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USE OF COMPRESSED AIR IN TORONTO SEWER CONSTRUCTION

A DESCRIPTION OF METHODS OF TUNNEL CONSTRUCTION WITH COMPRESSED AIR AND COST OF OPERATING A COMPRESSOR PLANT.

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COMPRESSED air was introduced into sewer tunnel work in Toronto for the purpose of lowering the cost of construction where the ground was of a fluid nature, such as in fine, wet sand which becomes fluid when the overhead pressure is removed. Tunnelling is, of course, possible in most cases without the aid of compressed air, but is much more expensive, for not only is a smaller length of tunnel completed each day but a greater quantity of and heavier timbering is required, and the difficulty of placing it is much greater. The sides and roof have to be solidly sheeted in order to prevent the water and sand from escaping into the tunnel in such quantity as to undermine the roadway or pavement or any overhead utilities, such as water mains, gas mains, conduits, etc. Tongue and grooved lumber is sometimes used, or two layers of planks placed one overlapping the joints of the other. This timbering must be heavy enough to withstand the overhead pressure (Fig. 1) as this kind of ground does not arch, but forms a dead weight on the sheeting. When this fluid ground extends to a depth below the proposed tunnel, and compressed air is not used, the bearing power of the soil must be strengthened, and to do this, it is generally necessary to open-cut from the surface, as the dead weight of the ground above will cause the timbering to sink if tunnelling is attempted (Fig. 2). In order to tunnel such ground successfully, then, without undermining overhead utilities, the water which causes the fluid nature of the ground must be forced back. When this water is removed, the ground becomes solid. It is loose enough, however, to be easily mined. To remove the water, compressed air is used, the function of which is to exert a greater pressure in the tunnel than is exerted by the overhead ground, thus forcing the water back beyond the line of the tunnel.

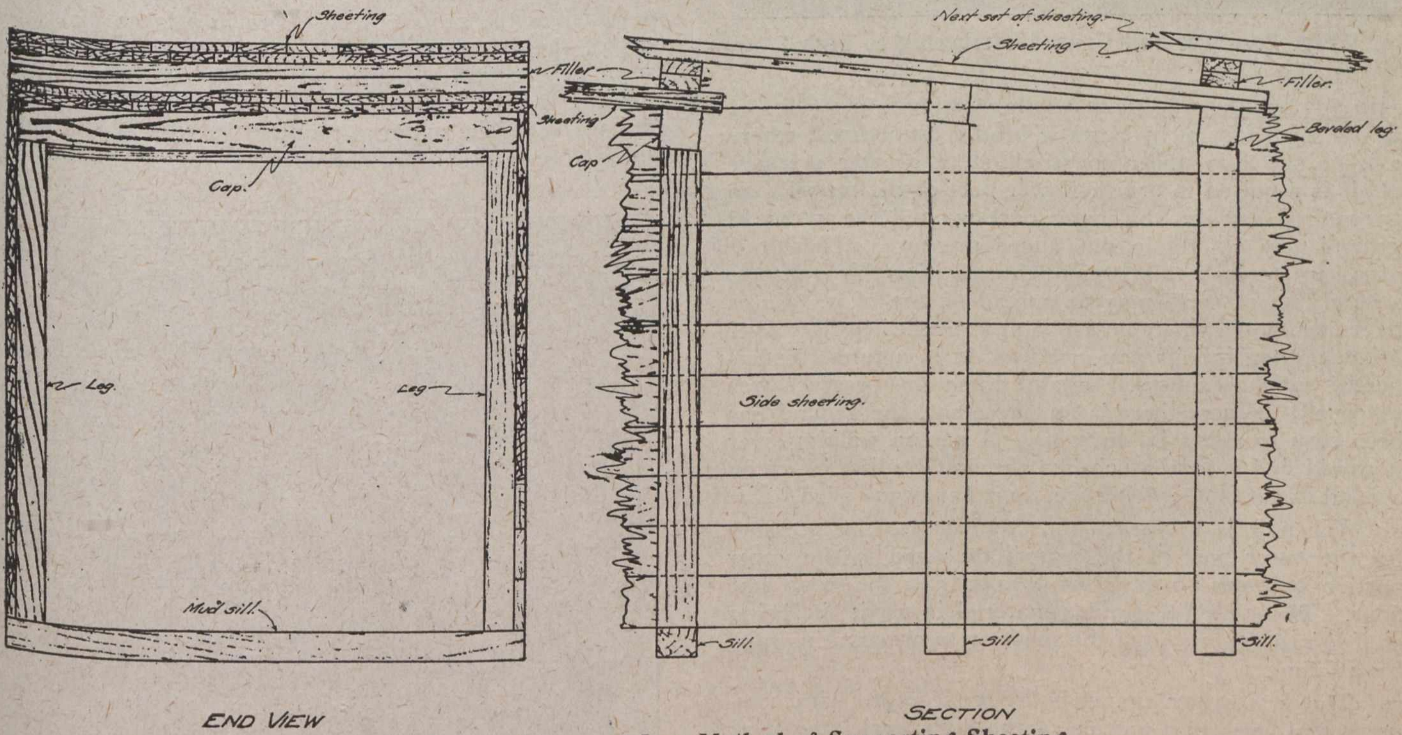


Fig. 1.—Detail of Cap and Leg Method of Supporting Sheeting.

The pressure of air required varies directly as the depth of the proposed work, the quantity of water and the nature of the overhead ground, whether all sand, a mixture of clay and sand or these two occurring in layers. It depends also on whether the ground contains any old sewers, mains, conduits, etc. Roughly, ½ lb. of air to the foot of depth is assumed, but conditions of the ground vary so much that it is never possible to go

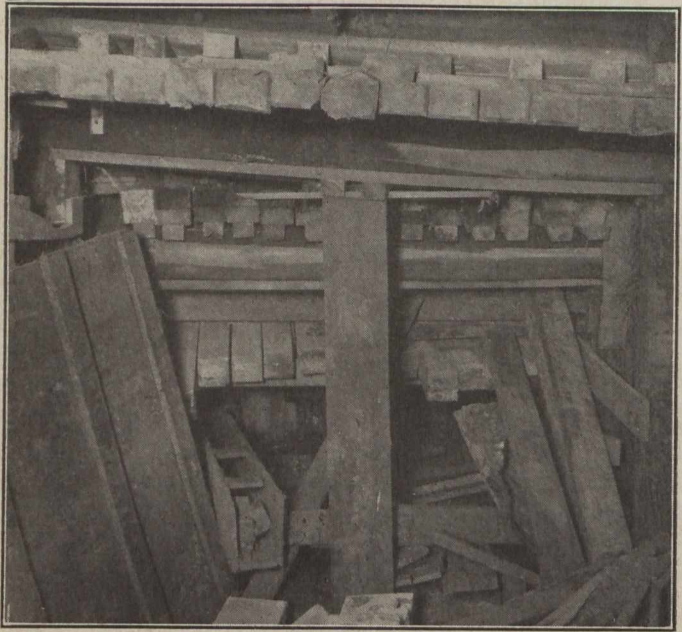


Fig. 2.—Wet Soil Caused Timbering to Sink.

entirely by this figure. Another estimate is ½ lb. of air for each foot of hydrostatic head. Sometimes, where a large sewer is under construction, a greater pressure of air is required to dry the lower part of the tunnel than is required to dry the upper portion, and the overhead ground may not retain this added pressure. Then it is necessary to load this ground down. For this purpose, several feet of earth may be spread on top of it. Cases have been noted where an asphalt pavement has risen over ½ inch when the air pressure was on in a tunnel underneath, and has subsided again when the pressure was taken off. Where there is no pavement, the ground has been seen to rise 1 in. to 2 ins. A person walking over it would find it very much like the first coating of ice on a pond in autumn—rubber ice, as it has been called.

