically impossible to make rails entirely free from seams, and that as the seamy conditions of the steel forming the head of the rail increased, its wearing quality would decrease, but I think it was not until the disastrous experiences with the "moon-shaped" failures that the danger from seams in the base of the rails was fully realized. It is true that rails with actual flaws in their flanges have been rejected as first-quality ones and that a very pronounced seamy condition of the bottom of the rail would also cause its rejection. Such rejections were the cause of frequent disputes between the mill operatives and the inspectors, the point being as to how far the inspectors were warrented in carrying their condemnation; but, as already said, it was not felt that a single seam would be dangerous unless very pronounced.

The crescent-shaped breaks were of such frequent occurrence that they indicated a very serious condition and led rail makers to experiment with the design of their rolling passes, with a view to obviating the formation of the bottom seams. It was found that fewer seams were produced by such changes, but they were not entirely eliminated. While more or less successful in preventing the formation of seams through lapping on the bottom of the rails, the formation of seams in other parts of the section was not particularly affected.

T. H. Mathias, assistant general superintendent of the Lackawanna Steel Company, determined that the most certain way of getting rid of seams was to remove that portion of the metal which contained them, and, as applied to steel rails, thus to eliminate them from both the base and head of the rail. Mr. Mathias reasoned that the primary causes of seams existed previous to any rolling of the steel, in fact, were incident to the casting of the molten metal into ingots. He knew that disk-like apertures were formed on the sides of ingots while the molten metal was being cast and were probably caused from air being entrapped against the sides of the ingot molds by the hot steel as it raised in the molds, a condition which was not controlled in regular manufacturing routine. It will be appreciated that, as the section of the ingot is reduced and elongated in the rolling process, so,

*Abstract of a paper read at the annual meeting of the American Society of Mechanical Engineers, New York, December 3, 1914.

of course, will the apertures be stretched longitudinally and thus be formed into seams.

Mr. Mathias demonstrated that there is another constant condition present in the rolling of large steel ingots, in the formation of a decarburized surface, about 5/16 in. deep on all four faces, and containing from eight to ten points lower carbon than the metal immediately under it, the decarburized envelope undoubtedly being produced through the oxidizing conditions to which ingots are subjected in the soaking pits where they are heated preparatory to rolling. A thick oxide scale is always formed on the surface of ingots in the pits, so that conditions are invariably present for the production of such a layer of lower carbon metal on their outside faces.

Mr. Mathias was convinced that during the process of rolling ingots into rails it was practical to remove mechanically the parts of the enveloping steel which would form the top of the head and bottom of the flange of the rail, and experimented accordingly. He designed and his company installed as an addition to their rail train, a milling, or hot-sawing machine, to cut off that metal without retarding the regular operation and thus interfering with the production of the mill.

The ingot is reduced in the blooming rolls to an 8-in. by 8-in. cross-section, and after cropping the ends the bloom is further reduced in the roughing or shaping stand of rolls by five passes. When it leaves these rolls, it is approximately 75 per cent. finished and at this period it is carried to the right and entered between two pinch rolls with its base or flange side up. A bar which will make four 33-ft. rails is about 60 ft. in length at this point in the rolling operation; therefore, the area of metal to be cut off or removed in the milling machine is approximately ⅛ in. deep, 7 in. wide and 60 ft. long. It is driven through the pinch rolls at a rate of 60 ft. in 30 seconds. The pinch rolls have a draft of about ⅜ in. and thus force the bar between the two milling saws, which are so arranged in the housing that they may be raised or lowered as desired. From 1/32 in. to 3/64 in. of metal is milled from the head and base of the bar, the front end of which, immediately on passing from between the rolls, is caught by a second set of pinch rolls which have a draft of about 1/16 in. These pinch rolls force the bar between the tools, pull it from between them, and also hold it in practically perfect line for the milling operation. The milling apparatus is driven electrically and requires about 600 h.p. for its operation.

As the milled dust or particles of steel are thrown out, they are hit by water under pressure which forces them into a chute and also prevents the material from adhering together. They are carried below the mill, through this chute, and are caught in boxes or receptacles suitable for charging as scrap into the open-hearth furnaces.

The milling tool is 5 ft. in diameter with an 8-in. face and revolves at a peripheral speed of 2,500 ft. per minute, thus causing an engagement of about 400,000 teeth per minute on the hot rail bar. The teeth are of 0.80 carbon steel, and it has been demonstrated that they will mill at least 30,000 tons of material without requiring dressing.

The milling on the flange does not reach the extreme edges of the bar, and on the head side does not affect the corners. Either by a modification of the shape of the piece as presented for treatment in the milling machine or, what will probably be more practical, changing the face of the tool, the milling can be extended to the extreme edge of the flange portion of the bar and somewhat around the corners of the top or head side. This will undoubtedly be perfectly practical and thereby eliminate the seams which may be located in those parts of the bar. The primary object has been to eliminate the seams from the central portion of the bottom of the rail which had been the starting point of the moon-shaped failures, and to remove them from the top or bearing surface of the head of the rail. Personally I think it will be desirable to extend the milling by the use of convex-faced tools.

The work of rolling which the steel receives after the removal of the more or less laminated metal, must produce a better product than if such elimination had not taken place, and it should not only make them less liable to breakage on account of seams in their flanges, but also enable them better to resist the abrasive effects of traffic.

During the many years of my connection with rail making I have examined a great many etched specimens of rails, not only directly in connection with the process under consideration, but for various other reasons. From such experience I can fully appreciate what Mr. Mathias has accomplished. The surfaces of practically all rails, when etched, will show some seams on both the base and head, and very frequently the extent of such defects will not be appreciable if the scale has not been removed. Even then, it is not always an easy or certain matter to estimate the depth of the seams. When the rails have been subjected to the Mathias milling operation and still show pronounced seams, it has been found that breaking tests will practically always develop the fact that the suspicious marking is an actual seam.

As the original defects on the sides of the ingots vary in extent, so will the character of the resulting seams vary, and it can be readily appreciated that some of them may have been too deep to have been completely eliminated by the milling.

While I have confined myself to the matter of steel rails, it is patent that the process will be of great value in the preparation of blooms for axles and all other kinds of forgings. As is well known, it is practically the universal custom to endeavor to remove the seams developed in rolling axle billets by chipping them out through the use of pneumatic hammers, and for some of the higher characters of forgings, notably for automobile parts, the endeavor to eliminate the seams is carried to the extent of turning off the whole surface of the billets. I am confident that by the Mathias plan the greater part, if not all, of such work can be superseded, and I regard the invention and its practical installation as a notable achievement in the art.

WORK OF THE U.S. BUREAU OF MINES.

The chief work of the U.S. Bureau of Mines during the four years since its establishment has been the investigation of problems having to do with the causes and prevention of coal-mine explosions and the safeguarding of the lives of coal miners. In addition, work has been done on the testing of coal and other mineral fuels belonging to or for use of the government of the United States. During the past fiscal year investigations were undertaken looking to greater safety and the prevention of waste in the metal-mining and miscellaneous mineral industries of the country. Recently a small amount of work has been done in an examination of several oil and gas fields of the country with a view to eliminating the large waste of natural gas in these fields. The need of such investigations may be plainly seen when it is understood that so large a part of this waste is easily preventable, that the supplies of natural gas are limited, and that the gas wasted yearly may be fairly valued at not less than $50,000,000.

ELECTRIC ARC WELDING.*

By J. H. Bryan.

ELECTRIC arc welding as a commercial process may be divided into two general classes: (1) Benardos or carbon electrode process in which the arc is drawn between the metal to be welded and a carbon electrode. (2) Slavianoff or metal electrode process in which the arc is drawn between the metal to be welded and a metal electrode.

These two processes are generally spoken of as carbon electrode and metal electrode welding respectively.

In addition to these there is the Zerener process, in which the arc is drawn between two carbon electrodes, as in the arc lamp, and the metal to be welded is placed in contact with the arc. This is, however, not considered a commercial proposition in this country, as its field of application is limited, and the apparatus itself is unwieldy.

Quoting from C. B. Auel in the "American Machinist" (1911): "In carbon electrode welding the metal to be welded is made one terminal of a direct current circuit, the other terminal being a carbon electrode. Upon closing the circuit by bringing the carbon electrode into contact with the metal and then withdrawing it to a distance, an arc is drawn between the two terminals. Through the medium of the arc, which is the hottest flame known (having a temperature between 3,500 deg. and 4,000 deg. Centigrade—6,300 deg. to 7,200 deg. Fahrenheit), the metal may be either entirely melted away, molded into a different shape or fused to another piece of metal as desired."

The metal electrode process of welding is a somewhat later development than the carbon electrode method, and differs from the latter in that a metallic electrode is substituted for the carbon.

