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MISSING

The Canadian Engineer

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KENILWORTH AVENUE SUBWAY, HAMILTON

A DESCRIPTION OF TYPICAL CITY GRADE SEPARATION WORK—NOTES ON WATERPROOFING — OVERCOMING OF FALSEWORK TROUBLE.

By **KENNETH CAMERON.**

THE gradual extension of the city of Hamilton and the more immediate need of the Street Railway Company to lay tracks on Kenilworth Avenue, necessitated the construction of a subway under the Grand Trunk Railway tracks at the point of their intersection with the street. This section of the railway is the double-track main line from Hamilton to Niagara Falls and Buffalo, over which there are a large number of movements—both passenger and freight—all the year round. Although the ordinary vehicular traffic is at present light, the street being the easterly city limit, yet a grade crossing of the electric line was considered inadvisable, and it was decided to construct a subway under the railway tracks, no change of grade of the latter being made.

When the work was first proposed a preliminary survey and general layout were made by the city engineer's staff, the latter dealing more particularly with the street arrangements, clearances, etc. After approval, detail plans according to this layout were prepared at the office of the chief engineer of the railway. The crossing is practically square (89° 27′); the approaches have 4 per cent. grades with plain concrete retaining walls, having a clear width of 50 feet between them. The bridge proper consists of a ballasted I-beam floor, carried on plain concrete abutments and a centre steel bent on concrete footings. The superstructure is built for four tracks, there being two crossing at present, and four up to a point within about half a mile of the subway; and to take care of any future requirements all columns and footings of the centre bent are alike, so that the outside ones can carry double load if additional tracks are added on either side. The floor is carried on 24-inch I-beams, spaced 2 ft. 0 in. centre to centre and parallel to the tracks. These are filled solid with concrete except for a "V" cut between bottom flanges. The general arrangement of these details is shown in Fig. 1, which also shows the columns and footings. One feature perhaps worth noting is that the girders carrying the I-beams are of unusual depth—with, of course, proportionate section—so that no further bracing of the columns is needed. The whole showing surface of the steel was given a finishing coat of grey paint to conform to the concrete work.

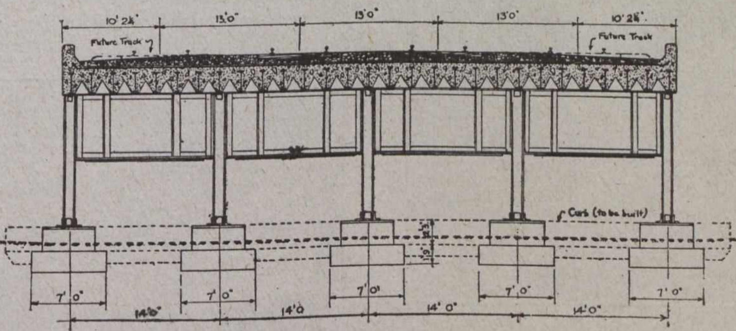


Fig. 1.—Cross-section of Bridge on Centre Line of Street.

From previous information it was anticipated that the main portion of the excavation would be in medium clay with soft shale near the finished road surface, and it was at first thought that some actual economy might be made by the use of raised sidewalks and correspondingly smaller depth of abutment footings. A comparison, however, seemed to indicate that costs would run about equal, but owing to the difficulty of getting good drainage, it was decided to adopt the raised sidewalks. The section of abutments as finally built is shown in Fig. 2, which also shows the arrangement of the sidewalk, retaining wall

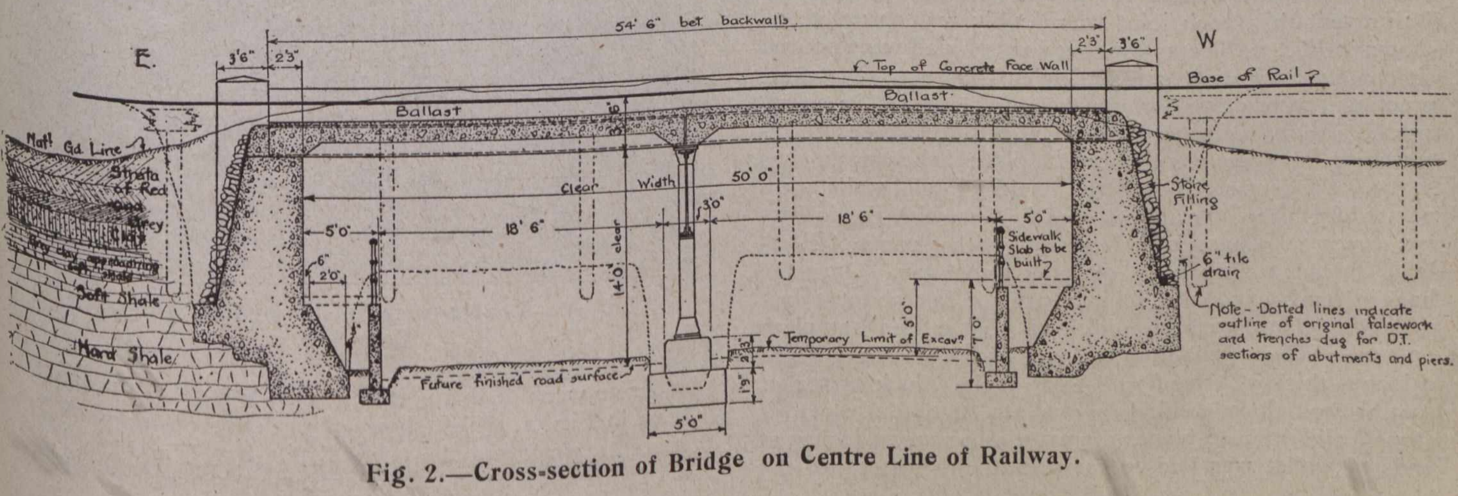


Fig. 2.—Cross-section of Bridge on Centre Line of Railway.

and slab. The surface of the latter is 5 feet above the crown of road and runs into the grade of the road, therefore, at points 125 feet from the sides of the superstructure. (See Fig. 5.) In general, the retaining wall sections are similar to the abutments, proportionate

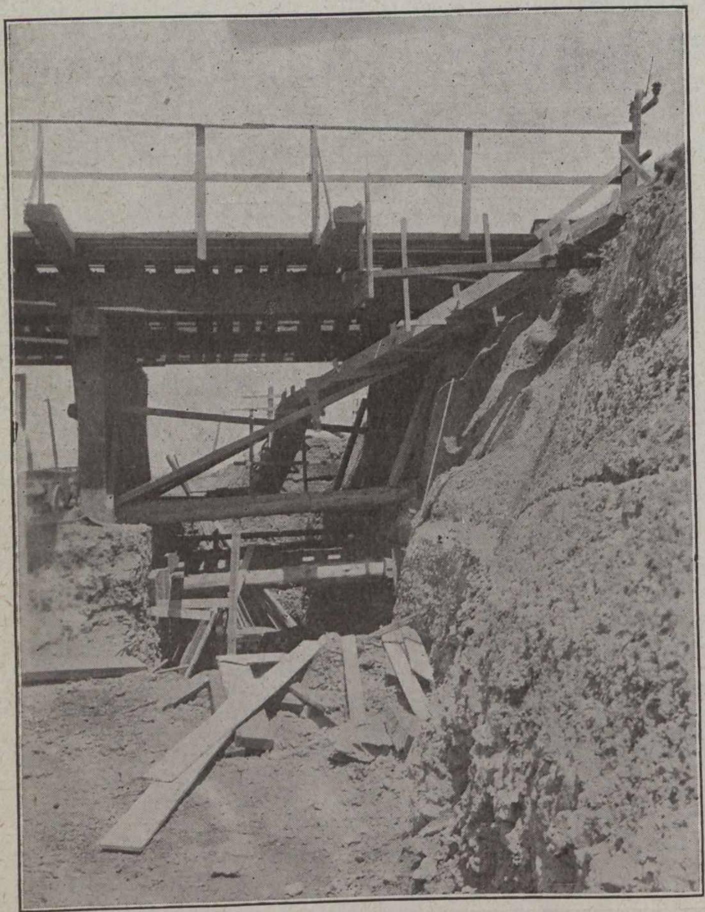


Fig. 3.—Trench for Double-track Section of East Abutment.

allowance being made for absence of superstructure and live loadings. Footings are stepped up at intervals along the grade, and expansion joints provided at 25-foot intervals.

The expansion joint, though very necessary, is often a source of much trouble, particularly through disfigurement by seepage of drainage water. In the spring season, especially, walls are frequently rendered very unsightly by seepage discolorations spreading out from the joints, and this notwithstanding the provision of weeping pipes. To prevent this, each joint was doubly waterproofed, as shown in Fig. 7. The 25-foot sections of wall were poured alternately, strips of felt (similar to that used in waterproofing the bridge floor, see below) being set in as required, and later bent to their final position when the intervening sections were poured. When the whole was set and the forms removed the backs of all walls were painted from top of wall to top of footing with the following mixture: 3 parts of kerosene oil with 4 parts of Portland cement and 16 parts of refined coal tar. Over the back of each expansion joint a strip of felt about 2 feet wide was placed with an additional coat of coal tar pitch on top. When backfilling, a layer of rubble stone about 9 inches thick at top of wall to 18 inches thick at top of footing was placed behind the walls. At the base of this stone a tile drain (6 inches diameter at centre, 4 inches at ends of walls) was laid to carry drainage water to the weeping pipes, of which there is one to every 25-foot section of wall. Although only one winter and spring has passed since the completion of this work, the conditions then were unusually severe, but so far no sign of seepage has shown at any of the joints. Although perhaps seemingly elaborate, the cost of this work was but a small item of the total, the obtaining of watertight joints being justification for the additional work.

By arrangement between the city and the railway it was agreed that the rough excavation for the road cut and retaining walls should be done by the city, who would also undertake the permanent drainage arrangements and the street and sidewalk paving. The railway company was to take care of falsework, complete the foundation excavation, do all other concrete work, and erect and complete the superstructure.

Pile-driving for falsework commenced on May 28th and at once indicated that shale would be met with higher than anticipated, only 12 feet of penetration below base of rail being obtainable. The depth of excavation required from base of rail to foundations was approximately 20 feet, so that unless some other plan were adopted it would be necessary to underpin the pile bents as the excavation proceeded—a tedious and expensive operation considering the security demanded by the heavy railway traffic. Instead of doing this, it was decided to carry on the excavation as far as possible, and then dig out trenches to take lengths of abutments and centre column footing sufficient to accommodate the existing two tracks, and complete the

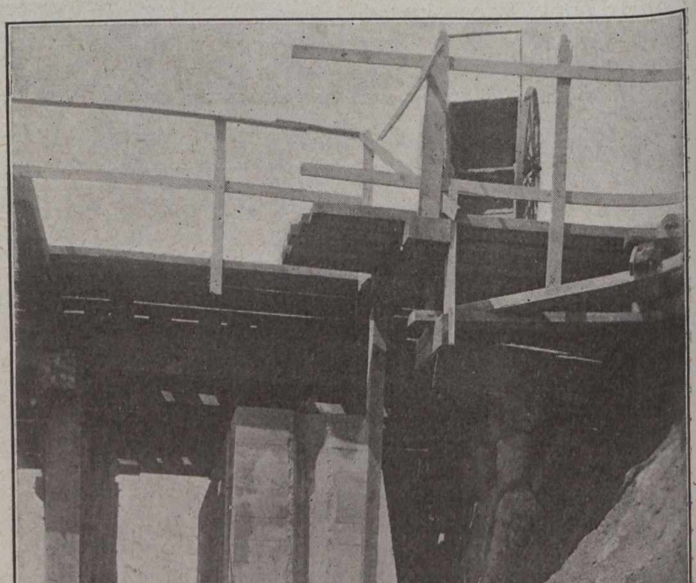


Fig. 4.—Double-track Section of East Abutment Complete.

concrete work of this portion. This is indicated in dotted lines in Fig. 2, which shows the relative positions of the concrete work and the original pile bents, and the lines of trench excavation. This arrangement was carried out (see Figs. 3, 4 and 5), a heavy temporary timber centre bent was erected (the steel columns not being then ready), the old falsework removed and the steel I-beams erected. Fig. 5 shows the conditions when the east section of the abutment was completed and work started on the west, old pile bents not yet removed. Fig. 8 shows both abutment sections and footings completed, the temporary centre bent erected, the old falsework removed and the I-beams in place. Note the camber to the beams to allow of sliding in the steel columns later on. The main operation, breaking track, removal of falsework, erection of beams, and relaying of track, was completed for each track in less than one working day, traffic being maintained over the alternate line without hindrance. When the operation was complete, therefore, the five spans of the original falsework were replaced by two clear spans, which much facilitated the subsequent substructure work and excavation.

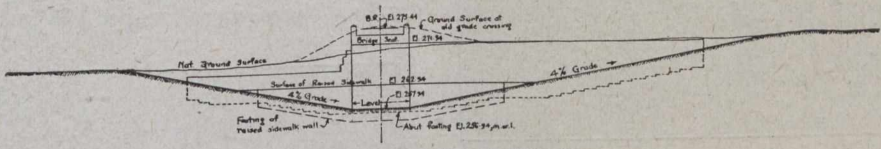


Fig. 5.—Profile of Work.

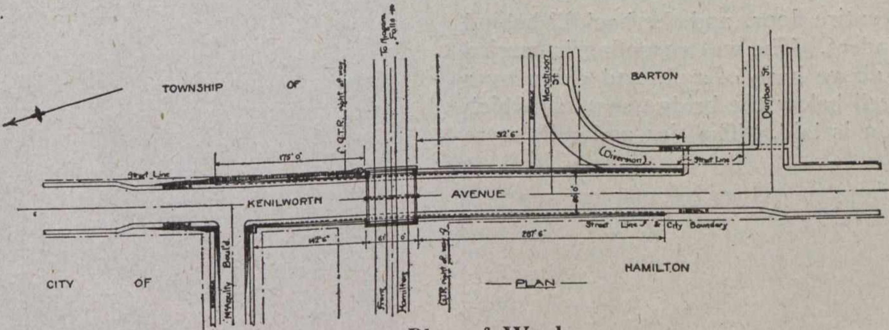


Fig. 6.—Plan of Work.

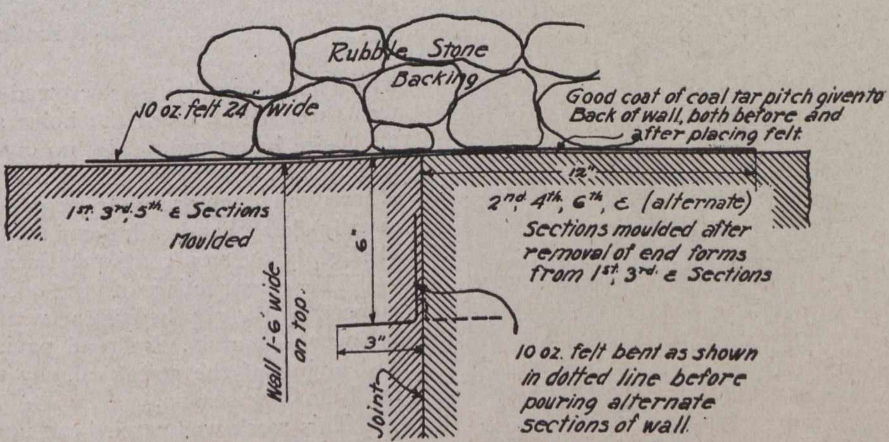


Fig. 7.—Waterproofing of Expansion Joints.

The latter, which, as before mentioned, was undertaken by the city, was commenced as soon as the falsework piling was driven and stringers placed. It was done by hand labor, the material removed by two-yard bottom dump wagons and teams, and wasted, where required, on neighboring property. Fig. 2 shows roughly the class of material encountered. At first it was loosened by plough, but when about 10 feet below base of rail the plough had little effect and small blasts were necessary. It was at this time that the trenches for abutments and centre footing were taken out, and once these sections were completed and the falsework removed (all of which was done in very short time) the excavation and teaming were much facilitated. In fact, it was figured that the gain thus obtained kept the extra cost of the falsework to much less than it would have been if underpinned, and the total cost of the excavation, after crediting the sale of the wasted material, only exceeded by 2½ cents the original estimate of 70 cents per cubic yard on a total of over 12,000 cubic yards.