When it is necessary thus to increase the pressure for the lower part of the tunnel, the sand in the upper portion becomes so dry that it falls from the roof like flour. Then, hay or similar material is used, it being stuffed into the cracks of the sheeting to prevent this sand from falling.

The first sewer tunnel built in Toronto with compressed air was that portion of the high level interceptor which runs from King Street and Fraser Avenue, along Fraser Avenue, Liberty Street and Dufferin Street to Springhurst Avenue. It was a 4-ft. 6-in., 2-ring, circular brick sewer, with an average depth of 25 ft. From 6 to 12 lbs. of compressed air were used. The contract was carried out by an American firm, the Gawne Contracting Co. A shaft was sunk and compressors erected on Liberty Street, near Dufferin Street. Work proceeded from each end of the shaft. At the east end, towards King Street, the lower pressure (6 or 7 lbs.) was used, this being sufficient to prepare the ground. The Dufferin Street end required 11 or 12 lbs. pressure to prepare the ground for tunnelling. More than an average quantity of air escaped owing to the close proximity of an old sewer and some other mains. In one case the air escaped through the joints of an old brick sewer on Dufferin Street, one which was built in the days when lime mortar was used instead of cement. It carried the surrounding sand with it into the sewer. The latter settled, spread and then collapsed. The earth over and around it was carried away and about 15 ft. x 30 ft. of pavement undermined. Fortunately, this happened in winter when the electric street railway tracks leading to the Exhibition Grounds were not in use. The rails acted as reinforcement for the pavement and heavy trucks passed over without having any appreciable effect. The cavity was finally discovered by the sewer maintenance men who, noticing a small depression between the tracks, sounded the pavement and so discovered the break.

The next tunnel in which compressed air was used was on Woodville Avenue in the West Toronto system previously mentioned in these pages. This was an 8-ft. circular, 4-ring, brick sewer, the details of the construction of which will be given in a later article. Then followed the main sewer in Moore Park on Sight Hill and Oakmount Boulevard, and another on Danforth Avenue, in East Toronto. A small air pressure was found sufficient on these contracts. Then it was used in West Toronto again and it is there that compressed air has been of greatest value. The ground in this area is all composed of sand and generally carries a great quantity of water at the elevation of the trunk sewers.

The cost of setting up a compressed air plant naturally varies with its size.

Besides the units costing more in a large plant, the cost of the foundations, wiring and all the fixtures will vary. The actual operation of setting up the plant, excavating for and building the locks requires from three to four weeks. The material required is, besides the units, concrete foundations for the compressors, foundation for

Fig. 4.—Steel Cylinder Air Lock.

the motors or engines if they be used, wiring, pipes for air lines, and buildings. If electricity is used, connections are made with the 500-volt system of, if possible, two companies. In Toronto, connections are made with both the Hydro and Toronto Electric Light Co. This is done so that if the power goes off in one system, power may be immediately taken from the other. If the compressed air is allowed to fail, even for a short time, the water which has been forced from the ground will return and bring sand with it into the tunnel. The result then may be the loss of one or two days in removing the sand from the filled-in heading, erecting new timbering or filling the cavity left by the sand which ran into the heading.

When compressed air is used, air-locks are provided at the shaft to confine the air to the tunnel (Fig. 3). These locks consist of a section of sewer with a bulkhead at each

Sometimes when high pressure is required, a wedge (Fig. 5) is forced into the solid ground at the end and over the lock to prevent the air from escaping back over the finished work. This wedge consists of a tight thickness of planks the width of the open cut forced into the ground horizontally with jacks, another row on the slant about 4 ft. above the horizontal row, the ends of these meeting the ends of the first. The earth is then removed between these layers of planks and the space rammed full of concrete.

Where the tunnel is for a small sewer, say, 4 ft. in diameter, the volume of air in the tunnel and the area for

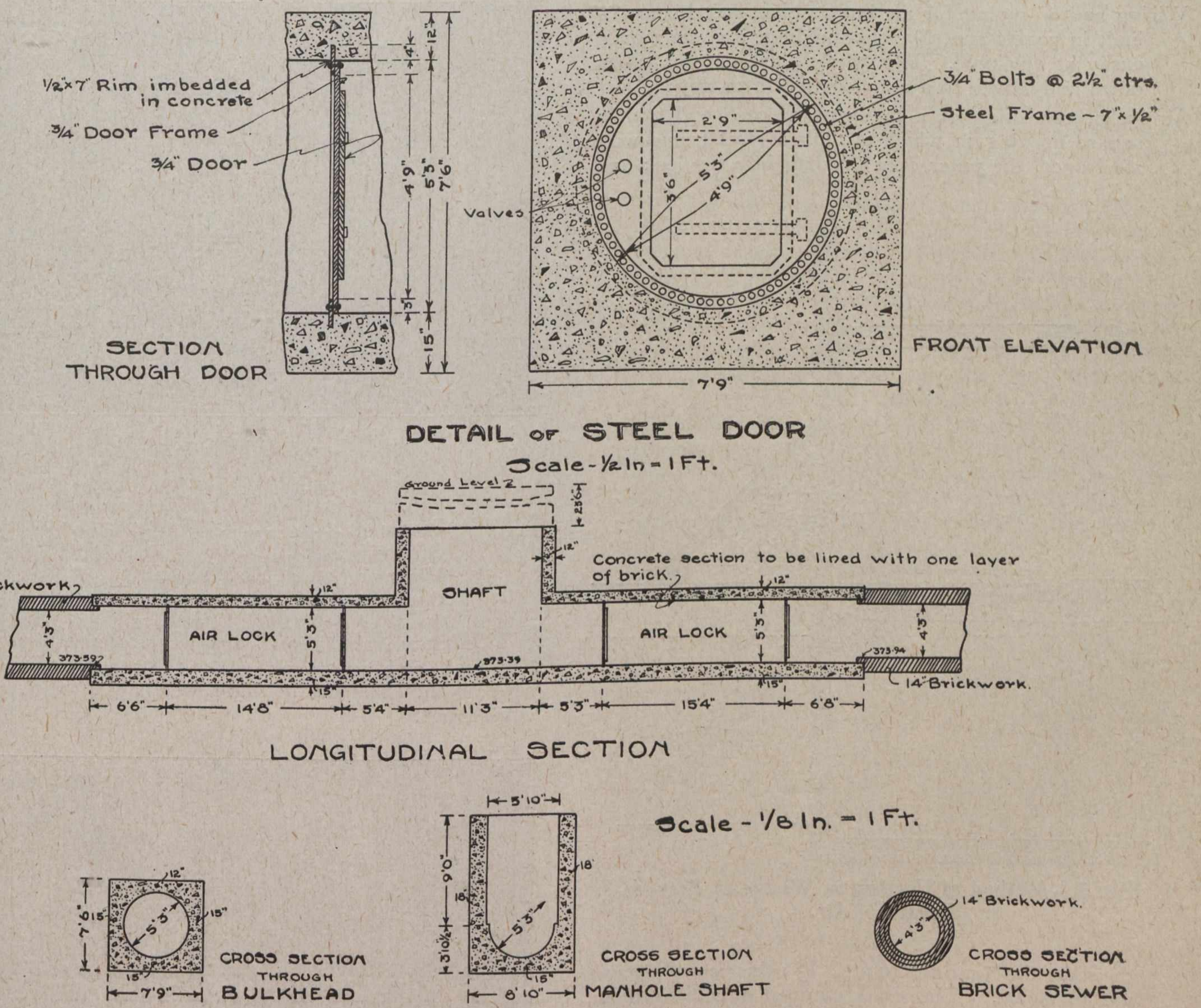


Fig. 3.—Details of Air Locks and Steel Door.