If direct current is available from a shop or commercial circuit, welding can be done directly from this source of supply, but this method has been found to be very wasteful of power and should not be resorted to except where welding is only to be done at very infrequent intervals. An additional disadvantage of the use of the shop circuit as a source lies in the fact that, unless arrangements are made for insulating the work from ground, the shop circuit is grounded, with attendant danger to other employees in the shop, as well as to the welding operators. A much more economical method is that of using a motor generator set, the motor being constructed with characteristics suitable for operation on the shop or other circuit, and used to drive a low voltage generator. The generator may be either shunt or compound wound, the shunt wound machine being satisfactory where only one arc is to be operated, while the compound wound machine is preferable if several arcs are to be supplied from the same unit. Experience has shown that generators giving a potential of 75 volts or thereabouts will enable satisfactory results to be produced. As different welds require different strengths of current, it is at once evident that there must be some means of regulating the current supply. This is usually effected by inserting resistance in the welding circuit connecting it in series with the arc.

A suitable electrode holder must be provided for both carbon electrode and metal electrode welding. Protective equipment is necessary for the operator on account of the fact that the exposure to the rays of the arc causes an irritation and subsequent peeling of the skin if the exposure has been sufficiently long, say several minutes. The irrigation is very similar to sunburn and is uncomfortable, but no serious consequences ensue, and at the end of a few days all traces of the burn disappear.

When the carbon electrode is used, the filling material is usually of the same metal as that being worked upon and may be used in any convenient form. When metal electrodes are used for welding iron and steel they should be of best quality of soft iron or steel wire and may range in diameter from 1/8 in. to 1/4 in. The length most generally used is about 12 in. Copper, bronze and brasses with a low percentage of zinc may also be welded by this process, in which case the electrodes should be of the same material as that being welded. Where the zinc content of brasses is high, it volatilizes to such an extent as to make the work porous and brittle.

The current required for carbon electrode welding varies from a minimum of about 200 amperes to a maximum of around 700 amperes, or even more in very heavy work. In general, however, 300 or 400 amperes have been found to be sufficient for ordinary carbon electrode work.

The metal electrode process, though a considerably later development than the carbon electrode method, has a field of application very distinct in many cases from the older process. Its principal advantage is on work where it is desirable to localize the heat to the greatest extent possible, thus minimizing strains due to expansion and subsequent contraction. An example of this is in the welding of sheet metal or of a broken bridge in a flue sheet. Another advantage of this process is that it enables welding to be done in a vertical plane or even from the underside of the piece to be repaired. With the metal electrodes much lower currents are used than in the carbon electrode process. The maximum value hardly ever exceeds 150 to 175 amperes. For a greater portion of the work a current of about 100 to 130 amperes is found satisfactory, although the amount of current required will vary with the size of the electrode and the class of work being done.

The carbon electrode process is also well adapted for cutting of metals. In cutting the arc is drawn just as in welding and is played along the line to be cut, provision being made for the melted metal to run off. Very rapid work of this sort can be done, especially if heavy currents are used. The heat generated varies approximately as the square of the current so that a comparatively small increase in current will give a considerable increase in the rapidity with which work may be done.

Among the principal uses of arc welding equipment in steam railroad shops are the following: Flue welding; firebox repairs; frame repairs, and building up of worn parts. Besides these there are innumerable minor tests for the equipment.

General practice varies as regards the best method of welding flues. The time of welding will probably average 15 per hour, although as high as 25 per hour have been reported. This time is for 2-in. flues. Five-inch superheater flues are being welded at about one-fourth this rate. It is interesting to note that the flue sheet is found to be in better condition upon removal of flues than is the case where flues have not been previously welded in. This is due to the fact that the welding builds up the sheet around the flue holes to about the original thickness.

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*Abstract of a paper presented before the Western Railway Club, November 17, 1914.

Closely related to flue welding is the subject of firebox repairs. The defects to be repaired include cracks in the side, flue, door and crown sheets, leaky staybolts, leaky seams, etc. Also sheets will often be found to be in such condition that repairs are impossible, and it is necessary to put in patches. All of this class of work can be done very satisfactorily by the use of the arc welding equipment. Broken locomotive frames also are very satisfactorily repaired by the use of the electric arc. One railroad (R. F. & P.) reports that it has in service at the present time 65 welded locomotive frames and has had only one failure; this failure was attributed to the fact that the arc weld was in close proximity to one made by another process.

The following figures are taken from records of actual repairs made in a large railroad shop in the middle west at various times, the figures given being a comparison between the actual cost of welding and that of putting the apparatus back into service by methods previously used, either by replacement or by repair of the old parts. The arc welding costs were based on a power cost of 51 cents per hour for the carbon electrode and 17 cents an hour for the metal electrode, together with cost of labor and an overhead charge of 40 per cent. The power costs used are slightly higher than those usually obtaining in shops of this nature:

	Cost of welding.	Cost by other methods.
Plugging 51 holes in expansion plate, holes 1 in. diam. by ½ in. deep...$	2.75	$ 10.15
Repairing mud ring	6.50	34.57
Cutting four 6-in. holes in tender deck sheet ½ in. thick	1.08	8.35
Welding eccentric strap, broken through neck	1.08	41.28
Repairing mud rings	6.50	24.57
Welding two spokes in driving wheel centre	7.98	99.98
Welding cracks in bulkhead in tender tank	2.33	8.00
Welding cracks in side sheets	26.15	31.79
Repairing firebox	134.89	869.58
Building up flat spots on locomotive driver	.40	225.00

No hard and fast rules can be laid down as to the size of outfit required, as no two installations will be alike in their requirements, and the matter of selection of apparatus of proper capacity is largely one of judgment and experience. In steam railroad shops installations are usually made of sufficient capacity to take care of not less than four to six operators, and the larger shops can occasionally use even greater capacities to advantage. Where a greater number of operators are to be supplied, however, it is generally found to be more economical to install additional outfits in other sections of the shop where welding is to be done, rather than to put in one large central plant. This is on account of the fact that as this work is usually more or less scattered the cost of line copper becomes an item for consideration.

Arc welding is not to be considered as a panacea for all the ills that the metal worker is heir to. There are many classes of work for which it is entirely unsuitable, but its range of usefulness is so wide that it has long since fully justified its existence.

BITUMINOUS MACADAM BY THE COLD MIXING METHOD.

SINCE 1906 the Rhode Island State Board of Public Roads has constructed a large amount of bituminous macadam by the cold mixing method. Much of it has been down sufficient time now to admit of some definite conclusions regarding the success of this type of construction. We feel that some of our readers will be interested, therefore, in the paper read by Irving W. Patterson, chief engineer of the board, at the Atlanta Road Congress, this paper giving a résumé of the work since its beginning, 8 years ago. The writer draws conclusions regarding the adaptability of the cold mixing method, based upon his experience with work of this type.

The first attempt made by the State highway authorities of Rhode Island to avoid the deficiencies characteristic of plain waterbound macadam construction by the incorporation of a bituminous binder was upon the Post Road, which is subjected to the heavy through automobile traffic between the famous shore resorts of Rhode Island and the large cities to the south and west. A traffic census upon this road taken during 1913 showed an average summer travel of approximately 600 vehicles daily, consisting very largely of motor vehicles. The construction work upon this section was carried out during midsummer of 1906.

At that time there was little reliable information concerning bituminous macadam available, so the exact methods of carrying out the work necessarily had to be decided upon more or less arbitrarily. It was decided to use a crude tar as a binder and to incorporate this material with the road metal by the cold mixing method. The mineral aggregate employed in the mix was crushed stone of sizes which were retained upon a one-half inch screen and which passed an inch and one-half screen. The stone employed was native field and wall stone, which is a rather coarse-grained, somewhat kaolinized granite. The metalled surface was constructed 14 feet wide with a crown of three-quarters of 1 inch per foot. All rolling was accomplished by means of a 10-ton, 3-wheel steam roller.

The construction in brief was as follows: Crushed stone which was retained on an inch and one-half screen and which passed through a 3-inch screen was first spread over the well rolled sub-grade, to a depth of 4 inches after compression. This course was not filled with sand or stone screenings but was well rolled. Crude tar was very lightly sprinkled over this first course of stone. Crushed stone of the sizes stated previously was then mixed with crude tar in the proportion of 15 gallons of tar per cubic yard of stone. Mixing was carried out upon a portable wooden mixing platform placed as closely as convenient to the point where the mixture was being spread. The mixture of stone and tar was spread over the first course of crushed stone to a depth of 2 inches after compression. The mixture was well rolled, after which a covering of stone screenings was applied.

No foundations and no sub-drainage were deemed necessary upon this work because of the stable character of the gravelly sub-soil encountered.

The results secured upon this first experimental section of bituminous macadam were remarkably successful. No repairs have been required to date. The surface today is perfectly intact and presents a perfect mosaic appearance, due to the top surfaces of the stones in the mixture being all in evidence.

In 1907 a much longer section of bituminous macadam was constructed. The method was almost identical with that employed the previous year. The results secured upon the section built in 1907 were inferior to the results secured in 1906. The surface began to ravel slightly in 1912, and during that year a seal-coat of refined tar was applied. To-day the surface is somewhat irregular and a few breaks are in evidence, although the riding qualities of the road are very fair. The relatively inferior results secured from work in 1907 is attributed largely to a less stable sub-soil.