From this point downward the material gradually changed from a hard grey clay to soft shale and hard shale, so that for the deeper parts of the cut and foundation work, blasting was necessary throughout. The railway forces had very little material to remove, therefore, before obtaining firm, sound rock bottom for their concrete work.

Heavy rains at this period several times flooded the cut, necessitating considerable pumping, and it was the fact that the cut appeared to be a centre for the surface drainage of the immediate neighborhood that caused the engineers to take the precautions above mentioned for waterproofing the walls.

The concrete work was continued uninterruptedly, each abutment being extended in turn to four-track width, and the retaining walls then completed in succession. Fig. 9 shows the southeast wall when completed. In regard to the concreting, it may be noted that a 1 cubic yard steam mixer, mounted complete on a car, was used, being placed on a siding extended for that purpose. An elevator tower belonging to the plant was erected, it being intended to chute the concrete for the walls, but owing to the temporary difficulty of obtaining metal chutes, hand buggies were used, these being eventually retained throughout.

The cost of the concrete work as a whole was low. Accurate records of all costs were kept and in the final analysis to obtain unit costs, all possible charges were included. The average cost of some 1,530 cubic yards of concrete in the substructure was about $6.50 per cubic yard. This includes not only the bare material and labor of mixing and placing, but also the building and removal of forms, surface finishing and waterproofing of the joints.

In the same way the average cost of the superstructure concrete (about 200 cubic yards) ran slightly under $9.80 per cubic yard. These low unit costs were, in part, due to small freight charges (the material supply sources being close at hand), but mainly to the economical handling of the work generally.

As soon as the balance of the superstructure steel arrived, it was erected, and when riveted up, the solid concrete floor was poured. One track was completed at a time, the other track being gauntletted to maintain traffic. When the concrete had set, the surface was waterproofed with four plies of 10-ounce felt with a centre ply of burlap, each layer being well swabbed with hot coal tar pitch before laying the next. Between felt and concrete was placed a layer of rosin paper to keep a free joint, and the same was repeated on top of the last layer. The whole was then covered with a 2-inch protective coat of cement mortar, reinforced with wire mesh, and graded to the ends for drainage. Stone ballast ($2\frac{1}{2}$-inch) was

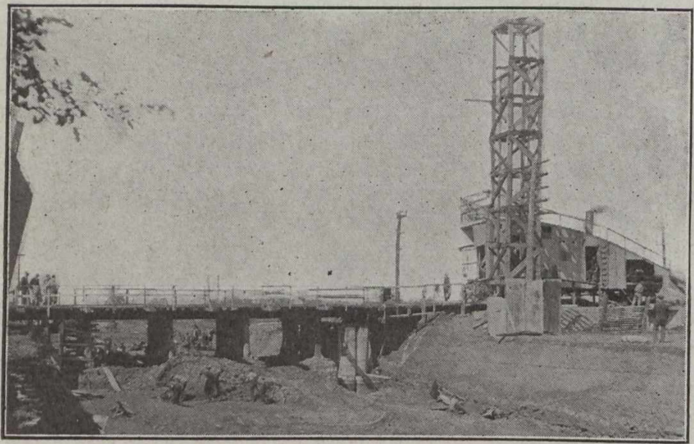


Fig. 8.—General View of Excavation.

specified to cover the entire floor, and the backfill behind the abutments is of cinders. The waterproofing is carried up the side parapets above base of rail, and down over the ends to a point well below the bridge seat, at which level a 4-inch tile drain is laid. The ties and rails were

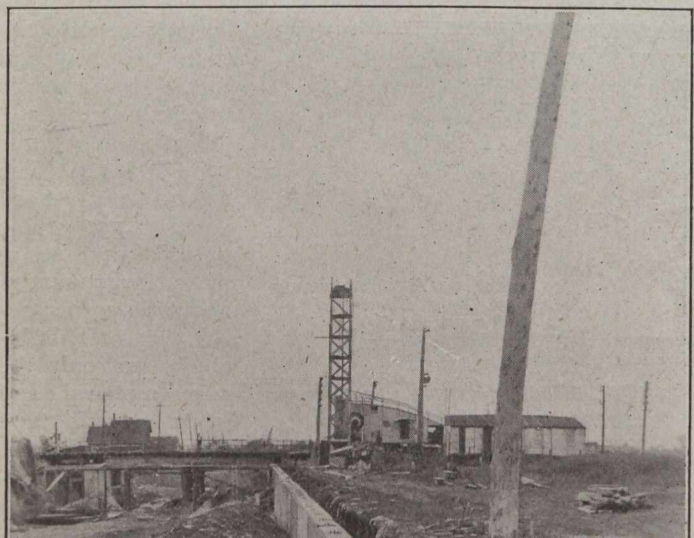


Fig. 9.—Completed Southeast Wall.

then relaid over the completed half, the ties being supported on timbers until ballasting was done. The other track was then gauntletted and work carried out on the other half similarly. Fig. 10 shows the conditions when the waterproofing was complete and ballasting in progress.

The rapidity with which this waterproofing was completed resulted in an unusually small labor charge, and a correspondingly small unit cost. Including a due share of the construction and operation of the gauntlet tracks (which was divided between this and the superstructure concrete work), the unit cost over some 3,500 square feet of bridge floor was about 15 cents per square foot.

After the completion of the bridge floor and retaining walls, the sidewalk retaining walls were poured, these being completed about the middle of October. The erection of the hand-rail completed those parts of the work to be done by the railway forces.

In regard to this hand-rail it may be of interest to note that the standards were of cast iron with flanged bases, and cast holes to receive the 2-inch railing pipes. Six-inch by $\frac{1}{2}$-inch bolts were set in the tops of the walls when these were poured, to receive the flanged bases,

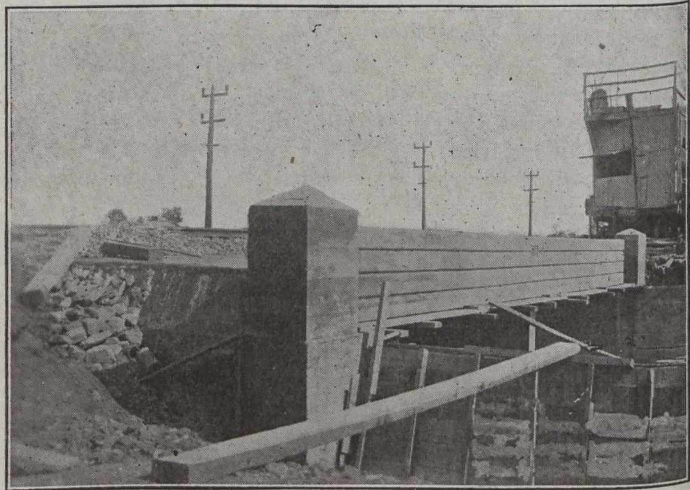


Fig. 10.—Southwest Corner of Bridge, Showing Waterproofing.

which has then only to be screwed down. The pipe railing was threaded through the holes and the ends connected up, there being practically no cutting or threading to be done. The cost of materials being fairly small, and that of erection comparatively negligible, resulted in an unusually cheap hand-rail, some 800 lineal feet being erected at slightly over 60 cents per lineal foot.

The construction of the drainage sewer was commenced by the city before the winter but the remainder of the work—that is, the road paving and sidewalk work, and laying of the street railway tracks, was deferred to the following season.

This work was carried out under the direction of Mr. H. R. Safford, chief engineer; Mr. R. Armour, masonry engineer; and Mr. H. B. Stuart, structural engineer, for the railway; and Mr. A. F. Macallum, city engineer, and Mr. E. R. Gray, deputy city engineer, for the city.

During the first half-year of 1915, sixteen building permits were taken out at Saskatoon, Sask., the total value of the improvements being $79,070, showing an increase over the corresponding half-year of 1915 of over $70,000.

The lightest-section arch-dam in the world is the Medlow dam, on Adams Creek, in the Blue Mountains of New South Wales. The structure is of concrete and is 65 ft. high from the foundation to the top of the parapet. The up-stream face is vertical. The wall is 8.96 ft. thick at the base, tapering on the down-stream face to 3.5 ft. thick at a height of 29 ft., keeping that width to the top water level and finishing with a parapet wall 1 ft. thick for the remaining 3 ft. of height.

AZIMUTH.*

By A. M. Jackson, Assoc.Mem.Can.Soc.C.E.

VERY naturally in deciding to read a paper before the association on any subject the first consideration is to find out what has been previously said on the subject. By the aid of the very excellent index of subjects prepared by our indefatigable secretary, and published in the Proceedings for 1912, it is very simple under the head of "Azimuth," to turn up all which has been said or written before this association on that subject.

The first paper on the subject was by Mr. John McAree in 1887 entitled "Solar Azimuths," but while Mr. McAree evidently preferred the method he described of obtaining the true azimuth, he still stated that he believed the method by observation on the Pole star to be the more accurate.

In the Proceedings for the next year, 1888, appears an article by Mr. E. Deville, the present surveyor-general for the Dominion, giving formulae for finding the time by observation in the vertical of Polaris.

The next year, 1889, a paper appeared entitled "An Ephemeris of Stars in the Vertical of Polaris," by Mr. F. L. Blake, which introduced a set of tables by that gentleman, for use in obtaining the azimuth of the Pole star, by observation of a time star in the same vertical.

There is now a gap of 10 years in the proceedings, during which period the subjects of azimuth and time are not dealt with, but in 1899 Professor L. B. Stewart presented a highly technical and very carefully prepared paper, again on the subject of "Time and Azimuth by Stars Observed in the Vertical of Polaris." This paper brought forth one in the following year, 1900, by Mr. Cyrus Carrol, entitled "Azimuth and Time by Observation on Polaris," in the discussion on which it was shown that the results obtained agreed very closely with those by the more intricate method described the previous year by Professor L. B. Stewart.

Mr. Otto Klotz, also in 1900, provided a paper on "Azimuth by Polaris," which dealt in simpler form with the formulae used the previous year by Professor L. B. Stewart, *i.e.*, for observations on Polaris and a time star in the same vertical. The discussion on this paper was interesting in that it brought out the fact that the solar compass was no longer in general use by the surveyors of Ontario, and the prophecy from the president of that year, Mr. Geo. Ross, of Welland, that the time was coming when all registered plans and descriptions would have to show the true astronomic courses.

There was then another considerable interval, six years, in which the subject of azimuth was not touched in our proceedings, but in 1906 Mr. F. L. Blake again approached the subject in a clear and extremely practical paper embodying a set of tables for determining azimuth by observation on Polaris at any time. The table of corrections given in this paper for the changes of declination throughout the year was, of course, for the year of issue only, *i.e.*, 1906. These tables, together with the accompanying instructions as to their use, were, I believe, issued by the department to surveyors engaged on municipal surveys in that year, and identified 1906 as the year in which our association attained its high-water mark, in the direction of supplying its members with an authoritative set of tables, for the ready determination of true azimuth.

The subject was, however, again dealt with in an article by Professor L. B. Stewart in 1909, in which he discusses a set of tables for use in determining azimuth, which were in that year appearing in *The Canadian Engineer*.

The determination of azimuth has not since 1909 been discussed in our Proceedings, and the tables referred to as published in *The Canadian Engineer* in that year, have ceased. To-day we stand as an association in the position in which we have always stood, with the exceptions of the years 1906 and 1909 referred to, without the data for the easy and accurate determination of a meridian. The thanks of the association is undoubtedly due to those members who have so ably discussed this matter in the past, particularly to Mr. F. L. Blake, and Professor L. B. Stewart, for their continued efforts to provide us with the means of determining a meridian by other than the sitting-up-all-night elongation period. As an association, it would surely be unnecessary for us to rely on the courtesy of any individual, or the publication of any journal unconnected with the association for the supply of the data necessary to enable us to comply readily with the requirements of the Survey Act. The act, however, provides in Sections 27, 31 and 39 and the new Section 47 of last year, that astronomic courses shall be given to lines covered by those sections. There can be no doubt whatever, as has been shown in the discussions on the papers already referred to, that the infrequency of astronomic bearings on all record of the present time in Old Ontario, is due very largely to the want of a ready and comparatively inexpensive method of obtaining the same.

The surveyor called upon to make a survey in Old Ontario usually has to follow out an old plan on which are given bearings and distances. The bearings, as a rule, he knows are only an approximation, and therefore cannot be fully relied on. Thus, of the fundamental data required, a part is lacking. The reason for this he knows to have been the inconvenience and cost of taking an observation. At the present time we are to a great extent perpetuating this malpractice. If the profession of the Ontario Land Surveyor is to be kept up, or should I say brought up, to the status to which it belongs, the information supplied on plans must be as accurate as it is possible to make it.

In the past generation or two the country has been cleared and land has become far more valuable. It is easier now to make an accurate survey than it was thirty or forty years ago. The expense of an accurate survey is now justified, and I find that the people expect accurate work and are willing to pay for it. It would seem to follow that to make our work as accurate as is possible, astronomic bearings should be used in a very large proportion of our every-day work.

The sets of tables issued by the Surveyor-General's Office at Ottawa for the survey of Dominion Lands are designed to enable observations for azimuth and time to be made whenever Polaris is visible, with no more difficulty or fatigue than is encountered in recording any two sights in an ordinary survey, and by their use the reduction of the observation is made so simple that it will occupy only five or ten minutes and will give results always within a limit of error of one minute of arc.

For the use of these tables it is assumed that the surveyor is equipped with a sidereal watch and a transit having a quite ordinary telescope. The use of such a set of tables, compiled for Latitudes 42° to 52° would enable any of us to record true bearings on a very large proportion of our work, by the use of an ordinary watch and standard time.

It must be borne in mind that while a sidereal watch is an essential on Dominion lands or Northern Ontario

*Paper read before the Association of Ontario Land Surveyors.

surveys, it is not indispensable for azimuth observations in Old Ontario, where accurate standard time can be had at any railway station which has a telegraph operator. The Dominion tables are calculated for sidereal time 0 hours to 24 hours and not, as is so often the case with such sets of tables, for mean time hour angles, *i.e.*, the angle between the star and the meridian east or west. With the Dominion tables the azimuth of the star is given in degrees, minutes, and decimals of a minute for every ten minutes of sidereal time, so that with the azimuth of the Pole star written in the tables 359°—36.3′ or 1°—49.7′ it is impossible for that simplest of all errors in azimuth observations to be made, *i.e.*, the placing of the meridian on the wrong side of the star.

To conclude, might I suggest that a committee of the association be appointed to decide on the form such a set of tables should take to be of the greatest amount of use to the greatest number of our members, the information they should contain, and the frequency of publication necessary, and that a resolution be passed by this association authorizing the publication of such tables in the form recommended by the committee and their distribution to all the members of the association.

Discussion.