end. The bulkheads each contain a steel door and frame. The doors are fitted with rubber around the edge in order that they may fit tight against the frame when shut. Sometimes a steel cylinder is used for a lock. This only requires a bulkhead at one end (Fig. 4). Generally enough sewer is built in open cut to contain the locks—60 to 70 ft. But sometimes this portion is constructed in tunnel, which is probably cheaper to begin with, but the work is never so tight and it is difficult to maintain the necessary air pressure. When the locks are built in open cut, the ground is all filled in again except the space left for a shaft between the two locks, if two are built. A concrete or brick lining is then erected in this shaft for about 10 ft. above the future sewer or above the possible water line.

its possible escape will be comparatively small. Air pumps of 500 cu. ft. capacity will be sufficient. If an air pressure of less than 20 lbs. is required, motors of 40 h.p. are quite sufficient to operate the pumps. Where a larger pressure is required, larger pumps are necessary. In several cases where large sewers were built in Toronto, pumps of 900 to 1,000 cu. ft. capacity were used and these required motors of 50 to 75 h.p. to operate them. The horse-power depends on the load to be carried.

The following is a table of material and costs of a 1,500 cu. ft. capacity plant consisting of two units of 750 cu. ft. capacity each. This table was kindly furnished by Messrs. Jennings and Ross, who are contractors for a trunk sewer on West Toronto Street.

Two Bury (Erie, Pa.) compressed air pumps, 16″ x 10″, 180 r.p.m., which will give up to 20 lbs. air pressure.

Two Westinghouse motors, 50 h.p., 720 r.p.m.

Two leather belts, 9″ and 10″, 15′ 3″ between shafts of pumps and motors.

Two 8′ x 8′ x 3′ 6″ concrete beds of about 1 to 12 mixture.

Four 8″ x 8″ x 16′ timbers.

One tank for cooling and muffler, 6′x16′, tested to 135 lbs.

One building, 24′ x 30′, for housing plant. This is built in sections and may be easily taken apart and set up in any location.

Wiring and 6″ piping for air lines. (The switchboard is built in panels and, like the building, may be moved easily at any time. This whole plant may be taken down and moved to a new location in 10 days.)

Air locks, consisting of a bulkhead at each end with a square opening in which is built a steel frame with steel door, the outer door opening into the lock and

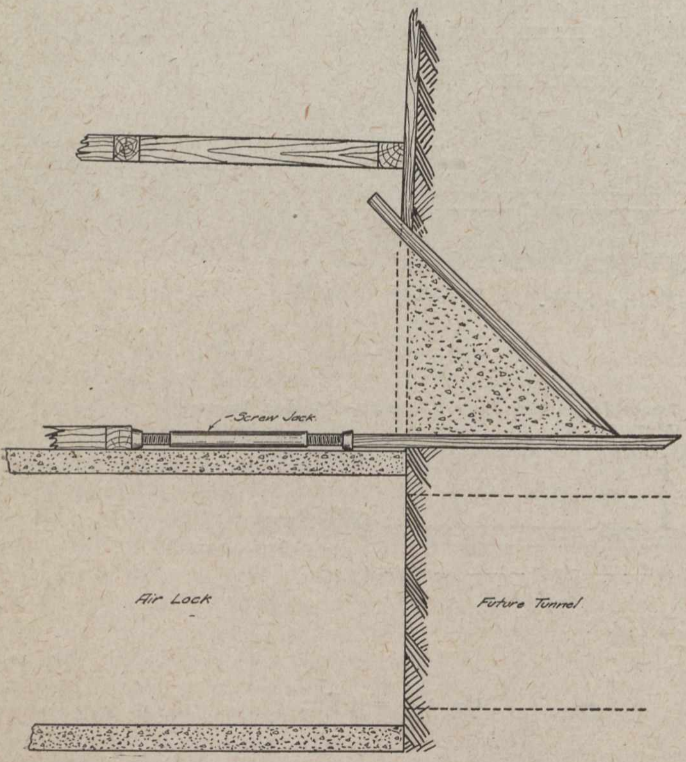


Fig. 5.—Method of Forcing in Wedge to Prevent Escape of Air.

the inner door into the tunnel. (In this case the gates are 16′ apart. The air is pumped directly into the tunnel. Valves are placed through both bulkheads. When a man wishes to go into the tunnel, he walks into the lock and closes the outer door. Then he opens the inner valve which allows the air from the tunnel to escape into the lock, making the pressure in the lock gradually as great as that in the tunnel. He then opens the inner door and proceeds into the tunnel. On coming out, he closes the inner door and opens the outer valve, allowing the air in the lock to escape into the outer atmosphere till the pressure becomes normal.)

The costs of the plant, installation and operation are as follows:—

Cost of Plant.

2 compressors	$3,000
2 motors	1,300
1 tank	225
2 belts	200
Concrete beds	100
Timbers	10
Building	200

Cost of installing above plant, including wiring and piping, $330.

Gates	$ 395
Valves	100

Cost of installing gates and valves, $112.

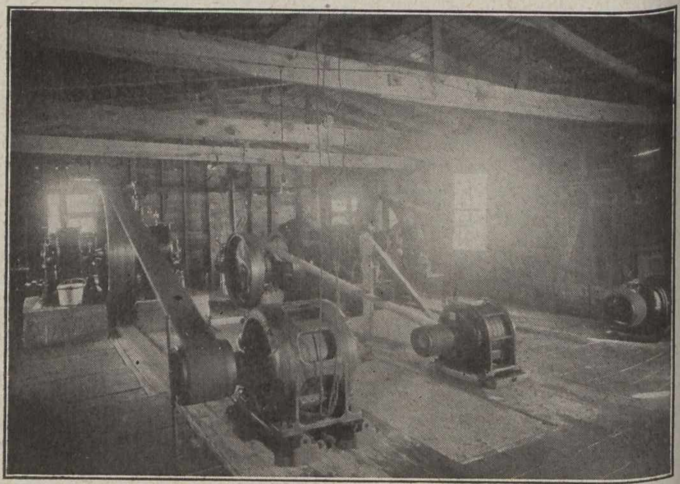


Fig. 6.—Compressed Air Plant.

Maintenance.

Power	$360 per month
Oil and waste	20 " "
Wear and tear	20 " "
Operation	350 " "

On an average, 500 ft. of sewer are built per month; therefore, compressed air costs $1.50 for each foot of sewer built. The size of this sewer is 3′ 4″ x 5′, 3-ring, egg-shaped.

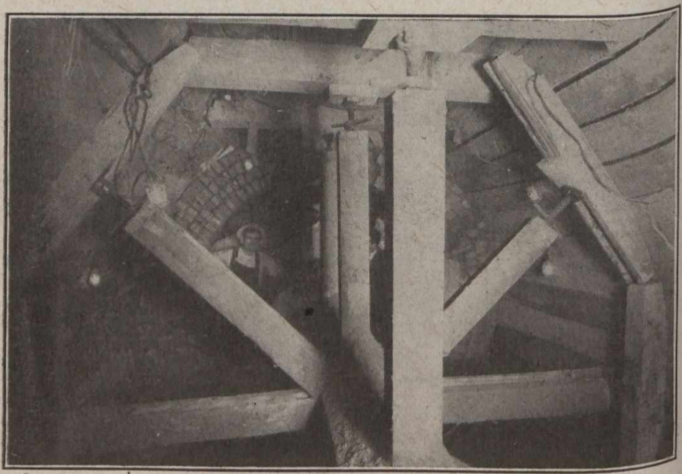


Fig. 7.—Needle-beam Method of Supporting Sheeting.