It will be noticed from the foregoing that no seal-coat was applied at the time of construction. Subsequent experiments have proved the advisability of seal-coating. The marked success of this early work in spite of the absence of a seal-coat is due largely to the character of the travel. The horse-drawn traffic over both of the above sections is very light. The blows of horses' shoes upon the exposed surfaces of the soft stones would be destructive if horse-drawn traffic occurred in any considerable amount.

In 1908 bituminous macadam by the cold mixing method was taken up to much greater extent. Various experiments both in materials and methods were carried out, and to-day it is evident that these experiments were largely negative in results produced. Many materials and combinations of materials were tried which did not give satisfaction, and no work noticeably superior to the work of 1906 and 1907 was done. Results approximating those secured in 1906 and 1907 were secured, however, upon sections constructed in the same manner as were the bituminous roads built those years. Perhaps the greatest failures in the work during 1908 were upon sections where tar products and asphalt products heated in separate kettles were used in combination as a binder for the top course of crushed stone. Where this combination of binders was employed, ravelling started the following year and increased in extent very rapidly as time went on. In 1913 a heavy seal-coat of asphalt was applied to several of the roads bound with a combination of tar and asphalt and the results secured from this treatment appear highly satisfactory.

In 1909 some very interesting experiments were carried out and these experiments produced some very positive results. It is true that there was work done in 1909 according to methods tried out in 1908 and since proved unsatisfactory, but at the date of the construction of the 1909 work it was not to be ascertained for a certainty what of the 1908 work was satisfactory and what was not, due to the short time the work had been done.

Upon the Nayatt Point Road in the town of Barrington the most interesting and valuable experiments of the year were carried out. The section of this road selected for the experiments offered excellent opportunities for experimental work because of the remarkable uniformity and excellent stability of the sub-soil encountered. Foundation troubles have not been responsible for any of the defects which have developed in any of the experimental sections. These experiments have been completed long enough now that certain definite conclusions may be drawn from them. (Mr. Patterson's paper then presents in detail the chief features of experiments carried out at Barrington in 1909. Their insertion here is precluded for want of space, and only the materials used are given. Experiment 1.—Crude tar and asphalt in mix with asphalt seal-coat; trap rock. Experiment 2.—Same, with native stone instead of trap. Experiment 3.—Refined tar in both mix and seal-coat. Experiment 4.—Asphalt in both mix and seal-coat. Experiment 5.—Refined tar with 20% asphalt in mix and seal-coat. Experiment 6.—Same, but with only 10% asphalt in both. Experiment 7.—All refined tar in both. Experiment 8.—Refined water-gas tar. Experiment 9.—Crude tar in mix, asphalt seal-coat. The paper then goes on to draw the following conclusions.)

These experiments seem to prove that certain forms of the cold mixing method are very satisfactory upon roads subjected largely to motor vehicle traffic. Only two of the sections have necessitated repairs of any account during the five years they have been laid. Both of the sections requiring repair were laid with the same combination of binders, and the much greater extent of repairs necessitated upon the section constructed of trap rock is of interest in consideration of mineral aggregates.

It was shown conclusively that a seal-coat of asphalt is much more permanent than a seal-coat of refined tar, although both the crude tar and the refined tars gave excellent results as far as their binding of the mineral aggregate is concerned. The effectiveness of refined water-gas tar is also proven. The section built of this product is superior at present to either section built of refined coal-tar.

Bituminous Macadam Subsequent to 1909.—In 1910 the typical construction employed was a mixture of crude tar and crushed stone, seal-coated with a heavy asphaltic product. This construction is identical with the construction employed in Exp. 9. The facility with which the crude tar could be handled and the good results secured with this material previously, accounted for its extended use in 1910. The results secured with this type of construction in 1910 were very successful. With one exception these roads have required only the lightest of repairs to date, the exception noted being located upon the main street of a large village and constructed of 2¼ and 1¼-inch trap rock. This road had disintegrated somewhat by the spring of 1911, and from that time on the disintegration rapidly became greater in extent. By the spring of 1913 the condition of the surface was serious. Several breaks of 10 sq. yd. or more in area appeared, and small breaks were very numerous. It was decided to patch the breaks with a mixture of ¾-inch trap rock and refined tar and to apply over the entire surface a seal-coat of asphalt covered with clean ½-inch trap rock screenings. Asphalt of approximately 15 mm. penetration was applied at the rate of ½ gal. per sq. yd. of surface and covered while hot with screenings, which were rolled with a 6-ton tandem roller as soon as possible. This work was done in June, 1913. The results of this treatment have proved very satisfactory, no further ravelling having taken place to date.

Mixing in 1910 was accomplished by the hand-mixing method upon wooden platforms.

In 1911 no appropriation for road work was made and consequently no bituminous macadam was constructed.

In 1912 an attempt was made to duplicate in effect the excellent results secured in 1906 by the use of crude tar by employing a comparatively light refined tar. It was the express intention to apply to the roads built with this refined tar a seal-coat of asphalt as soon as need for such treatment was evidenced, thereby securing eventually the same type of road which was so eminently satisfactory in 1910. Mechanical mixing was introduced for the first time in 1912. The type of mixer employed upon practically all of the work was a cube mixer of approximately one-half cubic yard capacity fitted with a heating device. The stone was not heated previous to mixing, the heating device being employed merely for the purpose of keeping the inside of the mixer warm so that it would not become clogged. The stone employed was both local 1½-inch stone and commercial 1¼-inch trap rock. The results secured with the local stone averaged superior to the results with trap rock.

The results secured in 1912 were variable. In 1913 it was deemed necessary to seal-coat with asphalt approximately 42 per cent. of the total area of the roads constructed in 1912. During 1914 approximately 6 per cent. of the total area was seal-coated with asphalt. The roads which have not been seal-coated are in very good condition at present, but the necessity is anticipated of applying a seal-coat to all of them during the next two construction seasons. The seal-coating of the work done in 1912 has been very effective to date, but it is as yet too early to draw conclusions regarding the results of the 1912 work after seal-coating as compared with the results secured in 1910 where the seal-coat was applied at the time of construction.

During 1913 the amount of bituminous macadam constructed by the cold mixing method was small as compared with the amount constructed in 1912. Two methods were employed. The type of construction employed in 1910 was taken up to some extent with a refined tar in place of a crude tar—a seal-coat of asphalt being applied at the time of construction in exactly the same manner. An asphalt of characteristics similar to the asphalt employed upon Exp. 4 was used to some extent in both mix and seal-coat. The work by both methods has proved perfectly satisfactory to date, although the construction is so recent that definite conclusions cannot be drawn. Trap rock was employed satisfactorily in the mix for the first time during 1913. The commercial ¾-inch size of trap rock was employed in place of the commercial 1¼-inch size which was previously used, and this product has given excellent satisfaction to date.

It has been proved that the utmost care in constructing bituminous macadam by the cold mixing method is necessary. The crushed stone must be perfectly dry at the time of mixing and all stones must be perfectly covered with bitumen in order that good results may be secured. The manner of carrying out the rolling is also important in its effect upon the results obtained. It is, of course, necessary to secure by rolling as compact a mass as possible, but considerable care must be exercised in regulating the time and amount of rolling. If the weather is cool at the time of construction, the heavy rolling should be postponed until mid-day, when the maximum warmth is experienced, although the initial rolling is done as soon after the mixture is laid as possible.

The character and sizes of the crushed stone employed are also of great importance. We have secured the best results, as far as stone is concerned, with our native rock, which is rather variable in character. As a rule, this native rock is softer than trap rock and breaks with a much more irregular fracture than trap rock. There is more or less breaking of the native stone by rolling, and this appears to be beneficial rather than otherwise in that a denser pavement is secured. We feel that if trap rock is employed, smaller sizes are necessary than with a softer stone, unless there is a certainty of securing a perfect crusher-run from 1½-inch to ¼-inch or less.

We have experimented with heating the aggregate previous to mixing, but these experiments seem to show that inferior results are secured as compared with the results obtained with the same materials where the aggregate is unheated. The aggregate in bituminous macadam contains at best a large percentage of voids, and in the heated aggregate there was noted a tendency upon the part of the binder to run off from the stones, leaving only a very thin coating upon each stone. In several cases, for instance, 18 gallons of binder per cubic yard of stone were necessary to cover all stones in our unheated mineral aggregate, but when the aggregate was heated, 12 gallons would cover all stones and there would be considerable bitumen which would run through the mineral aggregate and be lost. The tendency for the bitumen to cover a heated aggregate very lightly seems to be due to the fact that the heat retained by the stones does not allow the binder to become hard for a considerable time, with the result that it continues to run for some time. We recognize that it is necessary to heat the aggregate in a dense mixture such as a bituminous concrete pavement affords, but in bituminous macadam work by the mixing method we prefer a cold aggregate or an aggregate heated but slightly.

The weather conditions influence the results obtained in bituminous macadam by the mixing method considerably. We have noticed that roads built late in the fall just before freezing sets in are not apt to be as satisfactory as those built in mid-summer, even though the temperature at the time of construction is not low. It seems to be a decided advantage to roads built by this method of construction to have a comparatively long period of warm weather immediately after construction in order that the surface may become freed from the top covering of stone screenings and well smoothed out before snow and ice appear. In Rhode Island we consider the season most favorable to this type of construction to be between the middle of May and the middle of October.