Mr. Dobie—Mr. President, I am very glad to hear Mr. Jackson bring up that subject, and treat it in the manner he has done. I have had some idea of preparing a paper along that line myself for some time. Now I guess I will have to look for another subject. But the use of these tables is something that, I have found amongst surveyors, is not as general as it should be; there are not nearly as many of them used as there should be. The Department of the Interior have gone to a very great deal of trouble to prepare these tables, covering a couple of years in advance, and distribute them gratis to anybody that wants them. I send in myself at the first of every year and ask the Surveyor-General to send me a set of them, and he always does, and with these tables and a sidereal watch the taking of an observation, if Polaris is visible, is the simplest possible matter, and it can be done with a very small telescope. I have a small transit with a four-inch circle and three-quarter inch object glass, and I have frequently taken observations with that telescope just after sunset, when Polaris and the picket on the line were both quite visible, so there was no necessity for using a candle or artificial light around the object at all. Those tables he speaks of, unfortunately, are compiled for Dominion land purposes only, and they start at the 49th parallel, and the interpolations are for township numbers and start at zero, and the next is township twenty and township forty, and so on, so that they are hardly suitable, without some modifications, for use in the older parts of Ontario. The Topley Company, of Ottawa, a few years ago published a small pamphlet containing those same tables, and they were prepared in different forms; they were prepared for surveyors in the other parts of the Dominion, and my recollection is that they started with latitudes 43, 45, 47 and 49, so that you could interpolate in between, the information obtained in this way being very much more valuable from our standpoint in Ontario than information supplied by the Department of the Interior. For some reason, I understand, the Topley Company has discontinued the publication of that little pamphlet. I wrote to them for it at one time, and they sent me a copy, and said they were preparing these at their own expense and distributing them free of charge, and whether they would continue to publish them or not would depend on whether the surveyors throughout the province appreciated them enough to keep up the demand, and I presume the fact that they discontinued publishing them is probably due to that cause. However, I quite agree with Mr. Jackson that some steps should be taken whereby every member of the association should have a copy of the azimuth tables prepared, so that an azimuth observation on Polaris can be taken at any time. These tables have the azimuth for every ten minutes of sidereal time and have a list of about twenty first and second magnitude stars, and so that no matter where a man is, or at any hour of the night when he can see a star, or usually on in the afternoon when a star is visible, he can check up his watch and take an observation. With the assistance of those tables it is not any more difficult than taking an ordinary sight on the line. I know I have one or two cases. In one case, I remember, in running a base line, in working along in the afternoon, there was a big rock; it was one of these sloping things; you couldn't get set up on it, just a shoulder that stuck out over the line. I had these tables in my pocket, and I ran up to that rock and put the picket on the top and moved my transit around to the other side and set it up, sighted on Polaris, and then went right on with the work. That one sight alone saved me enough time to repay me for all the time I had spent to send and get them. A sidereal watch is not absolutely necessary, but it is a great convenience; the Waltham people have a very fine one. I have one that cost me $45; I check that thing up right along, and it is never out more than ten or fifteen seconds in a month; that is all it has ever varied. In taking your watch and taking the observation it is such a simple thing, and the information in those pamphlets is so valuable, it seems to me the surveyors should be supplied them. I don't think it would cost very much. We got a set of tables one time that were prepared by Mr. Blake—I have one of them yet. That was some years ago. The declination of Polaris changes from year to year, and they are only applicable to certain months in the year. The change is not very great, but still it is enough to necessitate practically the preparation of tables from time to time. I don't think the preparation of a set of those tables and the publication of them and the distribution of them to each member of the association would entail very much expense on the part of the association. I believe it is something that would well repay the association for whatever little bother or expense it would be put to. I would take great pleasure in moving that Mr. Jackson's paper be received and printed in the proceedings, and that he be congratulated on the manner in which he has treated that subject.

Mr. Le May—I have much pleasure in seconding that motion. I represent, perhaps, a different class of work to that represented by Mr. Dobie, but I can assure you that in Toronto we would feel the benefit of a set of tables of that kind quite as much as they do in the outside. These new sections of the Survey Act require observations, and anything that will help and enable us to get those observations more easily is a thing very much to be desired.

In a paper read before the July meeting of the Diesel Engine-Users' Association, Mr. Philip H. Smith suggested the following dimensions for Diesel engine crankshafts, D being the diameter of the cylinder: Tensile strength, not less than 34 tons; ductility, not less than 25 per cent. in 2 in.; diameter of pins and journals, 0.525 to 0.54 D; length of main bearings, 0.75 to 0.8 D; length of big-end pin, 0.525 to 0.54 D. Thickness of webs not less than 0.32 D, but centre to centre of cylinder made minimum possible, and any excess over the proposed length of pin and journal to be put into the webs.

THE DESTRUCTION OF A MACADAM ROAD.*

By T. W. Arnall, A.M.Inst.C.E.,
City Engineer and Surveyor's Office, Birmingham, England.

MANY studies are available to members of the institution of the way in which a macadam road is made, may be made, or should be made: the way in which such a road is destroyed may be a useful addition.

It will be assumed that the road is made up of fragments of broken stone, of various sizes, compacted together into a more or less solid mass having as small a proportion of voids as possible, and perhaps bound or slightly cemented together by dust or mud. It will be convenient to give but small consideration to positive cementing materials such as glutrin, roc-mac and others more or less soluble in water; and to others not soluble in water such as tar, plascom, bitumen, and the like. It will be further convenient to assume that the foundation is quite hard and unyielding: if it be not so the agencies which are destroying the macadam must be supposed to extend into the foundation which thus becomes part of the structure to be destroyed.

It must first be emphasized that it is impossible to make a solid mass with rounded stones of any size. If round marbles of any size, but all of one size are thrown loosely into a box, there may be 40% or more of empty space, and no amount of shaking or arrangement can possibly reduce the voids to less than 26% of the total. This proportion is quite independent of the size of the marbles: if they are 1-inch diameter they cannot fill more than 74% of the total space, and they cannot fill more than 74% of that space if they are too small to be separately visible. This supposes that they are all of one size, but obviously if the box be first filled with big marbles other smaller ones can be placed in the cavities, and there is room for still smaller ones in the cavities then left. The voids can thus be reduced without limit by introducing smaller and still smaller balls into the cavities. It is, however, essential that the sizes be properly graded: it is of no use trying to fill the interstices with balls of only one size, however small they may be: the spaces must first be filled with balls of as big a size as possible, and the smaller ones kept back until no larger ones will go in. (See Figs. 1 and 2.)

For round balls substitute rounded stones of any size or shape, and the argument is substantially true: with oval or potato-shaped pieces the voids may be reduced below what would be given by round balls, but the voids cannot be altogether abolished however small the rounded pieces may be and however carefully they may be graded and packed.

This argument breaks down when applied to flat-sided stones free from rounded edges and corners, and it would follow that the road should be made up of such flat-sided sharp-edged pieces, but even then they must still be graded into suitable sizes. A sett pavement in which the equal sized pieces are separately placed by hand is not under consideration: a macadam road is made up of random sizes and random shapes, mixed in some way and compacted together as solidly as possible by rolling. Many of the edges and corners are rubbed off in this process, and many of the stones are broken: it is truly a rough and unmechanical process, but it has to serve since no better one is known.

The Bearing Cone.—The effect produced by a load placed upon a stone forming part of the surface of such a mass may be readily traced. If the stone is resting upon one other only it must sink or roll over until it bears also upon two or three others: each of these in turn must rest upon at least three others, so that in the result the pressure of the load is passed downwards to the foundation in the shape of a cone, with a rather broad base at the bottom. The cone cannot be closely defined, principally because there is not enough known about the shape and arrangement of the stones composing it. Their size has not much to do with it. If they are all smooth and round like marbles or bicycle balls they are easily pushed aside and the base of the cone must be a very broad one. If they are flat and parallel, say like pieces of slate laid flat, there will be no side-long pressure, and the base may be no larger than the last piece resting on the foundation. If the pieces are still flat and parallel, but *not* laid flat, the cone will appear in some form or another and result in a broadened base. In general, it will perhaps not be far out to assume that the slant side of the cone is at an angle of 45°; its base will then have a diameter equal to twice the thickness of the macadam. If this is 6 inches the pressure of an isolated load on the top will be spread over a circle about a foot in diameter, and it may therefore be concluded that a steady load concentrated on a small area on the top produces but a moderate pressure per square inch at the bottom.

The way in which the cone would be modified when the load takes the shape of a wheel is indicated in Figs. 3 and 4. A 3-inch tire will give a cone about 15 inches wide at the bottom, or 5 times the width of the tire: an 18-inch tire will give a cone about 2 ft. 6 ins. wide, or something less than 1¾ times the type width. The proportionate width of the cone is much less in this latter case than the other, and it must obviously be less in proportion the greater the width of the tire.

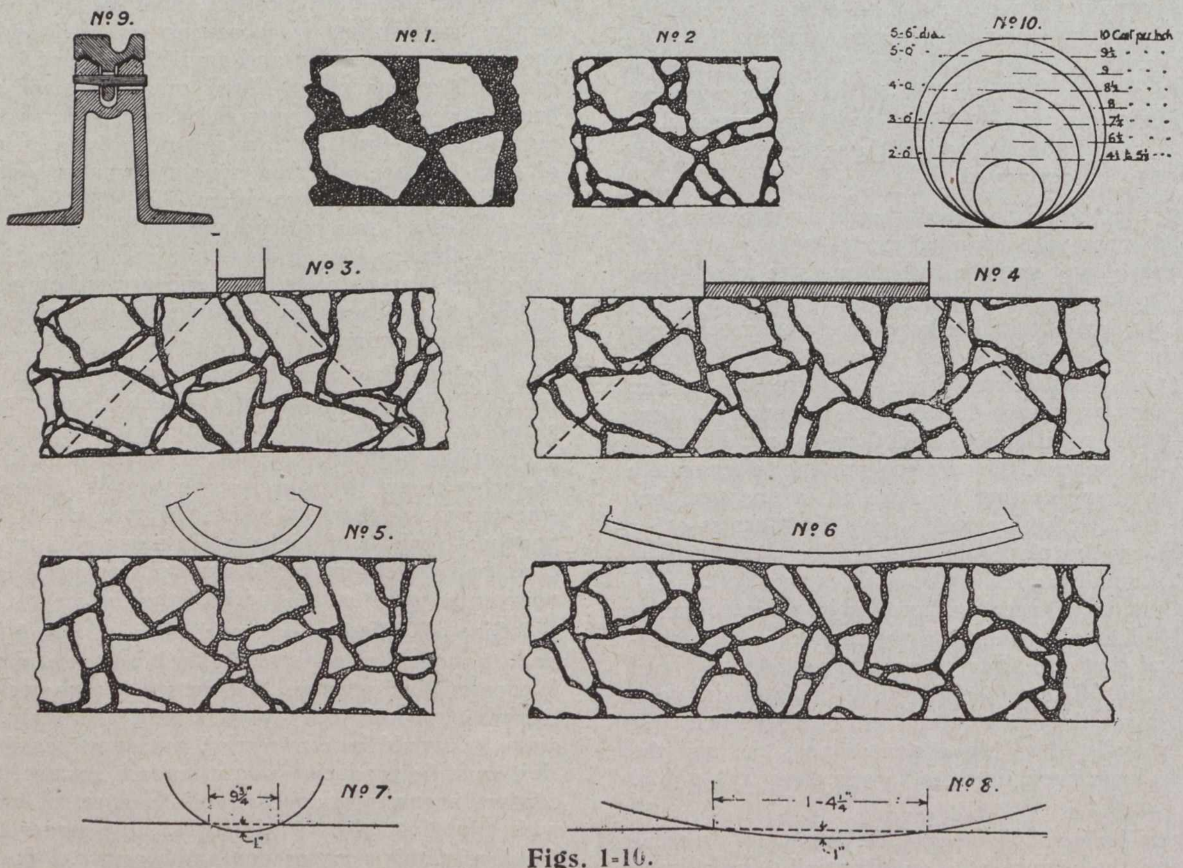
Size of Wheels.—From Figs. 5, 6, 7 and 8 it is evident that the size of the wheel will have an important influence on this question. If the road were perfectly hard the wheel would touch it in a thin line only, and its diameter would be immaterial, but some sensible depression must be produced on a macadam surface, the line of contact becomes widened out into a sensible area, and with any given degree of sinking, the larger the wheel, the larger this area of contact becomes. To fix ideas, Fig. 7 shows that if the sinking is 1 inch the length of contact will be about 9¾ inches with a wheel 2 ft. in diameter and 1 ft. 4¼ ins. with a wheel 5 ft. in diameter, as in Fig. 8. In other words, the maximum pressure under a 2-ft. wheel will fade away to nothing at a distance of about 5 inches from the centre, and at a distance of about 8 inches in the case of the larger wheel. Hence it is certain that for a given load the sinking of a large wheel must be less than that of a smaller one, for the same pressure is spread over a greater surface, and its average intensity must be reduced in proportion. The mischief done to the road must also be reduced in something like the same proportion, hence the reason for the loadings of the wheels of heavy motor cars as fixed by the board of trade rules, which are summarized in Fig. 10. Roughly speaking, the permitted loads per inch of width of the tire are proportional to the square root of the diameter of the wheels: they are not exact probably because the practical dimensions of inches and cwts. would lead to awkward fractions if more precisely worked out. As the length of contact varies in the same proportion

*Abstracted from a paper prepared for the 43rd Annual General Meeting and Conference of the Institution of Municipal and County Engineers at Blackpool, 29th and 30th June and 1st July, 1916.

with different wheels, the net result is that the different loads and wheels give the same average load per square inch upon the surface.

The cone is not shown in Figs. 5 and 6 because there is no definite spot on the surface to start it from: whatever the depression caused by the load may be, it dies away gradually to nothing at the point where the wheel leaves the ground. Still, the cone is there nevertheless. In Figs. 3 and 4 its sides are bounded by a definite crack starting at the surface, passing somewhere between the stones big and little and tapering away in thickness as it nears the bottom. In Figs. 5 and 6 the crack is replaced by an indefinite looseness amongst the stones, perhaps aggregating in amount to the definite crack met with in the other case. The only way to prevent the formation of these cracks is for some of the material to escape sideways out of the cone and close up the crack as fast as it it will be a useful help in dealing with the present subject. A section of the rail is shown in Fig. 9. It was a steel rail in pieces 10 yards long, supported on and fastened to closely spaced cast iron sleepers 2 ft. 11 ins. long by steel keys, two to each sleeper. The sleepers were solidly bedded in concrete in the usual way, and the cavity inside them was also solidly filled with concrete. Attention must be fixed upon the successive pairs of bearing surfaces—first, the bottom of the rail and the top of the sleeper; next the bottom of the hole in the rail and the bottom of the key; next, the top of the key and the top of the hole in the sleeper; lastly, the bottom of the sleeper and the top of the concrete. The theory of the arrangement was, that when the rail was worn out it could be easily removed, a new rail keyed to the sleepers in its place, and the whole structure would then be as good as new.

These expectations were not realized. The only wear



Figs. 1-10.

is formed. But in the absence of cavities into which this material can escape this amounts only to pushing the crack into another place, or probably making many little cracks instead of one big one. That there is such a sideways tendency to escape is well seen in a pulpy road: the rut formed by a heavily loaded wheel is plainly due to a lifting at the sides as well as to a sinking under the wheel. Often it may be seen in front of a roller at work on a thick coating: the mass rises as a flat wave in front to be forced down again as the roller moves over it. In any case, there is no salvation whether the view of one big crack is taken or a multitude of small ones; whichever view is taken the destruction of the material goes on just the same.

Barker's Tram Rail.—There is a principle at work here which is worth a closer study, and it is perhaps best brought out by considering what happened to some tramway rails laid down in Birmingham in 1882. They may appear to have little to do with a macadam road, but the experience gained by them was so clear and definite that expected was that on the top surface and it was found to be the least important of all. Much greater was the wear on the bottom of the rail and the top of the sleeper, and the sleeper wore more than the rail. There was further wear between the key and the rail, and between the key and the hole in the sleeper. Then the surface of the concrete suffered. Leaving the bottom of the sleeper out of account, it will be seen that there was wear going on at seven different surfaces that had not been provided for, and long before the rail was "worn out" in the ordinary way the wear on these other seven surfaces gave serious trouble. It will be seen that they were all one behind the other, somewhat like the links in a chain. An electrician would say that they were arranged in series, and the same current of destruction had to pass through them all. There was not much to measure at any one surface, but the aggregate was sufficiently imposing.

The stability of such a structure depends upon the stability of every part of it. Consider the first three mentioned pairs of surfaces. If wear takes place at one of them, that pair is loosened, and, as an inevitable consequence, the other two pairs of surfaces become loose also. As in a chain pulled tightly, if one pair of links becomes loose every other pair of links necessarily becomes loose also. It cannot be that all are tight except one; they must either be all tight or all loose. In this case, looseness of any one of the pairs of surfaces below the street level meant that grit was constantly getting in between them; every passing car crushed this grit, wearing away the surfaces, and making room for fresh grit to enter as soon as they were parted again. The frequent presence of water ensured this ground-up stuff being washed away and fresh abrasive material being brought into its place. The looseness of the rail caused the sleepers to become loose; water filtering into the bottom was violently surged to and fro as the car passed over the top. There could not have been much water to begin with, but there was always enough to completely fill the space below, and its scouring effect could have been no greater if it had been ten feet deep.