The following is the cost of a 2,000 cu. ft. capacity plant at present being used by Messrs. Fussell and McReynolds on St. Clair Avenue, to whom we are indebted for this information.

Two Bury air compressors each 1,000 cu. ft. capacity, 16″ x 10″, 185 r.p.m., will give 30 lbs. pressure.

Two Westinghouse motors, 50 h.p., 720 r.p.m.

Two leather belts, 11″, 2-ply, 15′ 3″ between shafts of motors and pumps.

Two concrete beds for pumps, 1 to 12 mixture, 7′ 9″ x 8′ 10″ x 4′.

Three concrete beds for motors, 1 to 12 mixture, 4′x6′x3′.

Four timbers to keep spacing between motors and pumps. These timbers are at ground level and between the beds; size, 8″ x 8″ x 16′.

One building, 24′ x 30′, in panels to make moving easy.

Wiring and 6″ piping for air line.

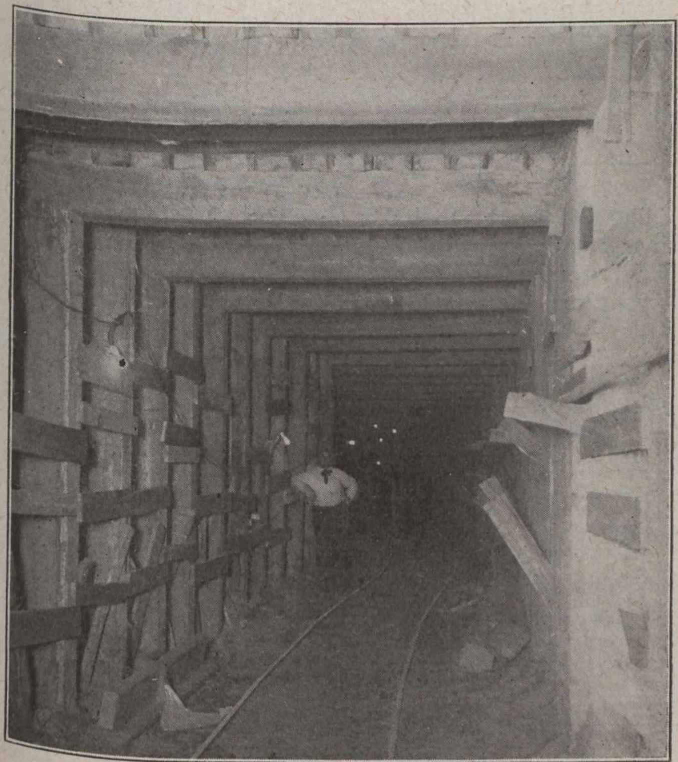


Fig. 8.—Cap and Leg Tunnel.

Cost of Plant.

2 compressors	$5,000.00
2 motors	1,300.00
2 belts	295.00
4 concrete beds	145.00
4 timbers	10.50
Building	225.00

The cost of installing the above plant, including piping and wiring, $330.

Gates	$ 400.00
Valves	100.00

Cost of installing gates and valves, including locks, $112.

Maintenance.

Power	$22.00 per day
Oil and waste	.90 " "
Repairs	.60 " "
Labor	11.00 " "

An average of 24 ft. is constructed here per day of 4′x6′, 3-ring, egg-shaped sewer. The cost for compressed air is, therefore, $1.45 per foot, not including interest on investment or depreciation.

When the work has progressed several hundred feet, it is generally advisable to move the locks nearer to the heading. When this is done a smaller volume of air is required and there is a smaller area for possible escape. Sometimes, if air is escaping rapidly, it has been found profitable to discontinue work for a day and pump in grout through the brickwork to seal the space between the brickwork and the sheeting over the arch. This will prevent the air from escaping from the heading back over the finished sewer to the shaft and thence to the surface. This is another reason why the shaft is lined with concrete above the future sewer.

The methods used for supporting the sheeting in compressed air are in many cases the same as those used in ordinary tunnel work with the exception that less and lighter timbering is required. These methods include the needle-beam method, the cap and leg method, the crutch method, the Christmas-tree method and other methods used when only very light sheeting is required.

The Needle-beam Method (Fig. 7).—To use this system the tunnel must be large and dry, or nearly so. (For a detailed description of this method see article in *The Canadian Engineer* for December 9th, 1915, on "The Keele Street Storm Overflow Sewer.")

Cap and Leg Method (Figs. 1 and 8).—This method is used in compressed air when the sewer is small (6 or 7 ft.) and when the sand is fine and has not enough clay mixed with it to give it the necessary consistency. The sand will cave in on the top or sides before sheeting can be placed to prevent it from doing so. The timber cannot be removed from the work and as the sewer increases in size the size of the timber also increases, thus increasing the cost of the work. The sheeting is driven just ahead of the excavation, the cap and legs being placed when the sheeting has been driven ahead of the previous set about 4 ft. The cap in this new set is placed low, and the next sheeting driven over it, the rear end of the sheeting being under the preceding cap, thus giving it always an upward

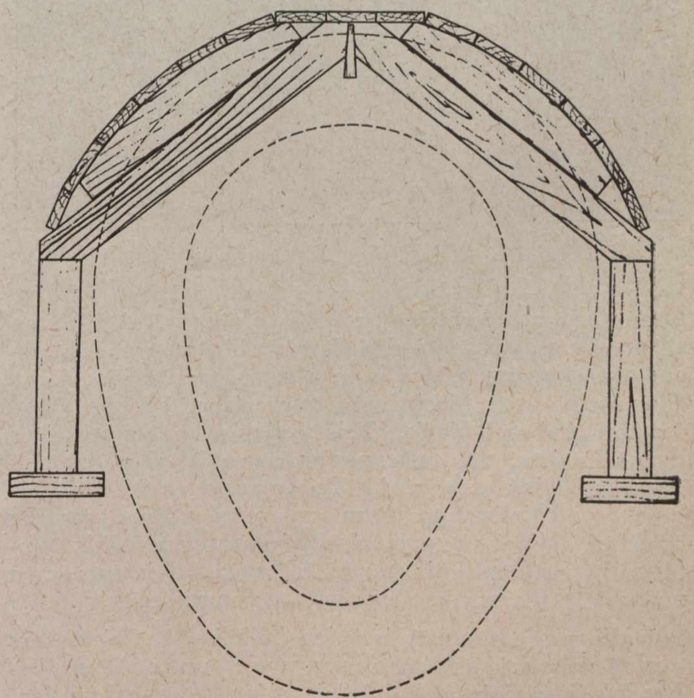


Fig. 9.—Crutch Method of Supporting Sheeting.

angle. When this set of sheeting is driven ahead its full length, a filler is placed between the sets over the cap, as shown in Fig. 1. The legs are cut on the slant, so that the cap always slants upward and the top sheeting, which is given an upward angle, rests evenly upon it.