Upon the whole, the cold mixing method of constructing bituminous macadam as practiced in Rhode Island appears to be an economical pavement for motor vehicle traffic. It does not appear to the writer as suitable for heavy horse-drawn traffic or for a heavy mixed traffic. The traffic upon several of the trunk lines in Rhode Island consists of motor vehicle traffic to the extent of over 90 per cent. of the total amount of traffic, and it is upon these roads that we expect in the future to confine our bituminous macadam roads built by the cold mixing method. Through large villages where the percentage of horse-drawn traffic is large, we expect to take up a stronger method of construction.

GOVERNMENT WHARF AT REVELSTOKE, B.C.

The Department of Public Works, Ottawa, has commenced the construction of a wharf at Hall's Landing, Revelstoke. It is 30 ft. wide and 280 ft. long, and is estimated to cost $55,000. It is to be constructed of timber piles.

The Dominion Government will also spend this winter $4,500 on mattress work for the protection of the bank of the Columbia River, near the site of the wharf. The mattressing will start at the end of the wharf and extend 400 yards down the river. The work of construction will start as soon as the water has fallen sufficiently to allow of mattresses being placed.

RAILWAY CONSTRUCTION ON THE GOLD COAST OF AFRICA.

It is estimated that the extension of the Gold Coast Railway from Komfrodna to Kumasi will cost about $6,000,000. The first section, to Komfrodna, will probably be opened early next year.

A SIMPLIFIED METHOD FOR THE LOCATION OF SIDINGS.

By W. F. French in "Railway Age Gazette."

A SUPERVISOR frequently has need of a simplified method by which the curves of a siding may be laid out on the ground, either at the time the preliminary survey is made, with the object in view of showing the applicant for the siding the salient features of the location or of making notes necessary to an estimate of the grading, when a tape line layout may be the only one possible, or at a later time when the siding is about to be constructed and a transit may be unobtainable or its use inconvenient. Doubtless many cases require some instrumental work and it is then useful to know how the processes can be simplified, as the corps will generally consist of the supervisor or his assistant and a trackman or two.

It is thought that probably the greater number of cases of siding layout can be met by the use of the tape line alone. Most supervisors carry with them at all times a 5-ft. extension rule and a 50-ft. steel tape and not a few a 100-ft. length of string to correct the general line of curves. By the aid of the simple rules of geometry and with the use of the accessories mentioned, it is possible to dispose immediately of very many cases and often avoid the necessity of a subsequent visit to the location.

The matter is greatly simplified by the fact that the right-of-way line is nearly always parallel with the tracks and the building which fixes the location of the siding is also parallel. The siding, therefore, is either parallel or at right angles with the track. But even for those cases where the siding is not parallel or at right angles with a tangent main track a special solution is possible which is not unduly complicated and which can be comprehended by most maintainers of track.

It is not claimed that any new theories have been developed, but is it claimed that certain of the solutions offered are not to be found in any of the field books. Of the many which are to be found there only those have

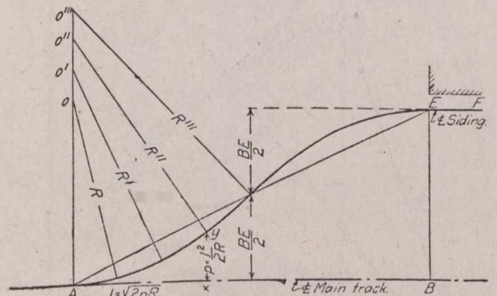

Fig. 1.—A Siding Parallel to the Tangent Main Track.

been selected which tend to simplify the supervisor's work and even to open the way for the safe handling of such problems by the brighter track foremen, not a few of whom are now entering the ranks of supervisor.

It will perhaps be thought by some that in neglecting the tangents introduced into the siding curve by the straight switch and frog accuracy is being sacrificed, but it will be found that for turnouts above No. 5 (and those below have been practically eliminated by the operation of the Safety Appliance law) no sensible error will result from this source. Stakes need not be set at either the point of switch or the point of frog, but their location should be indicated by marks on the rail and care should be taken that the half inch point of frog is always understood.

The simplest case is that of a siding parallel with a tangent main track and flanking a building, the location of which fixes the maximum offset distance. There is no practical need nor is there usually the space for introducing any tangent between the curves, but in order to render the physical conditions at the point of reverse as favorable as at the beginning and ending of the curve, it is quite advantageous to make the curves flatter at the reversing point. This may be done by using the formulae

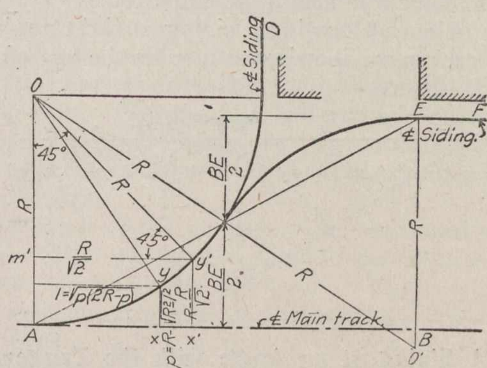

Fig. 2.—A Siding Parallel to or at Right Angles to the Tangent Main Track.

for the parabola. While this increases the length of the curve somewhat, the extension is not more than a few feet even for an extreme case.

The formulae symbolized are $p = \frac{l^2}{2R}$ and $l = \sqrt{2pR}$, or expressed in words signify that for a chosen distance from the point of the curve along the tangent, the offset is equal to the square to the distance divided by twice the radius, or conversely, for a chosen offset from the tangent, the linear distance is equal to the square root of the product of the offset multiplied by twice the radius. The field books employ these formulae for staking out a circular curve by offsets from the tangent and chords produced, the value of the offset from the chord produced being twice that from the tangent, when the distance used is a chord of the curve instead of a length on the tangent. The method is undesirable because the operation of successively producing the chords renders the process subject to cumulative error.

By the use of the formulae in the manner suggested, the distance from the end of the curve to the reversing point and from the reversing point to the point of switch may be obtained at once. These distances will be equal if the two curves are of equal radii and the reversing point will be midway between the line of the main track and of the siding. Whether the curves be of equal radii or otherwise, this point will lie in the line joining the two tangent points. Any number of intermediate points on both curves may be set after computation of the offsets. Those for the second curve may be made supplements of the whole distance between the siding and the main track and thus all the measurements be made from an actual base line and every source of error in the field work be eliminated. It should be noted that the offsets vary as the square of the linear distance and if the distances selected are in a simple ratio, the square of this ratio multiplied by the first offset will supply the other offset with a considerable saving in computation.

When the length of radius is not absolutely determined by limiting conditions, as indeed seldom is the case, one should be chosen which will make the offset at the point of frog equal to the gauge. This radius will be about 5 per cent. larger than the actual radius obtaining through the lead, but this advantage is quite desirable both from the maintenance and operating standpoints. This solution may be used for the case of a crossover between two tracks which are parallel, but which are so far separated that a tangent between the frogs is impracticable.

If it is preferred to make the reversed curves circular rather than parabolic, the formulae outlines for a continuous circular curve should be employed.

The problem of locating a siding at right angles with the main track may likewise be met by the use of offsets

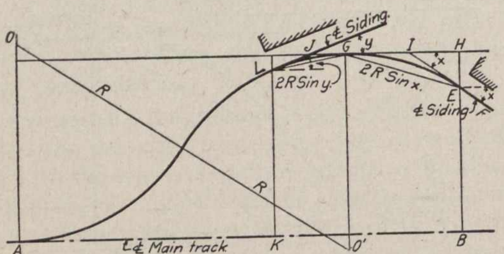

Fig. 3.—A Siding at an Angle with the Tangent Main Track.

and with as great accuracy as the average transit instrument will supply. It is necessary in any event to adjust the detail line of the curve when finally laid, and this can best be done with a string. The formulae for offsets employed in the preceding case will not answer for the circular curve required and the proper formulae for such cases are the following: $p = R - \sqrt{R^2 - l^2}$ and $l = \sqrt{p(2R - p)}$. These symbols signify that for a chosen distance from the point of curve along the tangent, the offset is equal to the radius minus the square root of the difference between the radius squared and the linear distance squared; or, conversely, for a chosen offset from the tangent, the linear distance is equal to the square root of the product of the offset multiplied by the difference between twice the radius and the offset.

This may be used for the offsets from either end to the middle of the curve, for which point it should be noted that the linear distance is equal to the radius divided by the square root of 2, which is 1.414, and the offset is equal to the differnce between the radius and this linear distance.

A test of the correctness of the layout will lie in the fact of the total measured length of the curve agreeing with the length as computed by the simple properties of the circle.

The problem when the line of the siding either converges toward or diverges from the line of the main track may appear to be quite complicated, but when understood becomes really quite simple. The field work necessary to a solution of such a case consists only in measuring the angle of divergence and the offset distance at the point of tangency. The problem then is to determine the position of a tangent parallel with the main track which, for the chosen radius, will make the curve pass through the point desired and be tangent to the line of the siding at that point.