There are four points to be emphasized in this experience, as follows:—

(1) The wear on the top surface was the least important of all.

(2) If one of the other pairs of surfaces became loose, all the others became loose likewise, and opportunities were set up for fresh wear taking place at every one of the surfaces.

(3) The smaller bearing surfaces suffered most. The bearing surface of the keys was only about a quarter of a square inch at the most, but each was as important to the stability of the whole as one of the larger surfaces.

(4) The presence of water greatly increased the mischief. It was under pressure and in motion. It was always bringing fresh grit into position, and washing away that which had been ground up into mud, and was no longer capable of withstanding any pressure or of packing any vacant spaces.

Every one of these points is immediately applicable to what is going on in the destruction of a macadam road.

(1) The wear on the surface is the least important of all.

(2) If a crack forms and makes some parts loose, all others behind them in the direction of pressure necessarily become loose also.

(3) The small pieces suffer most. The large pieces can carry no pressure unless the small ones support them, and a pressure which is sufficient to break any one of them may at the same time break scores of others behind it. The blow must be carried on from one piece to another.

(4) Water greatly increases the mischief. It cannot be kept out of such a porous mass. It is put in motion by every passing load, swilling away the smaller particles which might act as packings and so taking away the support of the larger ones which have to withstand the shocks. It acts as a lubricant and makes movements easy that would otherwise be impossible.

Rubber Tires.—The peculiar destructive effect upon the surface produced by rubber tires has not yet been referred to. The rubber may be easily shortened in one direction if left free to expand in another. Referring to Fig. 5, it is evident that there is no load upon that part of the tire which first comes in contact with the ground. As the wheel moves on, this part becomes loaded, the load increasing to a maximum when the part in question is under the axle, dying away again to nothing as it leaves the ground at the back of the wheel. As soon as the load comes on, the rubber is compressed in the direction of pressure, and must expand sideways to precisely the same degree. But the friction on rubber is enormous; as soon as it comes in contact with a stone on the surface, that stone is firmly gripped and must move along with the rubber which is expanding in one direction because it is being compressed in another direction. Thus the stones in front are pushed forward, at the sides they are pushed outward, until the axle comes over any one of them. Then the movement is reversed; the stones in the centre are gradually pulled back and those at the side pulled inward into something like their old position as the rubber recovers itself on escaping from under the load. The importance of this process arises from the fact that no stone displaced is ever pulled back into its old place. Not one of them can be violently pushed forward or sideways without at the same time disturbing multitudes of smaller ones which are not in contact with the rubber at all and are therefore free to take up new positions. This prevents the stones ever reaching their old positions as they are pulled back again. The passing tire leaves most of them lying loose on a disintegrated surface. It is commonly said that the loose stones are "sucked" out of the ground; it would be better to say that they are "shaken" out. Every one of them has been pushed in one direction and the next instant pulled back again, but in the meantime the bed on which it laid has been broken up, and it now lies loosely upon instead of being bedded in the surface.

Interstitial Wear.—It is certain, then, that the destruction of a macadam road is not a question of wear on the surface. A wheel may pass by and leave no track behind, but many of the small stones below have been crushed in carrying the load. The smaller these pieces are the less chance they have of escaping destruction when the pressure comes upon them. In some way the total wear will depend upon the total area of the pieces forming the mass, rather than upon their weight and number, and when these pieces are small the total area of surface they expose runs up in a quite unexpected manner. A cube of 1 inch side exposes a total area of 6 square inches. Cut up this cube into little ones of 1/100th of an inch side, *i.e.*, into pieces the size of fine sand: there will be just the same weight of material and it will fit just the same bulk of solid space, but the total area of surface will now be 600 square inches instead of 6 inches. If cut up into particles small enough to be classed as fine dust, or mud, the total area exposed by, say, an ounce of material becomes something enormous. Movement under pressure means wear and tear over a large proportion of this great area. For every grain that is crushed there will be many that suffer by having some edges or corners ground away. The idea that this fine stuff is useful for packing and bedding the larger stones may lead to a fallacy. A given stone may be so bedded on and supported by, say, 1,000 or 10,000 very small ones. When the blow comes upon it, that blow has to be passed on to, and in some way shared amongst the thousands of very small ones. The "sharing," however, can only be amongst those that are arranged (as an electrician would say) in parallel: those that are arranged in "series," or one behind the other, have the same blow passed through the lot. There is no "sharing" in this direction. In a water-bound mass no tension is possible, and one bit cannot help another one alongside it; it can only receive the shock in front and pass it on to the bits behind. It may be so broken in the process that when the shock comes next time it will have to be received and passed on by some other neighboring bit that had hitherto escaped. Water ensures that this fine stuff is kept on the move, and any really effective packing or support of some particular stone can only be of service for very few repetitions of the blow.

INTERNATIONAL SPECIFICATION FOR STEEL.

FOR some years the International Association for Testing Materials endeavored to secure the adoption of international specifications for iron and steel. The suggestion came originally from the American members of that body, which at its best could never be considered as representative of the steel industry of the countries which it professed to represent. The American steel manufacturers, however, cordially supported the suggestion that an international specification should be adopted, because they had at times very varying requirements to fill on export orders.

When the proposal was brought up for discussion it was found impossible to secure agreement, for very obvious reasons, and the matter was allowed to drop. It was rejected on the claim that it gave the same value to the steel from each country although manufactured under different specifications. The claim of the American members of the committee was that: "The time has passed when any specification or set of specifications with clauses calling for low phosphorus requirements, based on favorable ore conditions, would tend to confine orders to any one locality or country inasmuch as the basic and duplex processes have equalized matters in this respect, so that there is now no commercial advantage to be gained by insisting on specifications of this kind."

Mr. W. R. Webster, the Philadelphia civil engineer, who was one of the most ardent advocates of international specifications, has been giving a short history of the movement, which finally received its quietus in 1912 at the New York meeting of the International Association for Testing Materials. He has just read a paper before the American Society for Testing Materials in which he points out that a number of American standard specifications were translated into foreign languages for the use of the members of that congress.

Mr. Webster continues: Fortunately some of our steel manufacturers and locomotive builders, etc., distributed these specifications through their representatives abroad, and found that when the foreign engineers had these specifications before them in their own languages it was of great assistance in securing orders based on our specifications. This was the unanimous report of those who followed this course, and showed clearly that the best course to follow is to improve the American standard specifications wherever possible and to bring these specifications to the notice of engineers in foreign countries, and thus to make them available for use on export orders.

The Department of Commerce has become interested in this matter, and has seen the great advantages that would accrue to the manufacturers of the United States by following such a course. It has, therefore, agreed to translate and publish many of our specifications into Spanish, French and Portuguese. Each specification will have the original English version attached to it, and all numeric quantities will be given in both the British and the metric system. The Department of Commerce will distribute these specifications among engineers abroad through its own staff and the United States consular offices.

It is not reasonable to expect that foreign engineers who have had satisfactory results in service from materials manufactured in America under their own specifications will consider placing orders under standard specifications unless they can secure more prompt delivery. Nevertheless, the specifications should be sent them so as to be available when needed.

There is also decided objection in England to steel made by the duplex process, although we are getting excellent results in America from steel made by this process. In England the basic-Bessemer process is used at the start, and is followed by the open-hearth process. No doubt some of the highly oxidized basic-Bessemer metal is carried through the open-hearth furnace to the finished product, and this would account for the objections to this steel.

In America the metal is first blown in the acid-Bessemer converter, and is not as highly oxidized as that from the basic-Bessemer converter, which doubtless accounts for the better results obtained from the steel manufactured by the former method. In ordinary American practice the duplex-process steel is now supplied on orders calling for basic open-hearth steel, without making any distinction whatever, whereas on export orders it has always been necessary to explain carefully the differences between the processes of manufacture in this country and abroad, when it is desired to use duplex steel on orders calling for basic open-hearth steel. Additional variations are found between foreign specifications and American in the matter of drop tests on rails. These have given considerable trouble owing to the great variation in the conditions under which such tests are made in the United States and elsewhere. For instance, the weight of the tup varies from 2,000 to 2,400 lbs.; the distance between supports from 3 ft. to 3 ft. 6 ins. and 4 ft.; and the length of the test rail may be 6 ft. or 30 ft. The matter is complicated much further by the different weights of the anvils used and the character of their foundations, by which the effectiveness of the blow of the falling weight is so largely affected. Some foreign specifications prescribe a drop test of 30 ft. for rails 30 ft. long. For rails of the same weight other specifications require an 18-ft. drop test for rails 6 ft. long. In order to find out just what this difference in the requirements meant, a series of comparative tests were made, and it was shown that the long overhanging ends of the 30-ft. rails act as cantilevers, supporting the central part, and that the 18-ft. drop test is more severe on a piece of rail 6 ft. long, than the 30-ft. drop test on a 30-ft. piece of rail.

Another complication in the use of foreign specifications on export orders is that often minor points of difference cannot be settled quickly. Much of the existing confusion is no doubt due to the general change from acid open-hearth to basic open-hearth steel, since a higher carbon content is required in the latter for the same ultimate strength. This is better understood now than formerly when some of these specifications were first drawn up.

China is reported to be considering the restoration of the old canal system, of which there were at one time 60,000 miles within the empire.

The United States Reclamation Service, up to June 30, 1915, had constructed 100 dams, 9,683 miles of canals, 25 miles of tunnels, 91 miles of levees, 300 miles of irrigation and drainage pipe, 86 miles of flumes, 784 miles of wagon road, 82 miles of railroad, 2,554 miles of telephone lines, and 429 miles of transmission lines. Concrete lining has been placed in 140 miles of canals. The service has built 64,847 canal structures, 4,622 bridges, 5,714 culverts, and 1,068 buildings. In the performance of this work, 115,599,284 cu. yd. of earth has been moved, 7,585,948 cu. yd. of indurated material, and 6,964,136 cu. yd. of rock. In constructing the dams, 1,992,502 cu. yd. of masonry has been placed, 9,231,109 cu. yd. of earth, and 978,474 cu. yd. of rock-fill and crib structures. Other materials handled include 1,023,398 cu. yd. riprap, 615,583 cu. yd. paving, 2,674,977 cu. yd. concrete, and 2,501,382 bbl. of cement, the latter mainly for concrete.

WATER POWER POSSIBILITIES OF NOVA SCOTIA.

By K. H. Smith, A.M.Can.Soc.C.E.,
Engineer of Nova Scotia Water Powers Commission.

MODERN hydro-electric development in Canada has taken place where the most obvious natural facilities, such as large water falls and extensive drainage areas exist within reasonable distance of existing or prospective power markets. To a certain extent this offers an explanation of the fact that as yet no extensive hydro-electric development has been carried out in the Maritime Provinces. There are few large water falls, while the demands for power are not large or centralized.

As a further explanation, it is to be noted that large coal resources in these provinces combined with an abundance of small water mill sites, suitable for local and personal use have not made the immediate problem of obtaining power so pressing as in some other parts of the country.

Success in enterprises undertaken at large and obvious sites, the advantage and economy of central sources of energy and the principles of conservation as applied to coal resources have, however, drawn attention to water power sites perhaps not so large as a general rule and, at first sight, perhaps not so obvious.

Investigations recently undertaken in Nova Scotia by the Dominion Water Power Branch in co-operation with the Nova Scotia Water Power Commission and also an agitation for similar investigations in New Brunswick indicate that the Maritime Provinces are alive to the advantages of hydro-electric energy and to the proper principles of conservation. These circumstances, too, should lend interest to such a discussion as it is proposed to give herewith.

It is intended in the following to give a brief outline of the main physical features of the Maritime Provinces which have any bearing on water power development. This may serve as an introduction to such detailed information as will be published from time to time due to the investigations mentioned.

General Description.—The province of Nova Scotia as a whole is almost completely surrounded by water, the narrow isthmus which connects it to the mainland being only about 15 miles wide at its narrowest point. The extreme eastern portion of the province, Cape Breton Island, is entirely cut off from the other part of the province by a channel about one mile wide.

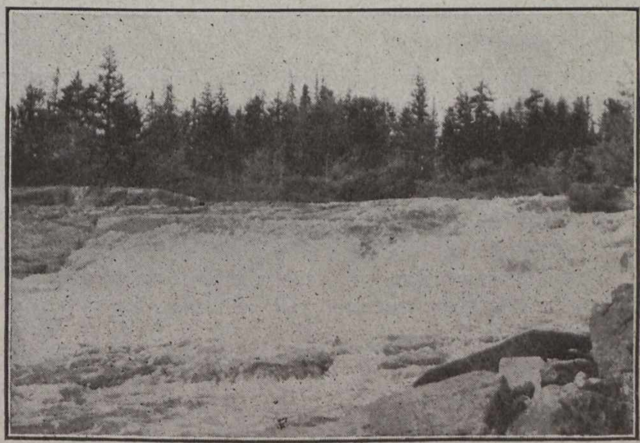
Taking the province as a whole, including Cape Breton Island, it is roughly 400 miles long and from 50 to 100 miles wide, with its main axis lying in a general northeast and northwest direction. It lies within north latitudes 43 degrees, 30 minutes, and 47 degrees, and within longitudes 60 degrees and 66 degrees west from Greenwich.

Its total area is 21,428 square miles, including a considerable proportion of water surface. The total population of the province is approximately 500,000.

Topography.—The topography of the country, while giving the general impression of rolling hills, is, on close inspection, rough and broken, with frequent rock outcrops and boulders. In fact, in the central part of the province, large areas of barren exposed rock are frequent. Lakes and streams occur in great abundance, most of which have rocky banks. There are no pronounced elevations, the greater part of the interior of the province lying from 200 to 700 feet above sea level, with one point in Cape Breton rising to an extreme elevation of about 1,400 feet.

Climate and Precipitation.—The climate is moderate with no extremes of either heat or cold. The mean temperature for various parts of the province ranges from 40 degrees to 44 degrees Fahrenheit. The winter season lasts in general from December to March, though the temperature for this period rarely falls below zero. The comparatively open winter, combined with the prevailing swift-flowing streams, is a prolific source of slush and frazil ice and must be considered in all power investigations, though at the same time a larger flow is available for the winter months than in places where extreme temperatures occur.

Precipitation records for long periods are available at a number of places in Nova Scotia, the longest records being available at Yarmouth, Halifax and Sydney. These records indicate not only a large total precipitation, but also relatively a remarkable regularity from month to month and from year to year. There seems also to be no excessive variation from place to place. The average



East River Sheet Harbor, Malay Falls, Typical of the Larger Rivers of the Atlantic Drainage.

annual rainfall varies from about 56 inches at Halifax to 33 inches in the vicinity of the Bay of Fundy. The average annual precipitation for the greater part of the province is from 45 to 50 inches.

Taking Halifax as typical, the mean annual precipitation for 48 calendar years is 56 inches in round figures, while the maximum and minimum for the same period are respectively 68 inches and 45 inches. The mean monthly precipitation is 4.7 inches, while the maximum and minimum average monthly precipitations for the same place are respectively 5.7 for the month of January and 3.6 for the month of September.

Main Divisions of the Province.—Based on typical, characteristic rivers and general topography, the whole province may roughly be discussed in four main divisions Cape Breton, the Atlantic Drainage, the Valley District and the Midland District.

Cape Breton.—The island of Cape Breton, being so distinctly cut off from the mainland, naturally presents itself for separate consideration. The whole central area of this district is occupied by sea level lakes known as the Bras D'or Lakes, which are connected to the Atlantic Ocean by narrow channels. The land area is therefore broken into relatively small sections, so that with one or two exceptions, no large rivers occur. Such land areas as there are, however, rise to considerable heights and a large number of small, precipitous streams exist. The streams are of little value from a water power standpoint except for small local use at certain seasons of the year. Such larger rivers as do exist, as for example the Margaree, Middle River and North River, flow generally in flat bottoms and with one exception, that of Lake Ainslee on a branch of the Margaree River, have no natural lakes or other opportunities for storage.