The Crutch Method (Figs. 9 and 10).—This method is used when the ground is quite dry and only requires sheeting in the upper part of the excavation. A narrow drift is driven ahead for 5 ft. or 6 ft. in the centre of the future tunnel, the top being the top of the future tunnel. The crown planks are then placed in position, the front end resting in a deep groove made in the solid ground at the front end of the heading. Should the ground be considered too loose to temporarily support the weight of these planks, a screw-jack on a post, or some similar method, must be used for their temporary support. The drift is then widened on each side enough to allow one plank to be placed at a time. When the sheeting is all placed, a hole is excavated on each side, outside the future masonry, and from the springing line of the future sewer to near the invert. Short planks about 10″ x 10″ x 2″, or possibly bricks, are placed in the bottom of this hole to act as a sill, and a post 6″ x 6″ placed on the sill. The posts are long enough to reach to the springing line. Timbers 6″ x 6″ are then placed which form what is called a crutch. That is, they form two chords from the upper ends of the posts to the top and centre of the tunnel. Should these chords be not tight, a wedge is placed between them and forced in until they are tight. A filler the shape of a segment of a circle is placed between the chords and the sheeting, which is in a semi-circle. Should the filler not be used, blocks have to be placed between these crutches and each plank. This section of the tunnel being then complete, the same performance is repeated and another section excavated. This may be easily done, as there is no timber to form an obstruction under the crutches. When the apportioned length of tunnel is complete the bottom of the tunnel (about 2 ft.) is excavated and neatly shaped the shape of the future sewer.

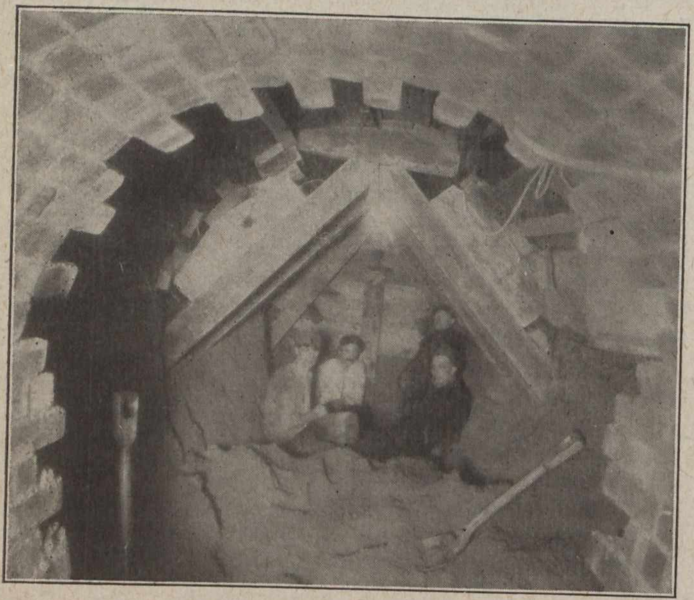


Fig. 10.—Example of Crutch Method.

When the masonry is being built by the bricklayers during the next shift, the lower portion up to the springing line is completed the full length of the excavation. Then the arch is built one drum (2½ ft.) at a time. When the work approaches one of the crutches the brickwork takes the support of the sheeting and the crutch is removed. And so the work proceeds to the last crutch, which is removed by the miners' next shift.

The Christmas-tree Method.—This method differs from the crutch method in that the full length of the shift (8 or 10 ft.) is excavated at once. It is used where clay and wet sand occur in layers, the bottom being dry and the wet sand not being in great enough quantity to require the cap and leg method. A narrow drift is driven ahead in the centre of the tunnel the full length of the shift and two or three crown planks placed in position. A segment is placed against them and a post on sills erected to support them. The drift is then widened as in the crutch method and the sheeting placed one plank at a time. A segment is placed against two or three of these and a spoke radiating from the post is placed to support them. This process is repeated until the sheeting is completed.

RESURFACING OLD MACADAM ROADS.*

ONE of the most important problems confronting road authorities to-day is the question of resurfacing or rehabilitating old stone roads. This condition in most cases is the result of neglect. Failure to make repairs or to restore the worn-out portions before a road has deteriorated through to the foundation necessitates the rebuilding of the road and a large expenditure; whereas, through skilled maintenance, the outlay can be reduced materially and spread over a period of years. There are, of course, other reasons for resurfacing old roads, as, for instance, the improper selection of the original material, which is responsible for rapid deterioration, and the constantly increasing and varied traffic, causing abrasive action too severe for the type of road. This latter condition is noticeable particularly in suburban communities and commmunties where water-bound macadam roads were laid in the early stages of development, and where the population has increased rapidly and where all classes of vehicular traffic have caused the original roadway to deteriorate more rapidly than would have been the case had the development not occurred, thus creating the necessity for repairing and resurfacing in order to make the wearing qualities of the road as good as those in the nearby cities.

The essential points to be considered in the selection of a proper type of surface for an old stone road are the character and amount of traffic, the grades, and, as a rule, that most important factor, the funds available for the work. When the traffic has been determined and the character of surfacing selected a thorough study should be made of the existing foundation and drainage facilities. Many surfaces have been sacrificed for the want of proper attention to the foundation, and too often it is taken for granted that any stone road is a suitable base for most any type of surface. Test-holes should be made at sufficient intervals in the road to determine the depth of the existing foundation, and usually it is found that a considerable portion must be restored before a surface can be applied. Irrespective of the type of surface selected, the preparation of the foundation must be given the same careful attention. Too much stress cannot be laid on the desirability of having proper lines and grades before resurfacing, in order to avoid increasing or perpetuating the difficulties of future improvement of these roads. The question of providing proper underdrainage must be considered, and drains installed where necessary.

Water-Bound Macadam.—The methods used in the preparation of the base for both water-bound and bituminous macadam are the same. If any holes or depressions are found in the base, the road should be dug out and replaced with good-sized clean stone, keyed with a smaller

*From paper before the Pan-American Road Congress, by William D. Uhler, Pennsylvania State Highway Department.

size and rolled with a ten-ton power roller until thoroughly compacted. The roadway should then be cleaned thoroughly and the existing surface broken or loosened with picks, harrows, or, if necessary, rollers equipped with spikes, so that the new material will bind properly with the old surface. Where the new surface is wider than the old base, or where, in improving the lines, it rests partly on the old surface and partly on the old shoulder, it is necessary to provide a new first course or base where an old one does not exist, in order to support properly the top layer or wearing surface.

After the base course has been finished, there should be laid a layer of properly graded, approved stone, passing a two and one-half inch mesh screen, and being retained on a one-inch mesh screen, this stone being known as "1½-inch." The stone should be spread upon the base course with shovels from piles along the side of the road or from a dumping-board, but in no case should the stone be dumped upon the first course surface. This layer should be rolled with a roller weighing not less than ten tons until it is compacted to a firm and even surface. The total thickness of the surface course should be not less than three or four inches after rolling. When a surface course of a depth of three inches is specified, it should be laid in one layer and a four-inch course should be laid in two layers of two inches each.

Should difficulty be experienced, while rolling, in getting the stone to compact thoroughly, sprinkling with water or spreading lightly with screenings will prove beneficial.

After the surface course of stone has been thoroughly rolled, screenings, varying in size from dust to ¾-inch, should be spread with shovels from piles along the side of the road or from dumping-boards, but, again, in no case should the screenings be dumped directly upon the surface of the stone. These screenings should then be thoroughly rolled with a ten-ton steam roller, additional dry screenings applied, and the rolling continued without the use of water until the interstices of the stones are filled. The road should then be sprinkled with water, rolled, additional screenings spread, and the sprinkling and rolling continued until the surface is well bonded and set. The rolling, in all cases, should begin at the sides and work toward the centre of the roadway, thoroughly covering the area with the rear wheels of the roller, and should be continued until the surface is hard and smooth and shows no perceptible tracks from vehicles passing over it.

To protect a water-bound macadam road from the ravages of automobile traffic it should be given a bituminous surface treatment of either approved tar or asphalt. Prior to applying this bituminous material, the surface of the road should be cleaned thoroughly by sweeping with machine and hand-brooms. After all the caked dust has been scraped off and the stone exposed uniformly over the surface, the bituminous material should be applied.