The field books develop with great interest to the mathematically inclined the problem of finding the equal radii for a known position of the line joining the two ends of the reversed curve. But as the effect of such a proposition is to establish a curvature that will generally necessitate the use of special frogs it is clearly not of much use in the solution of the practical track problem.

The angle may be obtained with the tape line by laying down equal distances along the two sides of the angle and measuring the spread at the ends of such distance and by dividing the constant 57·3 by the ratio of these measurements, which it will be noted is the same problem as used in measuring the angle of a frog.

The length of chord subtending a central angle of this computed value may be found with sufficient accuracy by dividing the angle by the degree of curve. The tangent offset for this chord will be obtained from the formula in Example 1, and the linear distance by a solution of the right angled triangle in which the chord is the known hypothenuse and the tangent offset the other known side. The position of the parallel tangent and the linear distance to the point of curve are now known and the solution of the problem becomes simply that of Example 1, except that for the diverging line a portion of the computed curve is imaginary and for the converging line a portion of the computed curve will be duplicated beyond the point of tangency with the imaginary parallel line.

The problem of establishing a connection from a curved main track requires instrumental work in measuring the angle between the siding tangent and the tangent to the main track curve at the point of intersection and of deflecting for the several stations after computing the length of curve between the point of intersection and the p. c. of the siding curve and of the distance on the siding tangent between the main track curve and the p. t. of the siding curve. This distance from the main track curve to a possible point of tangent for the siding curve should be measured as a check on the selection of radius for the siding curve. The choice of curves is limited to those

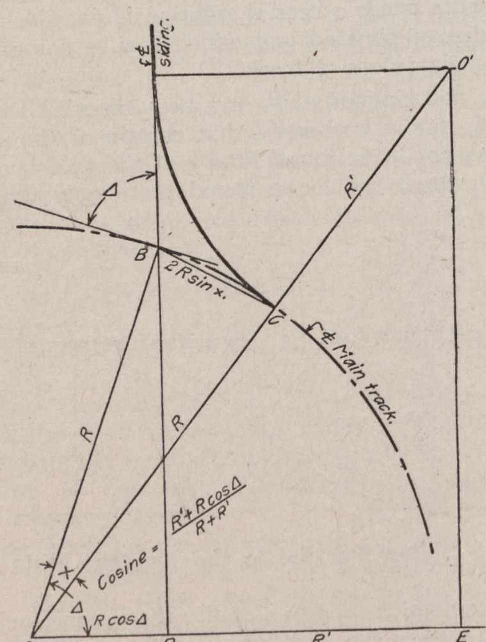

Fig. 4.—A Siding from the Outside of a Curved Main Track.

which will permit the use of a regular number of frog and will thus be the curvature of some regular connection plus or minus the degree of the main track curve, depending upon whether the siding is from the inside or outside of the curve.

There are six cases of this one general problem, of which the two that most commonly occur are given. The other cases include two more from the inside, in both of

N.B.—In Figs 3, 4 and 5, the quantity "2R sin x," should read "2R sin ½x."

which the angle Δ is greater than 90 deg. and R^1 either greater or less than $R \cos \Delta$, and two more from the outside in both of which Δ is less than 90 deg. and R^1 either greater or less than $R \cos \Delta$. Each case supplies variations which the mathematical skill of the engineer will readily differentiate.

The solution of all is rendered more facile by extending the siding tangent to a normal line which passes through the centre of the main track curve and intersects a line parallel with the siding tangent through the centre of the siding curve. This brings the measured angle Δ, which it will be noticed is included between the radius of the main track curve and the normal to the siding tangent, into direct geometric relation with the two known radii. The solution indicated for the two cases may be applied with apparent modification to all the cases when the angle between the siding tangent and the radii passing through the p. c. of the siding curve may be obtained, as well as the central angle of the siding curve and the distance to the actual p. t. of the siding curve when a test of the correctness of the assumed radius will be had upon comparison with the tentative measured distance.

When it is not necessary to establish the siding curve immediately, the work may be greatly simplified by taking scale measurements from an accurately plotted plan. These will answer every purpose if the original survey was correct and the drawing made to a scale as large as 1 in. to 40 ft., or preferably 1 in. to 32 ft.

The problem of locating a siding on a continuous simple curve which shall pass through two definite points is of very frequent occurrence, as when a property corner must be avoided and farther on a corner of a building cleared. The finite problem is capable only of theoretical solution when the results will be a curve which may or

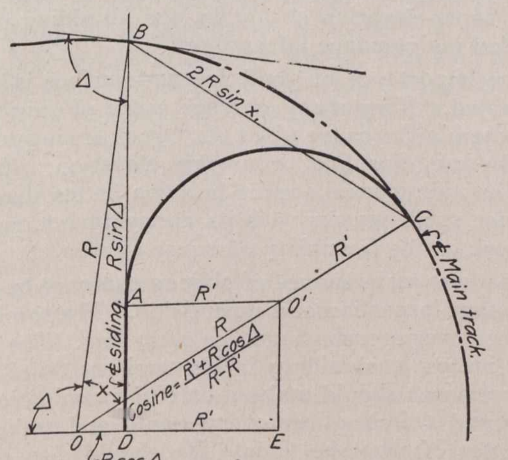

Fig. 5.—A Siding from the Inside of a Curved Main Track.

may not approximate that of some regular connection. But it will generally be possible to change one or both points so that the curve of the nearest regular number of frog may be employed.

The theoretical solution is readily made by means of the geometrical relations indicated in the diagram and furnishes the following formulae by which the radius may first be computed and if this answers the practical requirement, the distance from the point of curve to the foot of the perpendicular through the nearer point.

It will be noted that the formula for obtaining the radius has been reduced with a view of establishing the function R in its simplest form, which will be found to facilitate greatly the detailed solution. Indeed without this simplification the solution is immeasurably tedious.

$$R - \frac{a + b}{2} - \frac{c^2}{2\,(a - b)} = \frac{c}{a - b} \sqrt{2\,b\,R - b^2}$$

$$x = \sqrt{b\,(2\,R - b)}$$

The factor preceding the square root sign need only be carried to two decimal places and to the same degree of accuracy when squared. The remaining members may be used throughout of the nearest even whole number.

When the radius found is not of practical application, as when a radius of 375 ft. results, which lies midway between the curve of a No. 6 and a No. 8, No. 7 not being used, the problem becomes one of adjustment within the limits that are possible for changes in the two assumed points. The quarters will seldom be so close that a change of a few feet will not be practicable and in such event the choice will lie between a compounded curve and a special frog.

A solution of the extreme case mentioned will afford some hints that will tend to simplify the solutions of other problems. It should be noted that a radius within 50 ft. will furnish practical results in the use of any particular frog. Thus a radius of 300 ft. will answer for a No. 6 or 450 ft. for a No. 8. But upon the determination of the radius a computation should be made of the distance to the point where the offset distance is equal to the gauge plus ½ in., and this point be used for the point of frog and a proper lead laid off to determine the point of switch, which need not be exactly at the point of curve.

Let $a = 137$, $b = 51$, $c = 100$; then, $R - 152$

$$= 1.16 \sqrt{102\,R - 2601}$$

Squaring, $R^2 - 304\,R + 23104 = 138\,R - 3511$
(138) (25737)

$$R^2 - 442\,R + 48841 = 22226$$

(diff. 25737)

$R - 221 = 149$, or $R = 370$.

Changing to $a = 132$, $b = 56$, $c = 100$, $R - 160$

$$= 1.32 \sqrt{112\,R - 3136}$$

$R^2 - 320\,R + 25600 = 196\,R - 5456$
(196) (40964)

$$R^2 - 516\,R + 66564 = 35508$$

(diff. 40964)

$R - 258 = 189$, or, $R = 447$ ft., which permits the use of No. 8.

Changing to $a = 144$, $b = 44$, $c = 100$, $R - 144$

$$= \sqrt{88\,R - 1936}$$

$R^2 - 288\,R + 20736 = 88\,R - 1936$
(88) (14608)

$$R^2 - 376\,R + 35344 = 12672$$

(diff. 14608)

$R - 188 = 113$, or $R = 301$ ft., which permits the use of No. 6.

Practical Considerations in Siding Layouts.—The feature of clearance in siding layout is a basic one because it concerns not only the switching movements but affects also the question of safety to persons. Some roads prescribe the minimum distance from the track for structures and a few require that this limit shall be followed in the case of movable obstructions. But the addition to this minimum made necessary by the "nosing," overhang or tilt of the cars, which is a variable one, is not generally stated. Assuming that the widest car which moves in regular traffic is 10 ft. 9 in., a limit of 4 ft. 7 in. from the gauge line of tangents for all obstructions would allow a margin of 1 ft. 7 in. without any correction for accidental unevenness of elevation or for swaying of the car while in motion and with a fair degree of maintenance this would render operation entirely safe.