The Atlantic Drainage.—That section of the province which drains to the Atlantic Ocean is by far the largest part of the province, and though such a large area naturally varies considerably in its characteristics, its general geological, topographical and climatic features are essentially the same for all parts.

Freda Falls, La Have, Typical of Larger Rivers of the Atlantic Drainage.

The largest rivers of the province, such as the Tusket, Liverpool, Medway, Lahave, East River, Sheet Harbor, and St. Mary's, occur in this division as also the best harbors and the city of Halifax itself. Practically the whole area is studded with lakes of considerable size.

The rivers are generally large and terminate in tidal harbors of large size and moderate depth, with high, rocky shores.

The Liverpool River, one of the largest rivers of the province, and a few others similar to it, have no pronounced falls, but consist of alternate stretches of slow-moving water and long, rocky rapids. Some others, such as the East River, Sheet Harbor and the Gold River, have a number of sharp pronounced falls, of moderate height, connected by relatively long reaches of almost stillwater. Other rivers, again, such as the Medway and the Lahave, have some rapids, some "stillwaters" and some pronounced falls of moderate height. It will be observed that all these characteristics are simply variations of a common type.

Two large rivers included in the area under consideration, the Musquodoboit and the St. Marys, present some exceptions to the general statements made above. These rivers have no lakes of consequence in their entire basins. Near tidewater they exhibit the general characteristics mentioned, having a series of low falls or rapids and emptying into large rockbound harbors. In their extreme upper reaches, the smaller tributaries are precipitous, with some pronounced falls. Throughout their middle reaches, however, they flow in wide, flat, agricultural valleys.

Undoubtedly, this section has a large amount of potential water power, which can be made available by developments of a general low and medium head type, ranging from 30 to 70 feet as a rule.

The Valley District.—The outstanding stream in this area is the Annapolis River, flowing through a large valley parallel to the main axis of the province and into a tidal basin with restricted outlet to the Bay of Fundy. It is tidal for many miles from its mouth with large areas of tide flats many of which are protected by dykes, and throughout its whole course is a sluggish stream. The tidal range at its mouth is from 40 to 50 feet.

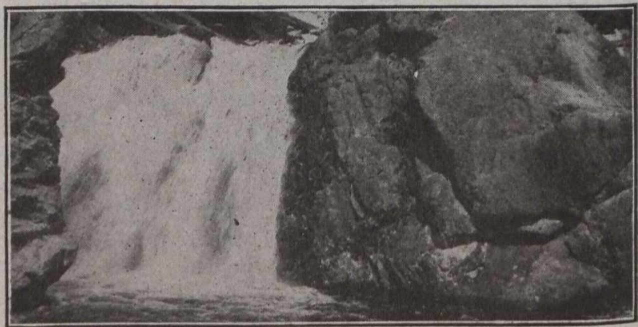
Flowing into the Annapolis River, particularly from the south, are a number of small but extremely precipitous streams which literally tumble from a height of 500 to 600 feet into the Annapolis River. These smaller streams are generally flat and sometimes tidal for a mile or so from their mouths, and generally have a series of still-waters and lakes in their upper reaches. Paradise River is one of the most characteristic representatives of this type, while the Nictaux, a somewhat larger river, flows in a narrow valley and is not so precipitous.

The Cornwallis River corresponds in all respects to the Annapolis River, except that it is considerably smaller and flows in an easterly direction, exactly opposite to the direction of the Annapolis River, emptying into Minas Basin. These two rivers, the Annapolis and the Cornwallis, rising in the same vicinity, and flowing in opposite directions, occupy a wide valley extending from Minas Basin to the Annapolis Basin, with pronounced ridges on either side known locally as the North and South mountains. This valley has obtained wide publicity for its orchards and general agricultural advantages, as well as for its historical interest in connection with the early settlement of the country.

The Gaspereau and Avon rivers, which may be included in this district, are an intermediate type between the flat tidal Annapolis and Cornwallis rivers and the extremely precipitous rivers, such as the Paradise, flowing into them. The Gaspereau empties directly into Minas Basin, is tidal for some distance from its mouth, has a well-defined agricultural valley of its own in its lower reaches, but in its upper reaches is practically a continuous rapid.

The Avon River is much the same as the Gaspereau but smaller, while one of its main tributaries, the St. Croix, has certain characteristics peculiar to the Atlantic slope, in that it heads in a large lake at a moderate altitude, and in its upper reaches has a narrow, rocky channel with several pronounced rapids or falls.

It is obvious that the smaller precipitous streams mentioned, with lakes at their heads, present opportunities



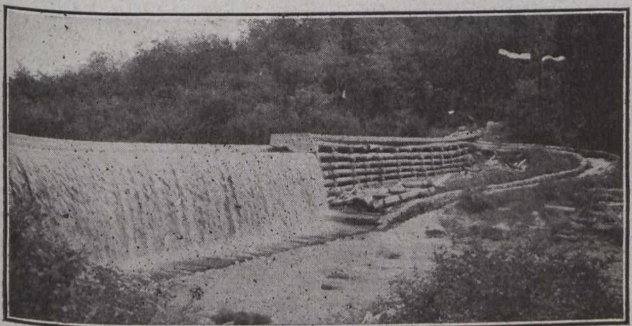
Fall River Falls—One of the Smaller Sites Near Halifax.

for power development of small or moderate size at relatively small cost. The general type of development suitable to them is entirely different from that suggested for the larger streams of the Atlantic slope, and is essentially of a high-head type, with long conduits but otherwise small structures.

The Midland District.—The rivers in this district have characteristics similar to both types already discussed for the valley district, except that here none of the characteristics are so pronounced. Some of the larger rivers, such as the Shubenacadie, Stewiacke, and Salmon, flowing into the Bay of Fundy, and East River Pictou, and River Philip flowing into Northumberland Strait, are tidal for some distance from their mouths and in their upper reaches flow through relatively flat agricultural valleys. East River, Pictou, and the Stewiacke River resemble the middle sections of the Musquodoboit and St. Mary rivers already discussed in connection with the Atlantic slope.

The chief characteristic distinguishing this whole district from those already discussed is that it contains no lakes of consequence whatever.

General.—In general, it appears that besides an abundance of small sites for purely local uses, Nova Scotia has many other sites which, from their location, distribution and size are well suited to the immediate and prospective needs of the country. The large precipitation throughout all parts of the province with its even distribution and the proximity of the larger power sites to deep sea harbors are distinct advantages. In fact, it is believed that the water power resources of the province, with the exception of the island of Cape Breton and a certain section of the Midland District, are much larger than any market demands yet realized or contemplated. It is to be noted in connection with this statement, however, that such an in-



Lequille River Dam at Annapolis Electric Light Plant.

dustry as the electrical fixation of atmospheric nitrogen, which would offer practically an unlimited market, is not here considered, due largely to the relatively small size of the power sites.

Some other electro-chemical processes based on the mineral resources of the province, might possibly furnish satisfactory markets for the available water power, while there is also apparently a good opportunity for the development of an extensive pulp and paper industry.

In connection with the nitrogen industry mentioned above, and in view of a recent paper read before the American Institute of Electrical Engineers, one cannot refrain from remarking that, so far as the possibility of obtaining power from coal for this industry is concerned, the very large coal resources of Nova Scotia located at tidewater offer a most promising field for investigation.

It is an interesting co-incidence, and has already been remarked in connection with other parts of the world, that in Nova Scotia, those districts which have large coal deposits have little water power, while large amounts of potential water power are found in districts remote from coal-fields.

An investigation of the integral method of waterprofing concrete has been undertaken by the United States Bureau of Standards in co-operation with manufacturers of compounds, and with societies, engineers and others interested in this problem. A questionnaire has been addressed to more than 800 architects, engineers, contractors, etc., and the tabulation of the replies received has been started by the bureau. An important feature of the investigation is the project for experimental concrete tanks along the river front of the city of Washington. The District Government has set aside a small piece of ground for this purpose, and plans have been completed for the construction of the tanks.

WHAT MANUFACTURERS LOOK FOR IN ENGINEERING GRADUATES.

By E. H. Fish.

[In *The Canadian Engineer* for August 3rd, 1916, there appeared an editorial entitled, "The Technically Trained Man in Business." In the article which is herewith reprinted from the "Engineering Magazine," Mr. Fish makes a number of suggestions, the adoption of which would doubtless lead to the production of graduates that would come nearer the type for which the business men and manufacturers of the country are looking.—EDITOR].

DESTRUCTIVE criticism of anything educational is easy. Constructive criticism is full of dangers, because we are just now apparently at the turning of the ways, where we seem to be getting ready to throw off much of the incubus of tradition and reach out into untried fields. Engineering education is a development from that of the college, which in turn was primarily monastic, and which for long years resented any implication of usefulness. To-day the world is almost ready, employers are wholly ready, to take the view that anything which does not have a use should be thrown bodily out of the curriculum. *Use* in this case, however, is applied broadly. The fact is recognized that many intangibles in education also have their value—in fact, that whatever serves to give the student a wider, happier outlook on the world is as useful as if its value could be expressed in dollars and cents.

Engineering courses are divided at present in two parts: the first inherited from the older cultural college, and the other the study of material things and their actions under varying natural conditions. Consequently we have the mathematical study of physics, higher algebra, the grammatical study of languages and so on, and on the other side the study of the strength of materials, laboratory and shop practice. Between these two diametrically opposed courses, however, the engineering of the human being is almost entirely neglected, except in so far as the student's athletic and social activities afford some crude study of the subject.

Less Higher Mathematics.—The principal tool of the engineer who handles materials is mathematics, as the principal tool of the man who handles men is language. Mathematics in college is apparently intended to cover every phase that will be encountered by the students in their work after graduation. If it were not for this a great deal of college algebra, much analytical geometry and all of calculus might very safely be omitted from the courses pursued by a great majority of college men. In fact, very few graduate engineers make use of anything higher than arithmetic, a few of the simplest equations in algebra, and the elementary geometrical theorems. It seems as though the courses in mathematics might be much abbreviated if it were considered that a school is a place in which men should be taught to study by themselves without further instruction. If that ideal can be reached, it should be possible to leave out much that is now covered in the class room, seldom to be touched on again.

Mathematics in engineering is a tool wherewith mainly to handle the various branches of mechanics. The writer's experience leads him to feel that instruction in this latter line is inadequate for the needs of the average graduate. In machine design, for instance, evidence is frequently seen that the effect of inertia and momentum have not been fully considered in the beginning and that their effect has led to a patchwork remedy after the machine was in operation. Too much time is devoted to abnormal and unlikely problems, as if everyday engineering life did not afford a multitude of interesting and live applications of mechanical principles.

Applied Mathematics Strongest Point in Engineering Training.—Then there is the application of mechanics to engineering problems, both in the school shops and in the laboratories. These are probably the strongest points in the whole of our engineering education. They are just strong enough so they could well be made stronger—not by adding more detail, but by laying greater stress on the general principles involved, and the variations from those principles and how to look out for them.

Next are the humanities—the languages, economics, history, and the other subjects with which undergraduates have comparatively little patience. To the outsider it seems ridiculous that any technical school should refuse a diploma for failure to pass a given mark in any of these subjects, because it is so entirely possible for a man to become a credit to his alma mater without any of them, and because failure to get the benefit of them in school by no means prevents the man who later awakes to his need of them from getting them easily and surely by reading. In fact, history is being made so fast that it seems as if it should only be studied as an unfolding of the things which lead up to the further history which the students themselves will shortly take part in the making. On the other hand, it must be realized that in these very subjects lies the meat of one of the most important functions of engineering education.

After years of study of mechanical methods, materials, and finance, manufacturers have at last awakened to the fact that the least understood of their problems are those of personnel.

Employment from top to bottom of their establishments has been a haphazard matter, depending on whim and passing fancy; and always to a greater or less extent on prejudices based on past and undigested experience.

One of the problems, the solution of which manufacturers find very insistent at present, is the place in their establishment which can advantageously be filled by engineering graduates. They realize that each year thousands of young men are turned out of the colleges and technical schools who are a picked lot. They may disagree with the method of selection; they may be sure that many who were dropped by the wayside would have been as valuable as those who were graduated; but they are certain that those who do graduate have a mental equipment above the average.

Qualities Employers Look For.—And really that is about all of which the manufacturer is certain. The specific studies which the graduate has pursued, and the results of the pursuit do not interest him as much as they do the faculty which set up the standards. He is interested in the understood virtues of honesty, integrity, sobriety, truthfulness. After that he looks for personal appearance, open-mindedness, analytic ability, persistence, affability, ability to mix with others, courage of his convictions and other qualities which college life and associations may have brought out but which are seldom consciously placed in the curriculum. Then, and next on the list come the underlying principles of the arts and sciences; and at the bottom, and least considered, the details and applications of these arts and sciences.

A short-sighted employer who selects a short-sighted graduate may make immediate use of practically the only liquid asset which the latter has, and place him on a stool in the drafting room where he is apt to stagnate from the start. The result is that both ultimately are led to condemn engineering education.

The far-sighted employer looks on the engineering graduate as a man with proved mental equipment, persistence, willingness to make sacrifices if the cause is sufficient, possessing a fund of principles which may serve as a foundation on which to build an engineer. If he gets more than that it is because of his own further selection among the graduates in which he has looked for personality, inquired into his adaptability and tested his open-mindedness.

It is here that the first conflict of opinion occurs between employer and faculty. The latter makes its test of ability purely an intellectual one. The business man is keen for mental ability but not to the exclusion of other and more social qualities.

Ability to Co-operate Test of Business Success.—Business is by no means a succession of pink teas, but it is nevertheless largely a matter of personal leadership and impressions. A successful man of to-day is one who can work in harmony with others, subordinate himself to the good of the many with whom he is working and yet impress his own personality upon those with whom he does business, both in writing and in speech action.

What is the difference between the viewpoint of the professor and the prospective employer which impels them to put different valuations on these qualities?

Possibly it can be found in the fact that what is an end in itself to the professor is only a tool in the mind of the employer. Mathematics, to the man whose livelihood is bound up in it, is an end. It is worth studying for itself alone. In fact, men would hardly study or teach pure mathematics if it were not possible to consider it in this light. On the other side, the employer can see no value in mathematics except as it is applied to material things. A man who can factor a cubic expression may get a high mark in college, but the employer whose business does not include cubic equations fails to see the beauty of the operation and places no value on the ability to handle it. He sees much greater value in the fact that the candidate had the grit to establish a two-mile record, or the physical courage to make the football team, or the faculty of leading others which made him president of his class. Or, since we are now considering technical details, he will prefer the man who can select the proper I-beam from the Cambria handbook to one whose first impulse is to reach for a slide rule and re-figure what has been kindly done for him.

Employers Expect Rough Sorting to be Done by Schools.—It is reasonable, in the writer's mind, for the employer to expect the school to do at least the rough sorting of men for him. If the seal of an engineering school has been set on a man it is reasonable to assume that he has established a presumption that he is of strong character, that he has some spark of originality, and that he gives promise of having a good appearance when he is more mature.

These things are intangible. We must admit that, but opinion does not differ greatly as regards them. There is a danger, of course, that insistence on these things would lead certain supersensitive professors into trying to graduate only puritanic men who would dress according to the most sanctimonious fashion. That is not what is required. It is individuality of the kind which does not repel. We like to talk much about dress and we give the tailor credit for some ninety per cent. of the man, while at the same time we know that if Abraham Lincoln re-incarnated were to walk into the office to-day, with his trousers bagged at the knees and tucked into high boots, we would recognize his claim to our respect before he had said a dozen words.