Bituminous Macadam.—In resurfacing with bituminous macadam, the base course should be prepared as for water-bound macadam, after which stone passing a two and one-half inch screen and retained on a one-inch screen should be spread upon the base course with shovels from piles along the side of the road or from a dumping-board to a depth of three inches after rolling. After the broken stone has been laid and placed true to line and grade and cross-section, it should be rolled with a roller weighing not less than ten tons until the stone has been thoroughly compacted and ceases to creep in front of the roller. When the rolling has been finished there should be spread evenly over the surface a quantity of approved bituminous binder, not less than 1½ nor more than 1¾ gallons to each square yard of surface area. The binder should be heated to the proper temperature for the material used. After the bituminous binder has been applied, there should be spread a layer of ¾-inch dry, crushed, approved stone, free from dust, and in such quantity as will just cover the surface and fill the surface voids. Rolling should be continued until the surface is thoroughly bonded; the surface then should be swept clean of all loose stone and an application of bituminous binder, of approximately one-half gallon to the square yard of surface area, applied evenly. This binder, in turn, should be covered immediately with a thin layer of dry stone chips, free from dust and rolled lightly. The quantity of chips should be just sufficient to absorb the excess of bituminous material remaining on the surface and to prevent the existence on the surface of an excess of binder.

Bituminous concrete and sheet asphalt pavements should be laid on a concrete base, instead of on the old existing macadam foundation, which, heretofore, has been the generally accepted practice for country roads. In view of the increased amount and change in character of traffic, even though slightly more expensive, it is advisable to provide for either a four-inch or a five-inch concrete base on top of the broken stone or telford base, due to the tendency of macadam to shift or to consolidate further under traffic and possible sub-grade trouble, all of which tend to bring about a wavy or uneven condition of the surface.

In the resurfacing of water-bound macadam it is frequently the case that the engineer in charge of the work allows too small a stone to be used, which, it is true, will require decidedly less rolling, but will not stand the motor traffic of to-day.

Another fault quite often found is the spreading of screenings before the one and one-half inch stone is thoroughly locked, and very frequently using too large quantities of screenings, thereby causing a heavy crust to form on the road surface.

The success of the bituminous treatment of water-bound macadam roads depends entirely upon the cleanliness of the road before the application of the material. Many failures are due to the lack of proper care in this most important detail. In cleaning the surface of the road the sweeping should be windrowed along the edges of the wearing surface, in order to prevent the running off of the bituminous material, which later should be swept back on the road. Special attention should also be given to the applying of the chips, just sufficient chips being used to prevent the traffic from picking up the bituminous material.

In bituminous macadam or penetration work no bituminous binder should be applied unless the stone surface is thoroughly dry, and the temperature of the air is 65 degrees or higher, and special attention paid to the heating and applying of the binder.

One of the important features in connection with obtaining the best results in bituminous concrete construction is the use in the wearing surface of good, hard, durable stone, free from dirt and decomposed material, as decomposed stone in the mixture will naturally develop weak spots in the pavement and ultimately result in failure.

The penetration of the asphaltic cement used in the mixture should be governed by the character of the traffic requirements.

As before stated, the success of all bituminous concrete and bituminous pavements is very largely dependent upon the rolling, and the best results can be obtained only by using a light roller for the initial compression and a heavier roller for the final compression, with an equal amount of transverse and longitudinal rolling.

In the laying of sheet asphalt or bituminous concrete, where brick gutters are used and adjacent to block runners along car tracks, it is good practice to lay the finished surface of the pavement from one-eighth to one-quarter of an inch higher than the brick gutters or runners. It is difficult in the rolling to secure final compression next to these blocks, and traffic will further compress that portion of the pavement, naturally causing the development of low spots, which hold water and result in deterioration.

Special attention should be paid also to the heating of the various aggregates entering into the pavement, and also of the combined mix, as many failures are caused by over-heating. No over-heated material should be used under any circumstances, as failure is bound to result.

WORKING AIR OUT OF PIPE LINE TESTED IN LONG SECTIONS.

By using a hand force pump to raise the test pressure to the required 250 lb. where necessary, loosening the high joints to permit the escape of air, and providing heavy end bracing and clamps to take the thrust of ½-mile sections under test pressure, an 8-in. steel pipe line about 8½ miles long was quite recently tested satisfactorily, according to R. C. Hardman in *Engineering Record.*

The specifications provided for testing the line to a pressure of 250 lb. per square inch before backfilling the trench. Part of the line received normally more than this pressure when the discharge end of the line was closed, but, as no valve was provided at the reservoir, static pressure could not be obtained in operation. Where the pressure exceeded the required amount the pipe was simply capped and the line examined. Where the pressure was less than 250 lb. it was raised to that figure.

The tests were made about every half mile immediately upon the completion of that amount of pipe-laying. A small hand-operated boiler testing pump was used for the purpose, although some doubt was had as to whether it would be feasible for increasing the pressure in such a long length of line—about 2½ miles being the longest section tested. In preparing for the test a cast-iron cap fitted to the end of the pipe and tapped to receive the discharge of the test pump was securely fastened to the last section of pipe. This was accomplished by means of a steel bar over the casting, through which bolts were passed, the bolts in turn being fastened at their opposite ends to a steel clamp which bolted around the pipe. Water-tightness was secured by means of a rubber gasket between casting and pipe end. As the pressure tending to force the casting off the pipe and to disjoint the line was about 12,500 lb., a system of timber bracing was employed. At the first test, which was at a creek crossing, the pipe was braced against the opposite bank so effectively that the line was buckled completely out of the trench, the last joint being broken.

As the line followed the contour of the ground there were many high points in which air collected. The procedure in making the tests was to cap and brace the lower end, loosen all high joints to allow escape of all air and close the valve in line at the intake. Water was then hauled in barrels for the operation of the pump. The time consumed in reaching the desired pressure was not uniform throughout the series, varying from two to six or seven hours for four laborers working in ½-hour shifts of two men each. The variation in time was due to the amount of additional pressure necessary and to the care with which the accumulated air had been released. At times when it was thought that the air had been carefully attended to no headway would be made by the pump, a more careful inspection always revealing the fact that some air still remained in the line. In fact, to increase pressure in this way it is absolutely essential that all air be removed.

FOURTEENTH ANNUAL MEETING OF THE ONTARIO GOOD ROADS ASSOCIATION.

Greater interest seemed to be taken in the meetings of the Ontario Good Roads Association this year than heretofore, nearly every municipality affiliated with the association was represented at the convention. S. L. Squire, of Waterford, was again elected president of the association.

The practical side of road building claimed more attention than usual this year, and the subject of financing good roads was also given its share of the program. Among the technical papers presented to the convention was a paper by Lucius Allen, county engineer of Hastings, on "When is Crushed Stone Profitable?" In it he described the various uses of stone, its adaptability to certain locations and conditions, and methods of good construction, dealing at some length on rolling the surface. Mr. Allen stated that a well-drained stone road with a surface impervious to water was equal to any type of modern construction. "When is Concrete Paving Possible?" was the subject dealt with by H. S. Van Scoyoc, chief engineer of the Toronto and Hamilton highway. Mr. Van Scoyoc stated that concrete roads are most profitable when they give better value per dollar of expenditure than any other type of satisfactory surfacing material. While improved roads create values that cannot be measured in dollars and cents, a commercial standard is the one most readily set up. More care should be taken in the preliminary work as the initial cost of concrete highways justifies more careful grading and drainage work than when a less permanent type of construction is used. The speaker stated that as concrete roads are a comparatively new type their lasting qualities were not definitely known. At any rate it is safe to assume that after, say, 20 years of service the concrete road can be used for sub-base purposes.