Car design is such that in a general way the nosing nearly equals the overhang on curves that are without super-elevation. The corrections may be readily computed for cars with 30 ft. truck centres by taking one-fourth the degree of the curve as inches of overhang and assuming that the nosing is no more than that figure and adding or subtracting whatever may be proper for the super-elevation employed. If this is 1½ in. as suggested, the tilt at the eaves of the car would add or subtract 4½ in. from the correction, depending on whether the low or high side were in question. The fact should not be overlooked that at the end of the curve a correction should also be made which is one-half that for the body of the curve. The distance beyond the point of tangency to the point where correction no longer applies is about 18 ft.

The overhead clearance limit is conveniently fixed at 16 ft. above the top of rail which meets the requirements of all present equipment and probably is ample for all future design. As this clearance will not pass a man

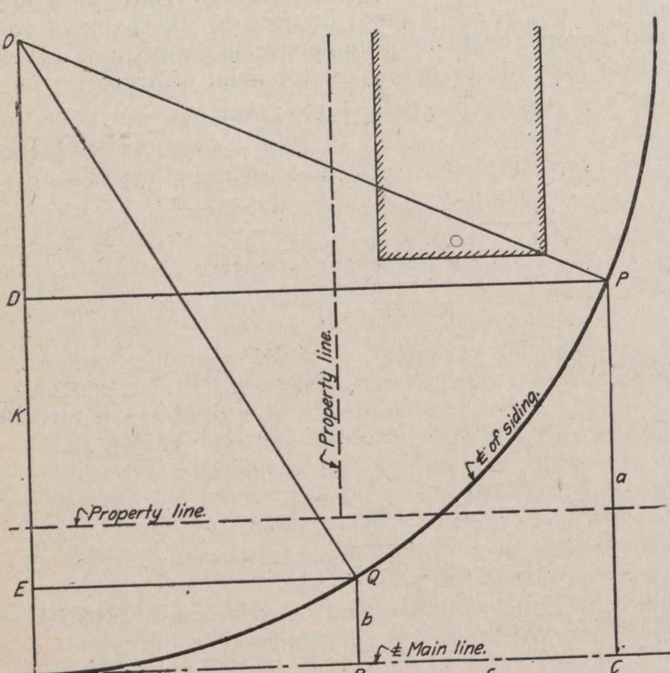

Fig. 6.—A Siding Required to Pass Through Two Points.

riding a car, tell tales should be placed. The least overhand clearance that will safely pass trainmen standing upon the highest cars is 20 ft. 9 in. above the top of rail.

The considerations of alignment, grade and super-elevation are other important elements in a siding layout. As a general proposition, if space is available, no shorter radius should be employed than can be operated practically by any class of engine. For most roads this is the curve of a No. 6 turnout from tangent which is 23 deg. or 250 ft. radius. This requirement is not practical in congested districts and it will often be necessary to modify the curvature to the minimum that a due consideration for safety in coupling cars will permit. This radius has been variously determined, but probably is close to that of a No. 5 turnout from tangent or a 162-ft. radius. Where sharp curvature and maximum gradient are both involved insistence should be had upon the best possible feature for each.

The allowable maximum gradient for siding connections for the best service is 2 ft. in 100 ft. and the maximum for a track upon which cars stand for unloading 1 ft. in 100 ft. It is possible to operate sidings with a gradient as great as 4.7 ft. in 100 ft., but the best drill engines cannot handle more than three loaded cars on such a gradient and the operation is therefore unprofitable. The danger of wrecks from cars running away with the possibility of fouling the main line even when derails are provided renders such a gradient highly objectionable. It is very important that all radical changes of grade in siding connections shall be eased by vertical curves, as the absence of such advantage is a frequent source of accident.

The general feature of gradient concerns the approaches to coal trestles more particularly, and is one where the road must often take a firm stand against the insistence of the applicant for more headroom. The adoption of a limiting gradient by the road many times would supply the means of combating such demands. If greater headroom is desired it can nearly always be had by excavating the site. Any less clear height than 6 ft. 6 in. below the stringers will not permit a horse being driven through and any greater headroom than 14 ft. will break the coal or grind a measurable amount of it into dust with a considerable loss to the dealer.

The question of super-elevation is one concerning which authorities differ. It will be argued that no super-elevation is possible through the connection and therefore none is necessary beyond the connection. But the difference is that the track through the extent of the switch timbers is more rigidly secured in line, surface and gauge, if tie plates be used on the timbers as should be the case, and there is less chance for distortion. It will be found that a super-elevation of 1½ in. for all siding curves is a decided maintenance advantage.

The importance of good line and surface is not fully appreciated. Very many obscure cases of siding derailment wherein the cause given as "truck failing to curve" is really irregular line or uneven elevation. To spend money in siding maintenance is much better than spending it for small wrecks with its annoying interruption to drill work or the possibility of injury to men.

The best maintenance of sidings can only be attained by constant inspection and supervision. The track walker should go over every siding once every day. The foreman should inspect each siding in his territory twice a week. The supervisor should make a careful examination of his sidings and switches once every month and make permanent notes of what he finds. He should also require a report every two weeks from his foremen stating that he has made his inspection and calling attention to any specified repairs that may be necessary requiring material that he lacks. For the best results the foreman should not be overburdened with siding responsibility. Probably 30 switches is the most that one foreman can look after if he has main track duties also.

The first pier of the new Balboa terminal of the Panama Canal is now completed. It is 1,000 feet long and 200 feet wide, the floor being supported on concrete caissons, there being 200 of these sunk to a depth of 61 feet to bed rock. The concrete used in the construction amounted to 27,000 cubic yards. Work was commenced on sinking the caissons in February, 1913, and completed in February, 1914. The superstructure was begun in March, 1914. The new concrete docks when completed will have a water frontage of 5,700 lineal feet.

Editorial

FREE LIME IN CEMENT.

For many years engineers continued in the habit of depending entirely upon the tensile tests of neat cement and 3 : 1 sands, and it was customary for them to ignore entirely the compression tests. It is now definitely known, however, that neat tests have become almost obsolete in European laboratories, the practice being for those interested to confine themselves entirely to the 3 : 1 sands in both compression and tension. But even these tests have been shown to be far from reliable, especially where fine-grain sands are used. In reinforced concrete work the concrete is rarely subjected to tension except in instances of accident in design, and it has been decided that the only use of neat tests is to determine the initial and final set of the cement, of which the initial set should be about one hour. Modern cement is much more finely ground than was at one time the case, and naturally great care should be given to the way in which cement for reinforced concrete work is stored. While previously, in the days of coarse grinding, it was necessary to give plenty of time for aeration in order to render it safe, as it contained a certain proportion of free lime, at the present time, if any of this is present, it is hydrated practically as soon as the concrete is made. If cement is stored in an exposed position it becomes greatly reduced in value, due to hydration, and the only safe method, where it is not required for immediate use, is to stock it in airtight bins. The most accurate test to ascertain the proportion of free lime in cement is still stated to be the "Chatelier," the testing instrument consisting of a section of a small cylindrical tube cut off at a given length, and with a saw cut along its axis. To this two arms are connected, of a given length as compared with its diameter. The cement is gauged with approximately 25 per cent. of water filled into the tube, and stored in cold water for twenty-four hours. After this it is placed in cold water, which is heated to the boiling point, and is then boiled as quickly as possible for six hours. Before this latter process the distance between the pointers is accurately measured, and after the boiling is over the difference in the distance between the arms will show the expansion that has taken place. This difference should not exceed 4 millimètres, and it is said that the concrete made with cement that has passed this test will be absolutely safe in use, and no accident can happen due to the presence of free lime.

CO-OPERATION IN PUBLIC UTILITIES.

This is the time of year when the champions of municipal ownership advance their hobbies into the political arena, and make great endeavors to sway public interest to a general and favorable conclusion with respect to the abstract question. It is interesting to note that, at a large conference of United States mayors held recently in Philadelphia, although there were a number of outcroppings of radicalism, as might have been expected, the dominant opinion was in favor of the privately owned and operated utility, with proper regulation, either state or municipal. Of interest also were the remarks of Mr. A. M. Taylor, director of city transit, Philadelphia, in outlining the city's policy in dealing with public utilities. "We recognize," said Mr. Taylor, "the great part which the railroads and other public service corporations can take in the development of this city and its industries, but to so take this part they must have credit upon which to raise large sums of money, and they must be assured of an adequate and attractive return thereon and immunity from unwarranted competition or political and public attacks. The capitalists of this country are going to invest their money in communities where capital is justly treated and permitted to earn attractive returns and are not going to invest money in communities where its security is impaired and its productiveness is unduly curtailed by unreasonable legislation, regulation or competition."

One decided advantage of the exercising of the "municipal ownership" hobby at election time lies in the tendency it has to convert antagonistic relationship between public service companies and the public into a relationship of mutual understanding. In the case of street railways, for instance, it should be the purpose of both railway and officials and responsible public officials to place the relations of the companies and the public upon a permanent basis of mutual confidence. It is necessary that the companies and the public understand and trust each other, otherwise the companies will not prosper, the service will be poor, and the public will suffer.