It may be said, and with considerable show of truth, that an engineer needs only to have a well-trained mind, that his work is with materials and that it makes no difference to the world whether he wears overalls or a dress-suit. It may have been the intention of the founders of these schools that the graduates should be purely mechanics, in fact, at least one well-known engineering school was very frankly intended to be a trade school, but the majority of engineering graduates find their best opportunities in engineering *men* as well as materials. The man who intends to be a designer may throw all the conventions of life to the winds, he may confine himself to a dingy office and never appear in society, and still design the best of machinery, or the most beautiful and useful of structures, but recognition comes slowly.

Of some six hundred technical graduates with whose careers the writer is sufficiently familiar to speak with certainty, over ninety per cent. are in positions which require active co-operation with other men. They either have authority over others, sell to others, or work for others in such professional relations that their ability to make a good impression and hold their own with other men is of the greatest importance. As things stand to-day the student who feels the ability to convert other men to his ways of thinking finds himself rather more discouraged than otherwise. He at least finds that these athletic and other social activities are limited to a chosen few who see fit to take the time for them in opposition to the demands of the faculty.

What changes in engineering school methods would be likely to bring out and develop ability along these non-scholastic lines? How can the line be drawn between the engineering of materials and the engineering of men?

How Schools May Increase the Practicality of Their Training.—Schools located in large centres can seemingly have little excuse for letting pass the many opportunities for their students to attend conventions and other meetings to which it would be easy for them to obtain access and where they could meet men of national reputation, and discover what it now takes them many years to learn, that these men are made of the same clay that they are, and that the difference between a successful man and a mediocre man often hangs on as thin a thread as his ability to carry one side of a conversation. It would seem as if their students might easily find opportunity to get in intimate contact with the workman's viewpoint through the employment and welfare departments of neighboring manufacturers. It is always possible to encourage them, instead of taking jobs as draftsmen through the long vacations, to get places where they will be thrown in contact with men of affairs in their offices. Lectures by successful business men at frequent intervals are often arranged, and would be very helpful, if the latter could only be persuaded to talk and not preach. The writer's experience has been that most business men consider it their bounden duty to tell college men to work hard, be on time and save their money, and consider it unnecessary to outline even the most elementary principles which they have found necessary in the conduct of their own business.

More Practical Experience for the Faculty.—Then, too, it should prove helpful if a larger percentage of the faculty who actually come in intimate contact with the students, could be persuaded to open themselves to the broadening influence of business life, and if they would take part in meetings where business men get together, and try to think outside the petty details of the particular subject which it may be their duty to teach.

Teaching is narrowing in itself, unless a very direct effort is made to avoid the influence of the deadly daily routine. When a man has taught a given subject to several divisions of students for two years in succession it becomes a matter of serious effort to avoid doing it in a perfunctory manner. It is easy for the professor to forget that he is lecturing to a group of living individuals who should be learning to think for themselves, even though it may make him more work and apparently produce poorer results than he gets by leading them to accept his own cut-and-dried thoughts.

The best teacher, the man to whom the graduate's thoughts turn, and on whose judgment the future employer can most safely lean, is not always the man under whose tuition the largest number of high marks have been earned, but the man who was able to see the human soul through the pranks and shortcomings of the body and mind that housed it, and who was able to inspire the man with a feeling of true power to conquer whatever problem, whether material or human, might come in his path.

At present, the graduate usually has a period of adjustment to meet the needs of business life. This requires from two to five or even more years. During that time he is apt to be intolerant, sensitive, self-centered. When this is followed by loss of faith in himself, and disgust with his alma mater, then his life is apt to be soured, but if out of this storm of emotions he discovers that the world is not half so bad and so slipshod as he thought and that commonsense may carry a man where figures will not, then he makes a creditable showing,—in spite of, rather than on account of, that same alma mater.

The employer who is wise, provides a course of training for these men, during which each can butt his head against the customs of business and find himself without unduly interfering with production and sales. Such employers find that this is a good business proposition. Why not incorporate some of these same principles in the requirements for a college degree, even though the graduate knows less of higher mathematics and unusable foreign languages?

INACCURACY OF PRESENT SYSTEM OF MEASURING NATURAL GAS.

The United States Bureau of Mines, which has been conducting experiments on the measurement of natural gases at high pressures, has found there is, in many instances where Boyle's law is used, error as great as 10% or more. The volume of gas, according to Boyle's law, is presumed to vary inversely as the pressure that is applied to it. This is found to be true only for pressures close to atmospheric. Billions of cubic feet of natural gas are yearly measured at pressures greater than atmospheric. The Bureau of Mines says, regarding these figures, in its report:—

Pressures of 300 lb. per sq. in. or greater are common. At 100 lb. per sq. in. an error of 3% has been made, at 200 lb. per sq. in. an error of 6%, at 375 lb. an error of 11%, and at 520 lb. an error of 15% has been made in many cases. Natural gas at these pressures is more compressible than a perfect gas. A concrete example will make the matter clear. If 50,000,000 cu. ft. of natural gas is measured per day at a pressure of 200 lb. per sq. in. and no correction is applied for the deviation from Boyle's law, then an error of about 3,000,000 cu. ft. is made.

NIAGARA-ON-THE-LAKE SEWAGE TREATMENT.*

The municipality of Niagara-on-the-Lake is located at the mouth of the Niagara River, having frontage both on the river and on Lake Ontario. It is a summer residence centre and is also the seat of summer encampment of the Canadian militia. The population varies from a permanent figure of 1,400 to a summer residence of 1,900, the latter figure including the hotel registration.

Water supply is derived from the Niagara River, and is heavily chlorinated because of the extreme pollution existing in the river at this point. Water is used to the extent of 150,000 gallons during the winter season and 400,000 gallons in the summer. The community is sewered, with drainage through three outlets which extend into Lake Ontario for a considerable distance. In addition to these lines, the militia encampment discharges wash water into the Niagara River at a point close to the boat landing. The fecal wastes of the camp are removed from the kitchen sinks to inland points and there buried, thus obviating any effect upon Niagara River conditions.

The existing situation is probably one that does not directly concern the International Joint Commission, for while discharging its domestic wastes into Lake Ontario, which is a boundary water, it is far from probable that these wastes are able to cross the boundary, owing to the barrier interposed by the swift current and large body of the Niagara River. For this reason, no very detailed study has been made of the local conditions, although it is believed that with the improvement of upper river conditions it would be proper and desirable for the corporation of Niagara-on-the-Lake to initiate improvements which would conform with those installed by superior communities, not only as a matter of equity, but also to protect the local bathing beach.

Sewage treatment, if installed, could probably be best handled in small individual tanks located at the several outlets which are separated some distance from each other, and are at such grade as to make perfectly possible the operation of the treatment plants by gravity. In brief, it is suggested that a proper interest in the improvement of the sanitary condition of the Niagara River district would lead the authorities of this town to construct at least small sedimentation tanks for the removal of organic matter. The cost of such installation would not be large, although estimates have not been made for the reason as stated, that this community does not properly present a problem to the International Joint Commission.

*From a report to the International Joint Commission made by Prof. Phelps, consulting sanitary engineer to the Commission.

NEW REQUIREMENTS FOR ENGINEER OFFICERS.

According to the new regulations recently issued by the Department of Militia an applicant for a commission in the Canadian Engineers must be a British subject; he must be certified by a medical officer of the militia to be physically fit for service; not under 5 feet 4 inches in height nor less than 33 inches in chest measurement, and should be between the ages of 25 and 40 years; a graduate of practical science or engineering from a recognized university, or a qualified land surveyor, or an architect or engineer, who, whilst not a graduate of any university, has had not less than seven years' experience in engineering or construction of various types and has held responsible administrative positions.

STREET RAILWAY TRACK CONSTRUCTION IN PAVED STREETS.*

By R. Keith Compton.

ONE of the most difficult problems which a municipal engineer faces in street improvement of to-day is the permanency of the street railway track construction. On this point hinges the durability and integrity of that portion of the pavement immediately in the railway area and adjacent thereto. Even in outlying suburban sections, pavements on streets where railway tracks exist are more difficult to construct and maintain than on streets where no tracks exist. The situation is intensified when similar streets are to be improved in heavy traffic sections of busy cities.

Early History.—The writer takes the liberty of introducing into this subject his experience in the city of Baltimore, Md., where this matter has been given most careful attention, both by the municipal authorities and the street railway officials. In collecting data on this subject from the principal cities of this country we find that other cities have passed through similar experiences. Some fifteen years ago it was the practice of street railway companies to lay the ties directly on the original earth foundation of the street, tamping up with whatever local material was convenient. Consequently, track structures had absolutely no stability other than that given by the natural earth foundation existing in the street, so that within a few months after the street was improved and opened to traffic the rails would vibrate under the movement of cars and heavy trucks, with the result that cracks would develop in the paving adjacent to and for several feet on either side of the rails, causing rapid disintegration of the paving, particularly in the case of sheet asphalt. If the pavement were of stone or vitrified brick, cracks would develop and the paving blocks would soon begin to "work" and loosen up. Within twelve months the paving in the railway area would be in such condition as to seriously impair the usefulness of the street. This disintegration did not confine itself to the railway area, but would gradually encroach upon the city area.

The next development in this construction was the installation of gravel ballast. This was somewhat of an improvement over the original construction, the only difference being that the development of cracks and disintegration was somewhat postponed. Gravel, being round and smooth, would shift under the strain of passing traffic, with results most damaging to the paving.

The crushed stone ballast was then used. On suburban streets with light car and vehicular traffic this was a decided improvement, and in some instances the results obtained, both as to track construction and maintenance of paving, were most desirable. Care, however, had to be taken by the track gangs to see that most careful tamping was done. The rock ballast construction, however, in heavy traffic downtown streets, did not give the results desired, so that in the past few years many cities have been installing a concrete slab, from 6 to 8 inches in depth, under the ties, then brought up and completely enveloping the ties in concrete, and the concrete foundation for the paving installed on top of this.

Right here it may be well to note the following list of cities which have used or are using concrete as a foundation for track construction, in whole or in part. Most municipalities do not use it exclusively, but use con-

*Abstract from paper presented before the American Road Builders' Association.

crete in the heavy traffic sections, and rock ballast in the suburban sections where car and vehicular traffic is light, or where the paving of streets may not be regarded as permanent on account of the surrounding property being undeveloped. This information was obtained in 1913 and 1914 through correspondence with municipal officials in the respective cities. These cities are as follows: New Orleans, La.; Chicago, Ill.; Buffalo, N.Y.; St. Louis, Mo.; Norfolk, Va.; Boston, Mass.; Detroit, Mich.; New York (Brooklyn); Cleveland, O.; Nashville, Tenn.; Memphis, Tenn.; Springfield, Mo.; Birmingham, Ala.; Dayton, O.; Cincinnati, O.; Baltimore, Md.

It is a fact that traction engineers as a rule object to concrete under the ties, claiming three distinct disadvantages:—

First, that concrete under the ties makes the track construction entirely too rigid, and that rock ballast gives equally as good results and overcomes this rigidity in that it allows a certain amount of resiliency, and that such resiliency is necessary, otherwise undue wear will take place on the rails from passing cars, and that rigid track construction is hard on the equipment.

Second, that in case of reconstruction the railway company is put to an unnecessary expense removing the concrete so as to replace defective or disintegrated ties with new ones.

Statistics show that there is no real ground for the first objection, and even if there were, this can be overcome by keeping the concrete base an inch or so low and bedding the ties in a thin bed of loamy sand on top of the concrete slab. Care should be taken, however, to bring the concrete up on the ends of the ties so as to confine the sand and prevent its shifting.

The second objection can be overruled by the fact that in replacing worn-out or disintegrated ties, the railway company does not have to remove any more concrete than it would otherwise remove were the pavement only on a concrete foundation of the usual thickness, as will be hereafter shown by the method of construction followed by the city of Baltimore. Furthermore, statistics compiled by the Board of Supervising Engineers in the city of Chicago, who have been giving this matter most thorough study for the past eight years, show that sound yellow pine ties, thoroughly embedded in concrete, are almost indestructible.

Another and third objection made by the traction officials is that the car lines have to be diverted, either by means of laying a third and temporary track on the street to be improved, or if the street is so narrow as to prohibit this, there has to be an entire re-routing of the cars, causing by either method serious inconvenience to the public and disorganization of the car company's traffic schedule. This claim can also be overruled by a method which the writer will outline to you later, as followed by the city of Baltimore.

The experience of all municipal engineers along this line has probably been the same.

In improving streets containing railway tracks the forces of the railway company and that of the paving contractor have to work in conjunction. The railway area is first graded out to the subgrade of the paving by the paving contractor. The railway company then takes charge and grades out to a point 6 inches below the bottom of the ties. New rails and ties are then installed where necessary, together with any new special work. The ballast, of the size and depth previously noted, is then placed and thoroughly tamped under the ties and up to a point 2 inches above the bottom of the ties, the rails brought to the proper grade and line, and when the entire construction is "tight" the penetration begins.

The grouting mixture is composed of 1 part cement to 2 parts sand, and is of about the consistency of thin cream. The operation is readily done without interruption to car traffic by the use of a small continuous mixer (known as the Coltrin mixer) placed just outside of and parallel with the railway tracks, with a flexible chute, in two sections, to convey the grout from the mixer to the ballast. Starting on the down-grade end and working up-grade, the thin grout is penetrated into the stone ballast, which, as previously noted, has already been securely tamped and made to carry the strain of the passing cars. As already noted, the chute is flexible and in two sections. When a car comes along the first section is thrown out of service and the second section is lowered to the ballast at about the ends of the ties and the mixer kept in service. After the car passes, the first section is thrown back in service.

It is true that during this operation some movement occasionally occurs in the tracks, but there is a city inspector on the work at all times who hunts for and locates loose ties and they are immediately tamped up with green concrete.

The natural supposition is that sufficient movement of the ties and the track would occur to injure the concrete while setting, but this is not true if the work is carefully handled and executed. On one street in Baltimore this work was successfully handled with five different lines of cars passing up and down the street with but 20 seconds headway at times during the day, while on another piece of work it was successfully installed with eleven different lines of cars passing over the special work with less than 20 seconds headway at short intervals during the day. The resultant mixture is about 1 of cement, 2 of sand and 5½ of stone, with the concrete very dense, as the ballast has been thoroughly tamped and voids reduced to a minimum.

This ends the work of the railway company, as after this section of concrete is installed, the paving contractor again takes charge, installing the concrete base for the pavement immediately on top of the railway base, and then the paving.

As a rule, there is no bond between the paving slab installed by the railway company and the paving base installed by the paving contractor, because generally the former is several blocks ahead of the latter, and in the meantime the concrete slab has set. This, therefore, overrules the second claim of the traction officials, and the penetration method pursued meets the third claim.

One of the principal points gained by this form of construction is that it shows up very clearly every weak place during the progress of the work. All loose or poorly tamped ties are made apparent by the bubbling or oozing up of the grout as a car passes over. Failures in finished pavement are avoided by immediately tamping such ties, which in many cases would otherwise have been overlooked. It has been found by careful cuts made in the finished work that this grout when properly applied penetrates the ballast to the subgrade, forming excellent concrete, and insures solid track construction, free from vibration, upon which the life of any pavement in the railway area depends.

From records kept and compiled by the Paving Commission it has been found that the total extra cost of this construction over plain ballast, including labor and material, is about 52 cents per lineal foot of single track.

In the last two years about 10 miles (single track) of such construction has been installed in the city of Baltimore by this process, in the busiest streets of the city, and car traffic interfered with to such a limited extent that you hear no complaint whatever from the travelling public during the course of the work. Included in the 10 miles of single track will be found all classes of paving within the railway area—sheet asphalt, wood block granite block, vitrified block and scoria block.

Type of Pavement.—It has been suggested that this subject could properly include a discussion as to the type of pavement between and adjacent to the rails which has been found most satisfactory. The most satisfactory type of pavement in the railway tracks on heavy traffic streets is granite block, with a cement filler. Excellent results have been obtained in Baltimore with the recut granite. The old blocks are from 8 to 14 inches in length. The 8-inch blocks are re-headed, while the 14-inch ones are split, making altogether, blocks smaller and much more uniform in size than the standard new block. The result is a very uniform, even surface, an excellent pavement for track areas.