E. A. James, engineer for York County Highways Commission, gave an address on "When is Bituminous or Other Paving Profitable?"

Numerous resolutions were drawn up and will be presented to the government. Most of them dealt with the cost of road building material.

The following officers were elected: S. L. Squire, Waterford, president; honorary presidents, N. Vermilyea, Belleville, and J. A. Sanderson, Oxford Station; 1st vice-president, C. R. Wheelock, Orangeville; 2nd vice-president, J. J. Parsons, Haldimand; secretary-treasurer, Geo. S. Henry, M.P.P.; directors, W. H. Pugsley, York; Major Kennedy, Peel; L. E. Allen, Hastings; F. A. Senecal, Prescott; David Clow, Leeds, and K. W. McKay, St. Thomas.

THE ADMINISTRATION OF A COUNTY ROAD SYSTEM.*

By G. Cameron Parker, B.A.Sc.

THE Council is the main executive body administering the affairs of the county; from its members are appointed various committees, each dealing especially with its branch of the work. The committee having charge of the improvement of highways is usually known as the Roads and Bridges Committee, and to this body the County Road Superintendent is directly responsible. The council usually lays down a programme covering the season's work, but any modification of this is authorized by the Roads and Bridges Committee.

It is essential, therefore, that the greatest co-operation exist between the superintendent and the committee, and the smaller the committee, the greater will be the despatch with which the work is conducted. It is impossible to call a large committee together on short notice, and, as the value of a committee depends to a great extent on its ability to meet and consider matters without delay, a small road committee is strongly advised as against the procedure in some counties of placing the whole council on the committee.

The success attained by a county road organization depends almost entirely on the knowledge and executive ability of the superintendent. He must, therefore, not only be a practical road builder, familiar with the work in all its phases, but he must possess business acumen in order to direct the general work or the organization.

The experience necessary to develop these qualities is not gained in a year, and herein lies the great disadvantage of changing the road superintendent from year to year, as is the custom in some counties. It takes a year or more to acquire a thorough knowledge of a county road system and to become familiar with local conditions, and this experience is gained at the expense of the county. Every time a new man assumes the office of superintendent this expense is repeated, at a loss to the municipality. We do not find private corporations changing their executive heads every twelve months. Once a suitable man has been placed in a position they make every endeavor to retain him, realizing that he is becoming more valuable every year. Why, then, should not municipalities practise the same economies that are laid down as basic priciples in other corporatons, and, securing a capable superintendent, make him feel that the position is his as long as he conducts the affairs of the road organization in a satisfactory manner. No man will take the same interest in, or put the same energy into his work, if he feels that his term expires with the present council that he would if he knew that the success or failure of "Good Roads" in his county depended on him, and that he was not only to plan for this year, but for those to follow. He will then consider road-building as his profession, and the best results are obtained when a man is working along one line, with a clearly defined object in view.

When appointed, the superintendent should make it a point to become familiar with the history of the county roads. Where the system has been in existence for only a few years this is not difficult. If the roads are not covered with snow he should cover every mile, paying special attention to present and future traffic requirements and the condition of the districts through which the roads run. The work done by the townships prior to the introduction of the system and by the counties since that time should be located and work necessary for repairs and maintenance made note of. As the appointment to the office of superintendent usually takes place early in the year, there follow several months during which this and a great deal of other valuable preparatory work may be done.

Special attention should be paid to drainage at this time. When the water is lying on the ground and in the side ditches it is much easier to determine what is necessary to provide drainage than when it has dried up.

This is the time also to have the machinery repaired and put in first-class condition. Delays on the work cost money, and they should be avoided as much as possible by a thorough overhauling of the equipment, making any repairs that are necessary at the time, or which may avoid breakdowns later in the season. While all machinery should be attended to, special care should be taken with the roller and quarrying equipment. Once work has commenced these are operated for ten hours a day, six days of the week, and there are too many delays owing to bad weather without adding to them by the neglect of the equipment.

Provision can also be made at this time for the housing of the machinery during the following winter. If sheds have not been erected they can be built before the men are needed on the road. Every day that is taken in moving an outfit from one job to another expense is going on and no results are obtained, apart from delays in the work. In counties owning several outfits the sheds should be built at the centres of the districts served. A framework of stout studding, covered with corrugated iron, will afford ample protection, but care should be taken to provide for wind stresses and snow loads on the roof.

If new equipment is to be purchased the superintendent should make himself familiar with all the types and makes on the market, and after giving the matter serious consideration and gathering the experience of others, he should decide on the type of machines desired and make an effort to have the council procure them, The council, on the other hand, should realize that the superintendent is in a better position to know the machinery he wants to work with and should be governed by his recommendations,

The spring is the "open season" for the grading machine. At no time during the year can it be used to such advantage as when the ground is soft and workable. A dollar spent in grading at this time will secure better results than twice the amount spent when the ground is hard and has to be broken into lumps and again compacted by traffic, and the work is not so discouraging to men and horses nor so wearing on the machine.

The grading gangs should be the first part of the organization to receive attention, and care should be taken to see that the man who is to operate the grader understands the work thoroughly. He may have used the machine and yet be unfamiliar with the minor details. He should be watched closely from the start and advised from time to time where his work can be improved. Failing to get one with experience, a man should be hired who lives nearby. He should not be overburdened with instructions at first, but taught the general principles and his faults corrected. In this way he will feel that he is improving from day to day and take a greater interest in the work.

*Read before the Conference on Road Construction, Ontario Department of Highways.

All the earth roads on the system should be gone over with the grader, leaving only the fine grading to be done where construction is to take place later on.

The draining of the roads should accompany the grading, and for the same reasons. The side ditches should be cut or cleaned out and brought to grade; the outlets should be opened, and cross and side culverts inspected and cleaned where necessary.

The roller should be put in operation on the roads already built as soon as the subgrade is sufficiently solid to support the load. The construction work done during the previous fall should be gone over and the tendency to rut and ravel reduced by several trips of the roller. In many cases where ruts have formed or pot-holes started a few shovelfuls of 1-inch stone will put the road in condition without the use of the roller. When the surface is moist and the spring rains are on the traffic will quickly compact the small stone. When not used on repair work the roller should be sent over the roads as much as possible. As said before, macadam sometimes will break up on the surface during the second year, owing, perhaps, to not receiving sufficient rolling in the hurry and rush of the construction season. This can be made up for by getting the roller at work early and keeping it on the road till frost sets in.

As soon as time permits attention should be paid to the materials that are to be used during the season. The life and service of the roads depend on the quality of the materials used in construction, consequently a wise choice is necessary. If local material is to be used the deposits should be inspected, provision made for removing the water and the most economical method of working them decided upon. In this connection I might say that I have noticed a tendency in some counties to use the inferior material near the surface rather than go to the trouble and expense of going deeper and securing better stone or gravel.

Limestone deposits in particular usually yield tougher and harder stone at a depth of from six feet down than they do above that level, and in most cases the first two or three feet consist of shaly layers that, while easy to take out, make very poor macadam.

Roads built of materials from quarries or gravel pits that have been worked should be inspected and the traffic which they carry determined as closely as possible. The service to be expected from the material and the desirability of using it can then be decided.

Where there is doubt as to the desirability of using domestic materials rather than importing them, if application is made to the Department a survey of the deposits in the county will be made, tests conducted, and a report furnished to the superintendent, with advice as to the best material to use.