At the winter meeting of the Pennsylvania Street Railway Association the relation between electric railways and the public was discussed by Emory R. Johnson, Professor of Transportation and Commerce, University of Pennsylvania. Prof. Johnson, who is also a member of the noted Public Service Commission of that city, makes the following statements:—

Electric railway and other public service companies can secure the confidence of the public, provided the companies adhere to methods of financiering and management that square with approved moral standards; provided the companies keep the public fully and accurately informed regarding the affairs of the corporations that serve the public; and provided the service rendered is adequate and efficient.

The affairs of public service companies must be matters of public knowledge, and it will be impossible for a company successfully to conceal operations that would not meet with public approval. Electric railway and other public service companies should keep accurate accounts according to uniform methods, and their financial obligations should be so straightforward that the public will be convinced that the companies are not resorting to the speculative methods of financiering which, though prevalent in the past, have now come to be condemned; also the companies should systematically publish information that will help the public to understand and correctly judge the financial and service operations of the companies.

Good service is fundamental and all important. It is essential to the success of the company and is necessary to secure public approval of what the company does. If the public feels that utility companies are straightforward in their financial management and are rendering good services, it will not be opposed to the maintenance of charges that yield adequate profits. The public demand for good service is stronger than for low fares.

The policy of every utility company should be to study the service demands as fully as possible, and the management may wisely study carefully all serious complaints to services. Careful attention to complaints will be helpful to the company as well as gratifying to the public.

Many electric railway companies have been apprehensive because of the increasing degree of public regulation of their finances, services and charges; but I believe there is less apprehension now than there was 10 years ago. Regulation of public service companies in increasing measure by state and municipal authorities has come about naturally and logically. It is necessary for each municipality to have a unified transportation service; and, with but few exceptions, there is now but one street railway company in each city. The requisite unified service is performed by a consolidated company.

Likewise, the larger interests of the people demand that the state shall, by appropriate regulatory, supplement municipal regulation of public utilities. State regulation is necessary, first of all, because the public service company often serves more than one municipal area. The power that regulates must be as extensive as the object regulated; moreover, state regulation is desirable because experience has clearly shown that in the supervision of accounts, finances, services and charges of public service companies there needs to be an executive body whose jurisdiction is state-wide and whose powers are as comprehensive as the tasks to be accomplished. If the regulation of electric railway and other public service companies were left entirely to municipalities, the regulation would be incomplete and would vary greatly as between different localities. Such a condition would be of disadvantage to the companies and not a benefit to the public.

PROTECTING METALS BY CALORIZING.

A NEW process which will lead to economies in various phases of manufacture by preventing metals, especially iron, from burning when subjected to high temperatures for either long or short periods of time, and for one or many heats, is described by data and illustrations in a recent paper by Messrs. H. B. C. Allison and L. A. Hawkins, of the Research Laboratory, General Electric Co. This process, the discoverer of which is reported to be Mr. T. Van Aller, first consisted of heating metals in revolving drums with mixtures containing, among other things, finely divided aluminum, by which a surface alloy containing aluminum is produced. In the case of copper, this alloy is of the nature of an aluminum bronze, but richer in aluminum than the ordinary alloy of that name and more resistant to heat, so that copper thus treated is protected up to the melting period of the alloy from the scaling which occurs when untreated copper is heated above 300 deg. C. The same general result was obtained in the case of iron and steel.

A modification of this process extends its application to pieces which, because of their shape and size, are not adapted for tumbling. It admits of their being calorized by packing them in, or painting them with, a suitable mixture and heating them. There appear to be many places where it is desirable to use iron vessels or apparatus at temperatures above red heat, and at such temperatures, ordinary iron rapidly oxidizes and scales away. After iron is calorized the effect of heating is slight. Instead of burning and the scale falling off, as in the case of untreated iron, practically no effect can be detected after a considerable time—certainly none which injures the surface.

The above facts seem to indicate that this is a simple method for extending the use of iron under oxidizing conditions at high temperatures, and for greatly prolonging the life in those instances where it is now used, but must be renewed at frequent intervals. In the case of small muffles on crucibles, where temperatures are below 1,000 deg. C., this treatment of cheap cast or wrought iron shapes seems very promising. While the life of the coating depends on the temperature at which it is used, as well as on the duration of time taken in its preparation, i.e., the quantity of aluminum which alloys with the surface of the iron, it does not permit of long use at temperatures much in excess of 1,100 deg. C.

Copper parts also, which are exposed to high temperatures, can have their life increased by calorizing. In some cases calorized copper may be used advantageously in place of aluminum bronze. In some cases, also, the life of copper contacts can be increased by calorizing. For instance, a set of railway controller contacts which were calorized showed double the life of the ordinary untreated contacts.

The effect of calorizing is to produce a surface alloy containing aluminum. The thickness of this alloy varies with the length of time to which the piece is subjected to the calorizing process, and the percentage of aluminum varies through the coating being greatest at the surface.

For iron, calorizing is intended only for protection at high temperatures. It does not compete with galvanizing, sherardizing, and other similar processes for protection against oxidation or corrosion at low temperatures. Its usefulness lies within a range of temperature much higher than a galvanized or sherardized coat could stand. For copper, calorizing is effective against corrosion at low temperature as well as against oxidation at high temperature. The upper limit is determined by the melting point of the alloy, which is somewhat lower the heavier the calorizing treatment, since that means an alloy with a higher aluminum content.

The probable explanation of the effect of the aluminum in the surface alloy is that a thin coat of alumina forms which prevents further burning of the metal beneath. It is well known that a pure aluminum wire may be heated in the air to a temperature several hundred degrees above its melting-point, without flowing, when the thin alumina shell which surrounds and supports the molten metal is easily seen.

AT LAST.

The following clipping is from the Kansas City Post, of recent date:—

"An engine that runs itself on its own power, developing energy to operate machinery, has been invented in this city. The inventor has been working for five years on his self-operating engine, and now has it near perfection. A few alterations are to be made. These will increase its efficiency.

"The engine is run by compressed air, making its own pressure as it runs. The exhaust from the cylinders returns through a series of 8-port automatic valves, to a large steel pressure tank. This tank is a double affair, there being a smaller tank within the larger one.

"An air space of 6 in. intervenes between the two tanks. Into the air space the exhaust from the cylinders is forced, the action being such that the nitrogen gases are separated from the oxygen and forming a lighter gas, rises to the top of the tank, at the same time creating a pressure which forces the fresh air down through the inner tank and back into the engine, which is operated by this pressure."

Coast to Coast

Vancouver, B.C.—The large wharf that is being constructed for the Vancouver Island division of the Canadian Northern Pacific Railway will be ready for use early in the new year.

Moose Jaw, Sask.—During the past season 9.85 miles of streets were graded, involving the excavation of 30,680 square yards of material at a cost of $8,530.17, or a rate of 27.8 cents per cubic yard. The city has 36 miles of graded streets.

Moose Jaw, Sask.—The city has 35.66 miles of sanitary sewers, of which 2.33 miles were laid this year. The mileage of water mains is 66.44, of which 2.90 miles were laid this year. The number of fire hydrants on domestic water mains is now 306, of which 22 have been installed during the season.

Galt, Ont.—The Lake Erie and Northern Railway line has been connected up with the C.P.R. line at Main Street. The ballasting of the new road in Galt is now about complete, and work has commenced on the erection of a station on Main Street pond, the filling in of which has been finished.

Victoria, B.C.—The construction of a wharf at Patricia Bay has been commenced by Mr. S. Doe, who has been awarded the contract by the Canadian Northern Pacific Railway Company. The structure will have a width of 64 feet and a length of about 145 feet.

Vancouver, B.C.—The Dominion Board of Railway Commissioners, in session at Vancouver some time ago, cancelled their previous order for viaducts at Pender, Keefer and Harris Streets, over the V., V and E. Railway. A similar viaduct on Hastings Street, ordered at the same time, had not been subjected to delay and is already nearing completion.

Lytton, B.C.—To conclude the section of the C.N.R. between Summit and Kamloops, about 105 miles of track are still to be laid between Albreda and Lytton. Some 65 miles have still to be laid between Port Mann and Kamloops. These are the only remaining sections of the main line. Work is being proceeded with at the rate of 4 miles per day.

Welland, Ont.—The first tubular steel flag-pole made in Canada has recently been erected in Merritt Park. It is 76 ft. long and weighs 2½ tons. It consists of four sections of lap-welded steel pipe. The pole is anchored in a concrete foundation 6 ft. square and 7 ft. in depth. It was manufactured by the Page-Hersey Iron, Tube and Lead Company, Welland.

Toronto, Ont.—Property Commissioner Chisholm recently presented a report showing that the gross value of all civic properties was $35,712,806. The principal items were: City Hall and other public buildings, $6,278,366; Public schools, $6,540,097; parks, $12,352,893; tax sale lands, $1,270,666; High schools, $1,798,922; waterworks, $1,022,795; revenue-producing property, $2,729,191; Hydro properties, exclusive of plant, $269,110.

Saanich, B.C.—On the branch of the Canadian Northern Pacific Railway Company from Victoria to a terminus on the Saanich Peninsula there is a large cut extending for a distance of about 700 ft. and involving the removal of about 50,000 cu. yards of gravel. The excavation is now practically complete, and has been carried out by the firm of McDonald, Nettleton, Bruce, Essbach and Company. Rail-laying on this section has commenced.