On streets which may be half business and half residential, or in the retail districts, vitrified blocks should be used.

All block pavements should be laid on a cement-sand cushion.

On strictly residential streets of very light traffic sheet asphalt has been used, but the writer rather deplores the use of this material within the track areas.

The block pavements are usually laid between the extreme outer rails, including the dummy, with two rows of liners on the outside of each outer rail. Selected granite block, on a mortar bed, is most desirable as liners on heavy traffic streets. On streets of lighter traffic and residential streets, wood block, 4½ inches deep, thoroughly embedded in the concrete and on a mortar bed, give most excellent results as liners and an excellent finish to the street, particularly where sheet asphalt is laid from the rails to the gutters.

In order to cheapen the cost of track paving our policy the latter part of last year was to install sheet asphalt in the dummy strip, where there is very little traffic, and which will give good results if the track work is stable. We will follow this policy almost exclusively this year, as a modification of our former standard, where asphalt is used between the rails and curb.

Track Details.—The rails are usually of the Trilby type, 105 lbs. to the yard, 7 inches deep, with a slight bevel on the outer paving edge. With this rail, and the use of steel tie plates and screw spikes, tierods may be eliminated, and by the elimination of the rods better results from a paving point of view are obtained. Tierods are a nuisance in track paving, causing a great amount of cutting if a block pavement is used, and usually have to be placed below the centre of the rail in case sheet asphalt is used in order to have them in the concrete instead of in the binder.

Comparison of Mixing and Penetration Methods.—Good construction could unquestionably be obtained by the re-routing of the cars, either by means of a third track and cross-overs or by diverting the cars to other streets, thereby allowing the concrete to be placed by the ordinary mixing method and at the same time allowing time for the concrete slab to set before car traffic is again restored. While this method is a safer way, it is much more expensive than the penetration method. Unquestionably excellent results have been obtained by the latter method such as have been described, its attractiveness being that it is cheaper as to first cost, owing, principally, to the economical manner in which the materials can be handled, and it overcomes the principal objection of traction officials, namely, interruption to car traffic, which is, of course, a serious objection.

In order to obtain good results with the penetration method, every detail must be carefully looked after by the inspectors, such as the quality and size of the stone composing the ballast, the tamping, and the mixing and placing of the grout. Frequent test holes should be cut in order to see that thorough penetration is secured, and wherever possible the penetration should be started at the down-grade end of a block and proceeded with up-grade.

Conclusions.—Under the old system of earth foundation or ballast, failures and troubles were numerous. Under the new system of concrete under the ties, installed as has been described, the percentage of trouble is infinitesimal, the principal defects being at crossings and around special work. It proves conclusively that for strictly up-to-date permanent construction, both for the street railway system and the pavement, the ties should be laid on a concrete base, from 6 to 8 inches in thickness, and completely enveloped in the same.

PULVERIZED COAL FOR LOCOMOTIVES.

The committee of the International Railway Fuel Association in charge of the subject summarizes the advantages of pulverized coal in locomotive practice as follows: (1) Smokeless, sparkless, and cinderless operation; (2) maintenance of maximum boiler pressure within a uniform average variation of three pounds without popping; (3) an increase of from 7.5 to 15 per cent. in boiler efficiency as compared with burning lump coal on grates; (4) saving of from 15 to 30 per cent. in fuel of equivalent heat value fired; (5) enlarged exhaust nozzle area, resulting in greater drawbar pull and smoother working of locomotive; (6) elimination of ashpit delays, facilities and expense and reduction of time required for and ease in firing up; (7) maintenance of a relatively high degree of superheated steam; (8) no accumulation of cinders, soot or ashes in superheater of boiler flues, smokebox or on superheater elements; (9) no punishment or overheating of firebox, new or old sheets, rivets, patch bolts, stay or flue beads; (10) elimination of arduous manual labor for building, cleaning, and dumping fires; (11) avoids expense and annoyance of providing various sizes and kinds of fuel; (12) eliminates the necessity of front end and ash pan inspection, and for special fuels, firing tools and appliances for building fires and for stoking and cleaning fires; (13) equal provision with engineer for fireman to observe signals and track, thus reducing liability of accident. "Your committee," concludes a recent report on the subject, "is of the opinion that the effectiveness and utility of the use of fuel in pulverized form has been demonstrated from the past year's development, and that progress in the use of this method of stoking and burning bituminous and anthracite coals and lignites for generating power, heat, and light on railways will be marked from now on." It is stated that railways in many countries are now seriously considering the use of pulverized coal, and that some in the United States are already installing pulverizing plants.

The Railways Department has ordered from the Algoma Steel Corporation, Sault Ste. Marie, Ont., 15,000 tons steel rails, A.S.C.E. standard sections, 80-lbs., for the Hudson Bay Railway, for 1917 delivery.

Editorial

POLLUTION OF BOUNDARY WATERS.

In the Public Service Monthly for July, issued by the Province of Ontario, some interesting notes appear dealing with the question of the pollution of boundary waters.

After dealing with the work of the International Joint Commission, to which reference has been made in recent issues of *The Canadian Engineer*, and pointing out the part which Canadian engineers have taken in connection with this work, the article says:—

"The required works, which are of considerable magnitude, involving an expenditure of approximately $11,500,000, will be an enormous boon to the many citizens of both countries now enjoying these waters for boating and summer resort purposes, to say nothing of the advantage to the several municipalities depending upon them solely for municipal water supplies, one of which, Niagara-on-the-Lake, has been recently compelled to instal an extensive purification plant for the protection of the troops located there. It is worthy of note that the population affected is 1,837,352 persons, and the annual cost of the works, including interest, sinking fund, and operation, averages 91 cents per person, a cost which appears small when compared with the benefit to be derived."

THE CITY MANAGER PLAN OF MUNICIPAL GOVERNMENT.

A few years ago, more particularly than now, a good deal of discussion centered around the advantages or the disadvantages of what is known as the city manager plan of municipal government. It was a new idea and had many advocates. Articles were written, papers were read before various bodies outlining the many blessings that would follow the introduction of the plan.

Just prior to that the commission form of government was heralded as the saviour of the situation, eliminating the council or the board of control system.

Some Canadian cities gave the city manager plan some serious consideration but were slow to adopt it in its entirety, feeling that to a very large degree the plan was yet in its experimental stage.

A combination of the commission plus city manager would seem to be the ideal. It would eliminate what is regarded as the principal objection to the straight city manager scheme, namely, the fear of one-man power. With the commissioners acting as a group through one controlled executive, the whims or fancies of any one man would be neutralized by the combined judgment of the other members of the commission. Furthermore, if any one member of the board happened to be selfishly interested in the passing of certain acts the passing of every act by the group makes it impossible for any one to put such deals over. In this way the manager would become servant and executor rather than boss.

While the pure city manager plan may not be suitable for the larger municipalities, the fact remains that in a number of smaller cities where the combined plan has been tried, there does not seem to be any desire to revert to the former method which, to say the least, is cumbersome and so indirect in its operation as to make it less efficient. Under the council plan there is often much confusion due to the fact that the work is divided and subdivided among the various committees.

While such confusion may exist with the commission plus manager plan, it is not likely that it will be so pronounced.

It is estimated that there are about three hundred and fifty cities in the United States that are under the control of commissions, while about twenty have adopted the system of control by city manager.

Of course, the success of the plan depends to a large degree upon the capacity, energy and honesty of the manager. In any event it is questionable whether any one with even a reasonable store of commonsense and judgment could waste as much or bungle as much as the average aggregation of so-called popular representatives who normally control civic affairs.

IMPORTANCE OF MAINTENANCE.

While many articles have been printed, many papers read and much discussion devoted to the problems incidental to highway construction, it is rather interesting to note that but a very small portion of space is devoted to the subject of highway maintenance. In Canada, as elsewhere, there is a disposition to give just a little less attention to this side of the problem than is actually demanded. Roads, whether in the city, the town or the country, no matter how well they may have been laid, will not last unless those responsible for their up-keep exercise vigilance and see to it that incipient holes, cracks and cuts are promptly and thoroughly attended to.

It is poor business to spend good money laying a modern pavement and then, as the result of the penny wise and pound foolish policy, negative the investment by indifference to the proper degree of maintenance for which the pavement calls.

A pavement, like most other things, is put there to render a service to the community. If, as a result of careless maintenance organization, it gets into disrepair and fails to give the service for which it was designed, it is to that extent as uneconomical as a pump or any other piece of machinery in a similar condition.

Delays in repairing small defects in pavements are always uneconomical and sometimes dangerous. Sooner or later they have to be attended to and will in most cases cost as much or more to attend to them when they are old as when they are new.

What are spoken of as permanent pavements will deteriorate, and cannot in the very nature of things have as long life if, after being laid down, they are not properly maintained.

LETTER TO THE EDITOR.

Re Rosewater's Hydraulic Table.

Sir,—In addition to the uses of the tables as described in your issue of August 3rd last there is another which will be found useful. Supposing two or more mains deliver water at a given point with the same total loss of head, but the diameters and lengths are different, it is an easy matter to estimate the discharge by each main. For example, say a 30-inch main is 10,000 feet long and a 26-inch main is 12,000 feet long, what will be the hydraulic grade to deliver a total of 15 c.f.s. and what will each main discharge? First, assume a grade for the 30-inch main, say, 0.10 per cent., then, according to the table, the discharge is 13.16 c.f.s. The assumed grade for the 26-inch main will be $\frac{10,000 \times 0.1}{12,000} = 0.083$ per cent. and with this grade the discharge is 8.18 c.f.s. The total will be 21.34 c.f.s. The next step is to ascertain the proportional discharge to give an aggregate of 15 c.f.s. — $\frac{13.16 \times 15}{21.34} = 9.25$ c.f.s. for the 30-inch and $\frac{8.18 \times 15}{21.34} = 5.75$ c.f.s. for the 26-inch, which is a part of the answer. The grades to give these discharges can be ascertained by example 6 given in the previous letter. $S = \left(\frac{9.25}{41.04}\right)^2 = 049$ per cent. grade for the 30-inch main and $\left(\frac{5.75}{28.27}\right)^2 = 043$ per cent. grade for the 26-inch main.

R. O. WYNNE-ROBERTS.

Toronto, August 12th, 1916.

SOME EXPERIMENTS ON THE PLASTIC ELONGATION OF WIRE.*

By A. V. de Forest.

In the course of tension tests on wire, using a dead-load method, it was observed that brass wire stretched very differently from copper, aluminum, nickel, soft iron and German silver. These latter stretched in fairly uniform manner, that is, the stress-deformation diagram showed an apparently smooth curve, while that for brass was an irregular one. Turning to the literature it was found that this phenomenon is clearly shown in Dalby's autographic stress-deformation diagrams, and is evidently the same effect as the well-known "self-hardening" of bronze, and certain aluminum alloys when tested in the usual manner. The amorphous cement theory, advanced by Beilby and extended by Rosenhain, seems to offer a simple explanation of this matter, and further experimental work was undertaken to support the theoretical reasoning.

As is universally known, the amorphous theory accounts for the hardening effect of cold work by assuming that a layer of amorphous material, sub-microscopic in thickness, is formed on the cleavage planes, and between grains where slip has occurred. This material is assumed to be of the nature of an under-cooled liquid, such as glass, stiff and brittle. The effect of this intergranular layer is to "cement into rigidity" the enclosed blocks of crystallin material. After the metal has been deformed, it may thus be regarded as composed of broken parts of the original grains, in the form of crystallin blocks, surrounded and supported by the amorphous cement. The manner in which the metal yields to a reforming force will then depend on the relative resisting power of the two components.

There is little direct evidence on this point, but what seems a simple idea of the matter will account for the observed facts. At room temperature the cement formed between crystallin blocks of some metals requires a considerable time in which to reach its maximum supporting power. Muir's experiments on mild steel show that several days are required before overstrain tension specimens reach their greatest elastic limit. Howe has likewise shown that iron and mild steel behave in a similar way with respect to hardness. Using a word readily suggested by the term "cement," it would seem that the amorphous layer required a given time in which to set. This time might be expected to be dependent on the temperature, whatever the nature of the setting process; whether or not this process consists in the recrystallization into the adjacent crystallin blocks of the surplus amorphous material, leaving a layer of the same order of magnitude as that filling the original intergranular spaces. In fact, both the above experimenters found the time required for setting was reduced from a few days to a few minutes by heating the metal to 100° C. Whether the properties of the crystallin component are changed by such a small change in temperature is unknown, but it seems reasonable to suppose that the effect of such change on the unstable cement would be greater than that on the stable crystallin matter. Even the unstable forms of hardened steel are apparently little changed by heating to 200° C. As the facts can be readily explained without assuming such a change, it will be omitted for the sake of simplicity in the present case.

The setting process is then probably largely a function of the temperature. It may likewise be supposed that the viscosity of this substance is also affected by smaller changes in temperature than those which sensibly affect the crystallin particles. The rapid elongation under constant or diminishing loads found by many workers at higher temperatures, and the great intergranular brittleness found by Rosenhain at temperatures close to the melting point, indicate a great change in viscosity.

From these considerations it would seem that a metal subjected to a gradually increasing dead load would stretch smoothly and uniformly, when the rate of stretch and the temperature were such that the cement would set comparatively slowly. The blocks of crystallin material moving along the slip planes would be supported by an amorphous layer so viscous that no rapid motion would be possible. The motion of the blocks would be gradually checked by the increasing area of cement, and its increasing stiffness as time was allowed for it to set. The retardation would be gradual and the end of the motion would be imperceptible. Under these conditions the stress-deformation diagram would be a smooth curve, such as is usually obtained from copper.

As the temperature is raised the cement between the blocks of crystallin matter becomes less viscous at its foundation, and therefore the slip becomes more rapid. Also the time required for setting is less, and the relative motion of the blocks is more suddenly arrested. As the deformation increases, slip along new planes begins, only to stop suddenly when the resulting cement stiffens in its turn. A much slower rate of loading might also result in the same form of irregular stress-deformation diagram, for the mobile phase formed by any one slipping movement would have time to yield to a perceptible degree before the load became sufficient to develop slip along new planes.

*Abstracts from paper read before the American Society for Testing Materials.

An arrangement has been completed by Italy with Great Britain for the purpose of obtaining cheaper coal for Italy next winter.

PERSONAL.

S. A. BENNEY, of the city engineering staff, Winnipeg, Man., has enlisted with the Second Field Force of the Canadian Engineers.

HEBERT & GIROUARD (Gaspard Hebert and Honore Girouard), Montreal, Quebec, civil engineers and contractors, have registered.

Pte. FRANK C. MAYNARD, builder and contractor, Edmonton, Alta., who left with the 51st Battalion last April, has been reported wounded.

FLOYD WEED, formerly manager of the McKane mine, Kirkland Lake, Ont., has left to assume a similar position in the iron fields of Birmingham, Ala.

Hon. P. G. MAHONEY, minister of public works for the province of New Brunswick, has resigned. He will be succeeded by B. FRANK SMITH, M.P.P.

HAROLD WEBSTER, assistant engineer on the staff of the Joint Sewerage Board, Vancouver, B.C., has been appointed a sub-lieutenant in the Royal Navy Patrol.

A. E. GRIFFIN, of Wingham, Ont., is going to Russia in the interests of Foley, Welch & Stewart, railway contractors of Vancouver, and expects to secure a contract for his company in that country.

THOS. J. MUSGROVE, chief engineer at the McPhillips Street waterworks plant, Winnipeg, is ill and will go to California to recuperate. He has been in the employ of the department 27 years.

LAWFORD GRANT, sales manager of the Eugene F. Phillips Electrical Works, Limited, Montreal, has been appointed assistant general manager and assistant treasurer, with a seat on the board of directors.

Sergt. W. STEWART LAING, son of Mr. George Laing, Peterborough, Ont., with the 6th Field Company, Canadian Engineers, has been appointed temporary lieutenant in the Canadian Engineers Training Depot.

ROBERT LIVERMORE, is resigning his position as manager of the Kerr Lake mine on September 1st. He will, however, be retained as consulting engineer, and will act in the same capacity for Gooderich, Lockhart & Co., New York. H. A. KEE, superintendent of the Nipissing Mines, has been appointed to succeed Mr. Livermore.