Hamilton, Ont.—The Dominion Railway Commission has directed the city's engineering staff, and also the engineering staff of the T., H. and B. Railway, to prepare reports and estimates on the cost of grade separation for submission to it on February 1st, 1915. This is in connection with the old dispute between the city and the company, occasionally referred to in these columns. The Commission has advised the city and railway to get together as much as possible in an attempt to settle their difficulties.

Outremont, Que.—A special feature of the town's new lighting system is that it is entirely served by underground cables, and also that nitrogen-filled tungsten lamps are used exclusively. In both these respects the town deserves publicity, in that it is the first Canadian municipality to inaugurate the above features completely. The town has about 20 miles of lighting system. The installation has cost about $75,000, and has been installed by Town Engineer Duchastel, with the consulting engineering supervision of Mr. L. A. Herdt, of Montreal.

Cobalt, Ont.—The preliminary work in connection with the draining of Cobalt Lake has been completed, and it is at present being lowered, by gravity, to an elevation of 6½ ft. below normal, at which elevation pumping will commence in the spring. The pumping equipment is now in place. The greatest undertaking in connection with this project has been the supply of water for concentrating purposes to the various mills now getting their supply from Cobalt Lake. This has necessitated the daming of a series of lakes and pumping water through an extensive piping system to the mills.

Guelph, Ont.—County Roads Superintendent Young's report outlines the work of two outfits of road machinery continuously employed during the season. Several bridges were built, including the following: Moore's, Pilkington Tp., $845.26; Burnett's, Pilkington Tp., $924.60; Powell's, Peel Tp., $505.26; Parkinson's, Eramosa Tp., $1,037.05; Walker's, Maryboro Tp., $349.11; Scanlon's, Nichol Tp., $458.81; Blyth's, Guelph Tp., $769.92; Moorefield bridge, retaining wall, Maryboro Tp., $2,416.83; Kitley's bridge, Maryboro Tp., $207.51. Considerable drainage, grading and resurfacing on several of the county roads have been proceeded with, the materials used for resurfacing being mainly broken stone and gravel.

Leamington, Ont.—The town has recently awarded the contract for the construction of a drain to consist of 6,500 ft. of open drain, with 6 ft. bottom, 3,371 ft. of 4-ft. concrete tile, 1,456 ft. of 36-inch, 2,935 ft. of 30-inch, 2,956 ft. of 20-inch, and about 2,000 ft. each of 12, 8 and 6-inch, together with 34 catch-basins, 17 manholes, and a small bridge. The contract for the work, which is known as the Selkirk drain, was awarded to the Webster Construction Company, of London, the price being $24,999.50. The contractor intends to manufacture his own concrete tile. Walter Thorold, C.E., consulting engineer, Toronto, was called in to report upon this work some time ago, and it is on his recommendation that reinforced concrete construction was adopted.

Moose Jaw, Sask.—According to a recently issued report of Mr. Geo. D. Mackie, city engineer-commissioner, there are now 40.16 miles of concrete sidewalk in the city, of which 11.25 miles were constructed this year. The Moose Jaw Construction Company had the contract for this season's work, the price being $104,968. The unit price per square foot for the sidewalk was 20.4 cents as against an estimated cost of 25 cents. The total area of the walk laid was 51,000 square feet, curb and gutter 56,000 lineal feet, excavation 20,000 cubic yards, and 7,400 square feet of lane crossings. This contract was stopped in August owing to the outbreak of the European war, and there is left still to be carried out under the contract on the 1914 work about 25,000 square feet of sidewalk.

PERSONAL.

ANDREW C. LAWSON, a graduate of the University of Toronto, has been appointed Dean of the School of Mining in the University of California.

PERCY E. JARMAN, who has been acting city engineer of Westmount, Que., since the resignation of Mr. Arch. Curry, about two years ago, has been appointed city engineer.

W. J. FULLER, of the Consumers' Gas Company, Toronto, is conducting a course of ten lessons in illuminating engineering for the benefit of the employees of the company. Courses in other subjects, by other instructors, are being given concurrently throughout the winter.

C. S. J. WILSON, construction engineer with the Dominion Bridge Company, read a paper before the Manitoba Branch of the Canadian Society of Civil Engineers on December 5th, his subject being "Bridge-building in the Rockies, and Engineering Problems Encountered in the Work."

R. G. McCONNELL, who has been acting Deputy Minister of Mines for Canada since the resignation of Mr. R. W Brock, was appointed Deputy Minister on December 1st. Mr. McConnell graduated from McGill University in 1879, whereupon he joined the staff of the Geological Survey. A great deal of the important exploratory work done by the Survey in Western Canada has been conducted by him.

J. B. CHALLIES and J. T. JOHNSTON, of the Water Power Branch, Department of the Interior, Canada, were in Washington last week by invitation of the United States Secretary of the Interior, Hon. Franklin K. Lane, to explain the water power laws and administrations of Canada to a special committee of the United States Senate, which is drafting a water power bill to cover the administration of water powers under the control of the Federal Government.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

Regular Meeting, December 17th, 1914.

The regular monthly meeting of the Canadian Society of Civil Engineers was held at the headquarters of the Society, 176 Mansfield Street, Montreal, on the evening of the 17th. The first part of the evening was devoted to a discussion of Mr. Surveyor's paper, "Making Our Water-Powers Valuable," a long reference to which was made in our issue of November 26th, 1914. The discussion was participated in by Messrs. Henry Holgate, L. A. Herdt, J. W. Evans, Frederick B. Brown and Ernest Marceau.

At the conclusion of this discussion Professor Peter Gillespie presented a paper, entitled "Methods of Treatment of Sewage Sludge" (referred to elsewhere in this issue), and gave an illustrated talk on the subject. The greater part of the lantern slides used were made from photographs taken by the author in Europe during the summer of 1913. Prof. Gillespie's address, 1½ hours in length, held his audience in rapt attention. He used no notes, and his familiarity with his subject and his views made it a delightfully smoothly-running and logically-connected discourse.

Mr. Walter J. Francis, chairman of the Meetings Committee, presided at the meeting.

On December 22nd the members of the Ottawa branch of the Canadian Society of Civil Engineers listened to a paper on "Submarines" given by Engineer-Commander P. C. W. Howe, R.C.N

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

This Branch of the Society held its annual meeting on December 5th, and elected the following officers for the ensuing year:—

Chairman—Mr. F. H. Peters.

Secretary-treasurer—Mr. P. M. Sauder.

Executive Committee—Mr. R. J. Burley, Mr. H. B. Muckleston, Mr. P. J. Jennings.

Auditors—Mr. J. S. Tempest, Mr. F. G. Cross.

The Branch has a number of prominent speakers in view for its winter meetings. It intends to hold a series of luncheons during the season.

At the annual meeting referred to above, Messrs. J. S. Dennis, H. B. Muckleston, F. H. Peters, P. T. Bone, G. Romanes, H. Siddenius and P. M. Sauder were speakers.

VICTORIA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the annual meeting of the Victoria Branch, held on December 10th, the following officers were elected:—

Chairman—D. O. Lewis.
Vice-Chairman—H. W. E. Canavan.
Treasurer—Frank C. Green.
Secretary—R. W. McIntyre.
Executive—A. W. R. Wilby, A. E. Foreman.
Auditors—E. H. Harrison, H. A. Icke.

In his retiring address, Mr. F. C. Gamble, who has been chairman for the past two years, made the following remarks:—

"To successfully accomplish the advancement of our profession to the position it should occupy, personal aim should be set aside and members should work together unselfishly as a determined body of men, whose sole purpose is to raise the profession of civil engineering to the highest plane of efficiency and influence. By following along the suggestions implied in these remarks we shall soon command a greater confidence and more of the respect of the public. The effect of your efforts may not be immediate nor of direct personal advantage, but indirectly every member will be benefited by the growing influence of our society.

"Each member of this branch should realize his individual responsibility and should not shirk his duty.

"In one direction our activity has not been as great as could be desired, and that is with regard to the preparation and the reading of papers at our monthly meetings. There has been a sad dearth of these. We have men amongst us who can write with ability most interestingly and instructively on subjects they are most familiar with, and I beg of these not to postpone their duty in this respect indefinitely."

On December 10th and 11th the general meeting of the Victoria and Vancouver branches was held. Among the papers presented was that of Mr. J. S. MacLachlan, Dominion Government Engineer, on harbor work at Victoria, who read a paper on "Harbors," and an interesting discussion followed. Mr. G. R. G. Conway, Chief Engineer of the British Columbia Electric Railway Company, and chairman of the Vancouver Branch of the Society, also read a very valuable paper, entitled "Legislation and the Engineering Profession."

The following were appointed to the board of directors of the Ottawa Light, Heat and Power Company at its annual meeting, held last week: Col. D. R. Street, present secretary-treasurer of the company, and Mr. F. W. Fee assistant secretary-treasurer. These vacancies were caused by the deaths of Mr. John Manuel and Mr. Honore Robillard.