Lieut. C. E. MacDONALD, son of Mr. Duncan MacDonald, Toronto, has been reported wounded. Lieut. MacDonald qualified as a lieutenant in 1914, but did not await an appointment here. He went overseas with the rank of sergeant and was commissioned upon his arrival overseas. He is 24 years of age, and a third year student in the mining branch of the School of Practical Science.

Major JOHN BISCOE has been seriously wounded while in action, according to cable advice received by his father, Col. V. R. Biscoe, of Toronto. Major Biscoe left Canada early this year as commandant of one of the companies of the 76th Battalion. He went to France in June with a draft for a Canadian unit at the front. Prior to enlistment he was engaged as engineer at the Coniagas Mine. His home is in Barrie, Ont.

Lieut. LEON ARCHIBALD, an officer of the Royal Engineers, attached to the Black Watch, and a brother of City Engineer G. D. Archibald, of Saskatoon, Sask., has been wounded for the second time during the present war. He was previously wounded while serving with the 5th Western Cavalry Battalion, at the battle of Ypres. Lieut. Archibald is a surveyor, and prior to his enlistment at the outbreak of war, was employed with Reilly, Dawson and Reilly, of Regina, Sask.

OBITUARY.

ALEXANDER KELLETT, one of the builders of the Grand Trunk Pacific, died in Vancouver recently.

C. T. WIMWOOD, who died at the home of relatives recently at Big Point, near Chatham, Ont., was a prominent mining engineer and mining operator. He was president of the Bisbee Copper and Development Company.

WILLIAM YELLOWLEY, superintendent of the Canadian Locomotive Works, Kingston, Ont., died very suddenly at his home recently at the age of 57. He was a native of Newcastle, England, and had been with the Kingston works for over fifteen years.

DONALD McDONALD, of Outremont, Que., passed away on August 18th after an illness of three months from heart trouble. The late Mr. McDonald was born at St. Hyacinthe, Que., 55 years ago. For 35 years he had been in the service of the I.C.R., being superintendent with that railway for many years at Levis, Que.

Lieut. H. J. A. HAFFNER, B.Sc., A.M.Can.Soc.C.E., was killed in action in France on May 30th last. Lieut. Haffner was for a long time employed as an engineer for the C.P.R., but for the two years previous to his enlistment was in business for himself in Vancouver, B.C., as consulting engineer. He was interested in irrigation problems of the province, and was at one time engaged by the government on this subject. He was a graduate of McGill University (1904) in applied science.

Lieut. S. F. WEEKS, 130th Field Company C.E., was killed in action on July 11 in Northern France. Mr. Weeks was the only son of Mr. F. Weeks of Bournemouth, England. He was educated at London University, where he obtained his B.Sc. in engineering. He was articled to a consulting engineer in London and after working for a time on sewerage works he came to Canada and was appointed as assistant to Mr. A. D. Creer, engineer of the Vancouver and District Joint Sewerage and Drainage Board in July, 1911. Immediately on the declaration of war he resigned his appointment and obtained his commission in the Royal Engineers.

Lieut. A. W. McKNIGHT, Jun.Mem.Can.Soc.C.E., son of Mr. Robert McKnight, registrar for North Grey, Owen Sound, Ont., was killed in action in France on August 11. Lieut. McKnight was a graduate of the Royal Military College at Kingston, and after his graduation was assistant engineer on a Hydro project in the Kenora district. He afterwards went to Prince Rupert, and later became town engineer at Port Moody, B.C. When the war opened he immediately entered the engineers' corps and went to England, and was soon sent to the front. On November 5th he had an exceedingly close call from a shrapnel wound. On his recovery he came home on furlough, returning again in April.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA GENERAL ANNUAL ASSEMBLY.

The General Annual Assembly of the Royal Architectural Institute of Canada will be held at Quebec, Que., on the 8th and 9th of September, 1916. A very interesting programme is being prepared which will include matters of interest to every architect in the Dominion. Alcide Chaussé, Hon. Secretary, 5 Beaver Hall Square, Montreal, Que.

GREAT BRITAIN'S BLACKLIST

Clippings of the blacklist now being published in *The Canadian Engineer* should be filed for reference. The publication in this paper was the first publication in Canada of the complete, correct and official lists. All Morocco, Portuguese East Africa and Persia firms are blacklisted. Eighty-five United States firms and individuals are blacklisted, the names and addresses being published in full in *The Canadian Engineer* of August 10th. The Argentina and Uruguay list, containing many names, appeared in our last week's issue. The Brazil blacklist follows:—

BRAZIL.

Achim & Company, Joinville, Sta. Catharina.
Ahrns, Edouardo, Rua Dos Algibebes, Bahia.
Albuquerque, Antonio de, Para.
Arp & Company, Rua do Onvidor, 102, Rio de Janeiro.
Banco Aleman Transatlantico (Deutsche Ueberseeische Bank).
Banco Germanico de la America del Sud (Deutsche Sud-Amerikanische Bank).
Barza & Company, Pernambuco.
Bayer, Federico & Company, Travessa Santa Rita, 22-24, Rio de Janeiro.
Behrmann & Company, Rua das Princezas, Bahia.
Bellingrodt & Meyer, Rua Sao Pedro, 70, Rio de Janeiro.
Bercht Brothers, Rua Voluntarios da Patria 46, Porto Alegre.
Berringer & Company, Para.
Bezold, Otto, Ceara.
Bluhm, Bernhard, Rua 28 de Julho, S. Luiz, Maranhao.
Bockmann, A., & Company, Rua do Apollo, 28, Pernambuco.
Borstelmann & Company, Pernambuco and Maceio.
Brando, Viuva Carlos, & Company, Florianopolis.
Brasilianische Bank fur Deutschland, Bahia; Porto Alegre; Rio de Janeiro; Santos and Sao Paulo.
Breithaupt, Victor, & Company, Rua Itororo, 8, Santos.
Bromberg & Company, Bahia, Porto Alegre, Sao Paulo, Rio de Janeiro.
Bromberg, Daudt & Company, Rua Voluntarios da Patria 54 & 56, Porto Alegre.
Bromberg, Hacker & Company, Bahia, Porto Alegre, Sao Paulo, Rio de Janeiro.
Buhle, C., Porto Alegre and Rio Grande do Sul.
Carioca, Manoel Vicente, Manaos.
Casa Allema (Wagner, Schadlich and Company), Rua 15 de Novembro, Santos; Rua Direita, 18, Sao Paulo.
Cia Lithographica Hartmann Reichenbach, Rua Gusmoes, 93, Sao Paulo and Santos.
Compania Brazileira de Electricidade, (Branch of Siemens Schuckert Werke), Avenida Rio Branco 79 and 81, Rua General Camara 87, Rua do Hospicio 29, Rio de Janeiro; and Rua Sao Joao, Bahia.
Companhia Commercial, Victoria.
Costa Almeida, M., Rua do Rosario, 17, Sao Paulo; Rio de Janeiro.
Costa Ferreira & Company, Rua Sao de Bento, 77, Sao Paulo.
Da Motta, A. Alves (partner of Fonseca & Company), Para and Rio de Janeiro.
Dannemann & Company, Sao Felix, Bahia.
Dauch & Company, Rua Frei Gasper, 16, Santos.
Deffner & Company, Manaos.
Demarchi & Company, Uruguayana.
Diaz Garcia & Company, Rua General Camara, 39/43, Rio de Janeiro.
Diebold & Company, Rua Santo Antonio, 56, Santos.
Domschke & Company, Rua das Princezas, Bahia.
Eiffler, Bernard, Manaos, Para and Pernambuco.
Empreza de Navegacao Mosqueiro E. Soure, Para.
Campos, Jose Pinto.
Officina Velhote Silva.
Officina Viuva Camillier.
Empreza Graphica Rio Grandense, Rua dos Andradas 447, Porto Alegre.
Empreza Hoepcke, Florianopolis, Santa Catharina.
Engel, Fritz, Pelotas, Rio Grande do Sul.
Englehardt, Carlos, Rio Grande do Sul.
Ferreira, J. G., Rio de Janeiro.
Fischer, Christiano, Rua Marechal Floriano, 73, Porto Alegre.
Fonseca, Abilio (partner of Fonseca & Company), Para.
Fonseca & Company (Coal Merchants), Para.
Fonseca, Arthur, Sao Francisco do Sul.
Fraeb & Company, Rua 7 de Setembro, 90, Porto Alegre; and Pelotas, Rio Grande do Sul.
Friedheim Aguiar & Company, Avenida Maranhense, No. 11, S. Luiz, Maranhao.
Friedrichs & Timmans, Rua dos Droguistas, Bahia.
Fuchs, J., & Company (Casa Fuchs), Rua Sao Bento, 83, Sao Paulo.
Gasmotorenfabrik Deutz, Avenida Rio Branco, 11, Rio de Janeiro; Rua Floriano Piexoto, 11, Pernambuco.
Graeff, Gustaf, Para.
Green & Company, Belem, Para.
Griesbach, Max, Para.
Guimaraes, N., & Company, Rua Luiz de Camoes, 16, Rio de Janeiro.
Hartmann, H., Rua Barao da Victoria, 25, Pernambuco.
Hasenclever & Company, Rio de Janeiro; Rua L. Badaro, 70, Sao Paulo.
Hermanny, Louis, & Company, Rua Goncalves Dias 54 & 57, and Avenida Rio Branco 126, Rio de Janeiro.
Hoepcke, Carl, & Company, Florianopolis, Santa Catharina.
Hoffman, Rudolf, W. H., Para.
Holzborn, Ernesto, Rua das Princezas, Bahia.
Huland, Oscar & Company, Ceara.
Jannowitzer, Wahle & Company, Rua de Candelaria, 49, San Pedro, 34, Rio de Janeiro; and Sao Paulo.
Joao Silveira de Souza, Joinville.
Jordan Gerken & Company, Sao Francisco do Sul.
Krause, Irmaos & Compnay (Krause Brothers), Para; Maranhao; Manaos; and Pernambuco.
Kroncke & Company, Parahyba do Norte.
Kuehlen, Otto, Para.
Landy, Carlos von, Rua Barao do Triumpho, 35a, Pernambuco.
Lemcke, Carlos & Company, Porto Alegre.
Lind, Von der, & Company, Rua das Princezas, Bahia.
Lobo, Manaos.
Lohse, Para.
Louro Linhares, Florianopolis.
Magnus, James, & Company, Rua Sao Pedro, 96, Rio de Janeiro.
Meyer, Irmaos & Company, Rua Sete de Setembro, 165, Porto Alegre
Monteiro, J. A., & Company, Rua de Candelaria, 49, Rio de Janeiro.
Monteiro Santos & Company, Sao Paulo.
Moreira, Julio Ceser, Rio de Janeiro.
Mosqueiro and Soure, Para.
Naschold, Ricardo, & Company, Rua Henrique Dias, 57, Sao Paulo; Porto Alegre.
Noronha, Carlos de, Rua General Camara, 22, Rio de Janeiro.
Ohliger & Company, Manaos.
Ornstein & Company, Rua Sao Pedro, 9, Rio de Janeiro.
Ostermeyer, Frederico, Rua da Quitanda 63 and 175, Rio de Janeiro.
Ottens, K. J., Bahia.
Overbeck, W., Rua das Princezas, Bahia.
Peterson, Adolf, & Company, Rua do Apollo, 36, Pernambuco.
Pintsch (Julius) Aktiengesellschaft, Rua Sao Pedro 9, Rio de Janeiro.
Pradez, Pierre, Rio de Janeiro and Santos.
Pralow & Company, Para and Manaos.
Reickmann & Company, Rua Boa Vista 42, Sao Paulo.
Ribeiro, Armando, Rua Voluntarios da Patria, 40 and 42, Porto Alegre.
Rombauer & Company, Rua Visconde de Inhauma, 84, Rio de Janeiro.
Rosa Neves & Company, Florianopolis.
Rothschild & Company, Rua 15 de Novembro, 31, Sao Paulo.
Runes & Bark, Largo Monte Alegre, 6, Santos.
Schar, Ernest, Pernambuco.
Schlee, Philip, Manaos.
Schlick, Alfredo, & Company, Rua da Assemblea 14; and Rua Quitanda 47 Rio de Janeiro.
Schneider & Company, Rua Voluntarios de Patria, 40/42, Porto Alegre.
Schoenn, Roberto, & Company, Rua Quitanda, 147, Rio de Janeiro.
Scholz, Manaos.
Schumann & Company, Para.
Seligmann & Company, Para.
Semper & Company, Manaos.
Simoes, Angelino, & Company, Rio de Janeiro.
Simonek & Moreira, Rua do Bon Jesus, 20, Pernambuco.
Sinjen, M., & Company, Novo Friburgo, Rio de Janeiro.
Sinner, Alfredo, Rio de Janeiro and Santos.
Sociedad Tubos Mannesmann Limited, Rua do Rosario 64, Rio de Janeiro.
Sociedade Anonyma Armazens Andresen, Manaos.
Solheiro, Luiz (partner of Fonseca & Company), Para.
Steinberg Meyer & Company, Avenida Rio Branco, 65, Rio de Janeiro; Sao Paulo.
Steiner, Pedro Maurico, Para.
Steinman, Emilio A., Manaos.
Stender & Company, Bahia.
Stofen, Schnack, Muller & Company, Corumba.
Strassberger, E., & Company, Manaos.
Studer, J., & Company, Rua das Princezas, 20, Bahia
Suerdieck & Company, Rua das Princezas, Bahia.
Teltscher & Company, Rua 7 de Setembro No. 122, Porto Alegre.
Trommel, A., & Company, Praca Tellas, 11, Santos; Rua Alvares Penteado, Sao Paulo.
Urban, Eugen, & Company, Rua Conselheiro Saraiva, 30, Rio de Janeiro; Rua Santo Antonio, 63, Santos.
Vasconcelles, Jose de, & Company, Pernambuco.
Vianna, Elyseo, Rua 51 de Novembro, Pernambuco.
Vieira, Francisco Salles, Manaos.
Wachtel, Marxen & Company, Rio Grande do Sul.
Wagner, Schadlich & Company (Casa Allema), Santos and Sao Paulo.
Weigandt, Para.
Weissflog, Alfredo, (of Weissflog Brothers), Rua Maranhao 21, Sao Paulo.
Weissflog Brothers, Rua Libero Badaro, 70, Sao Paulo.
Weissflog, Otto, (of Weissflog Brothers), Avenida Paulista 112, Sao Paulo
Weiszflog, Max, Sao Paulo.
Westphalen Bach & Company, Rua Cons; Saraiva, Bahia.
Wille, Theodor, & Company, Sao Paulo; Rio de Janeiro and Santos.
Wolff, Eric, Pernambuco.

NEW INCORPORATIONS.

Prince Rupert, B.C.—Delta Copper Company, Limited, $1,000,000.

Ashcroft, B.C.—Quesnel Forks Gold Mining Company, Limited, $100,000.

Milton, Ont.—Milton Foundry, Limited, $40,000. A. Fasken, D. McArthur, E. H. Brower.

Toronto, Ont.—Davidson Gold Mines, Limited, $2,000,000. A. Gordon, R. Purdy, A. Trebilcock.

Toronto, Ont.—Washed Sand and Gravel Limited, $60,000. D. Arnot, W. H. Williams, Ina C. Murray.

Windsor, Ont.—Ojibway Steel City Land Co., Limited, $40,000. J. H. Stewart, H. E. Baker, J. H. Nolan.

Wiarton, Ont.—Feldspar and Clay Products, Limited, $1,500,000. J. M. Ferguson, J. P. Walsh, A. J. Kiely.

Brantford, Ont.—The Dominion Steel Products Company, Limited, $500,000. W. S. Brewster, R. T. McGraw, G. D. Heyd.

Montreal, Que.—Sovereign Crude Oil and Asphalt Company, Limited, $1,000,000. J. C. Lamothe, C. G. Derome, E. Duplessis.