In counties where stone has to be imported or purchased from commercial quarries the superintendent should have specifications drawn up for him and call for tenders based on these specifications. The specifications should lay down the quality of stone required, as shown by laboratory tests, and the contractor should understand this, and know that his material was liable to be sampled at any time. Only in this way can the superintendent be sure of getting what he is paying for, and in the event of a dispute with the party furnishing the stone the specifications showing the requirements in black and white will form a basis of adjustment where it is necessary.

The specifications for stone as now used usually state that "It shall be a hard, blue limestone, free from dirt, etc.", and that "It shall be subject to the approval of the superintendent." These are right as far as they go, but often out of consideration for the contractor or in a desire to get the work finished the superintendent is inclined to be lenient in his decison. With proper specifications he is not put to the necessity of straining his conscience and the contractor is not so apt to furnish inferior material, trusting to his ability as a salesman to persuade the superintendent to accept it.

As in other matters pertaining to their organizations, superintendents will, upon making application, receive such assistance as they desire from the Department in the preparation of specifications and the selection of materials. In the event of the adoption of specifications not prepared by the Department they should be submitted for approval before proceeding with the awarding of contracts.

The actual road construction should commence as soon as it is practicable to haul materials. The construction gangs should be organized, and on the care with which this is done the smoothness of operation of the outfits during the whole season depends. For the position of foreman preference should be given to a local man, provided he is capable. Needless to say, a man with previous experience in road-building, or failing this, a man who can handle men well should be the first choice. He should have the selection and hiring of the men for the gang with the exception of the roller engineer. The man for this job should be hired by the superintendent only after consideration of his energy, ability and character. A roller engineer who has periodical "wet" spells in the neighboring town is no man for the job no matter what his qualifications are. Throughout the whole construction force the men should be kept at the same work as long as it lasts. The "breaking in" of men to new jobs involves a loss in money as well as in the quality of work. From the beginning till the end of the season each man should know his particular work and should be kept at it.

Where roads are built by contract the superintendent should have an inspector on each job, who should be furnished with a copy of the specifications and be instructed to promptly report any unauthorized departure from them on the part of the contractor. No matter how carefully specifications are drawn up there are always unforeseen conditions arising where they may be modified. Sometimes this is to the advantage of the contractor and sometimes it will be to the advantage of the county. There should, therefore, be a feeling of co-operation between the superintendent and contractor and a certain amount of give-and-take. Good and satisfactory work can never result when the two parties to a contract are at loggerheads.

The clerical work in connection with a county road system presents a big problem to the superintendent, and where there are a number of outfits working in widely separated parts of the county most, if not all, of his time is spent on the road. He should have someone in the office to look after the accounts when they come in and distribute the items under their proper headings. In this connection it might be said that attention should be paid to see that the maintenance charges do not creep into the construction accounts, and vice versa.

With little additional labor a unit cost system can be developed which will show the cost of the various individual items during the time covered by the pay-sheet. By closely watching these costs the superintendent can keep a check on the different gangs and alter methods and institute economies wherever necessary.

The contractor considers a unit cost system his most valuable asset. He watches this from day to day in order that he may stop losses on any of the small operations before they reach large proportions and keeps an eye on his equipment and sees that repairs are made promptly with the least delay.

There is no reason why the same principles should not govern the work in a municipal organization. The dollar is of the same value to the county as to the contractor, and it is the duty of the superintendent to see that he makes it do as much. To many the term "Efficiency" represents an ideal condition striven for by many but reached by few. In its plain meaning, where the expenditure of money is involved, it is the ratio between the value of results obtained from a certain piece of work and the amount expended on it.

WATER USERS' COMMUNITY PLAN OF CO-OPERATION IN BRITISH COLUMBIA.

THE following statements respecting recent water legislation in British Columbia are from an address by William Young, Provincial Comptroller of Water Rights, given before the recent convention at Bassano, Alberta, of the Western Canada Irrigation Association. The reader's attention is called to *The Canadian Engineer* for December 3rd, 1914, in which an article by Mr. Young appears, dealing with the changes that had been made from time to time up to that year in the water laws of the province and to the changes that were necessary to permit of effective administration. The following remarks refer to how the Water Users' Community legislation was adopted. We necessarily omit the various sections* of the Water Act given in Mr. Young's paper, but would refer to it those in other provinces desirous of community legislation of a similar nature:—

In speaking of the Water Users' Community legislation of British Columbia, reference must be made to the irrigation Corporation. The latter was in a measure the direct outcome of a resolution of the Western Canada Irrigation Convention, held at Kelowna, B.C., in 1912. The Irrigation Corporation Bill was accordingly prepared for the legislature session of 1913, but did not become law because it was pointed out that there were features which should be reconsidered; and it stood over until the session of 1914. This not only gave ample time to redraft it, but an irrigation season in which to administer under such amendments as had been made to the Water Act. The administration of water during that season (1913) revealed many defects, chief of these being the necessity for provisions that would make possible the enforcement of beneficial use, and also for provisions that would permit of co-operation in various other ways. These defects were remedied in the session of 1914, and the Province has now its particular laws on irrigation and the water bailiff, and on co-operation in the Irrigation Corporation, the Land and Water Company, the Mutual Water Company and the Water Users' Community.

*See Section 160 of Part VII. and Section 125 of Part VI. of the Water Act, British Columbia Statutes, 1914, for clause relating to the Water Users' Community, Irrigation and the Water Bailiff, respectively.

The Irrigation Corporation is familiar to many. The Land and Water Company provision replaces an imperfect law in respect of irrigation companies. Under this law it is no longer possible for the land promoters to incorporate first as a land company and then as a water company. They must now in their procedure outline a plan for the organization of a company for the benefit of the prospective purchasers of the subdivided lands, to be known as the Settlers' Association, and must further set out the proposed form and terms of the water clauses to be incorporated in all contracts for the sale of their lands. The Mutual Water Company provides that owners of land who are water licensees may organize a company with particular powers which will permit of the construction of joint works for conveying purposes. The Water Users' Community simply provides for a partnership of licensees in the construction, maintenance or operation of works. This is the subject of the address.

The Water Users' Community is of basic importance for the reason that where, as yet, in places the settlements comprise but a few farms, it permits of inexpensive but safe organization that later on may develop into one of the larger organizations mentioned. The law has supplied a long-felt need that was promptly taken advantage of in several valleys.

The feature that is new about the Water Users' Community is the fact that by following the instructions as set out in the water Act the members can avoid being **individually responsible** for all the acts of the Community. It was at any time possible for several licensees to co-operate under the "Partnership Act" as a "limited partnership." In this form of partnership, however, only the liability of the "special partners" is limited, the "general partners" being jointly liable for all debts and obligations of the firm, and severally liable for certain acts. Now, even though it was possible by means of this act and a series of agreements to co-operate with limited liability, it meant a procedure, not only expensive and complicated, but most uncertain. No attempts were, therefore, made to organize until co-partnership was fitted into the Water Act under the title of the "Water Users' Community."

Whenever a Water Users' Community is contemplated, attention is drawn to the sections in the Water Act in respect of irrigation and the Water Bailiff, as ultimate success largely, if not wholly, depends thereon. "In fact," states Mr. Young, "if we have had any measure of success in the administration of irrigation, it is quite as much due to these sections as anything."

To the Water Users' Community the sections on irrigation are tbe basis of any system of rotation agreed upon. In perhaps the fewest words possible the very essentials of successful irrigation are brought home to each member. In respect of the section on the water bailiff, it might be said that the powers conferred on him are too great. It, however, depends entirely on the man who should be selected as having qualifications that particularly fit him for the work.

How this Form of Co-operation Works Out.—A prospective community, if left to itself, does not readily get together in agreement; different views are presented. The holder of the first record probably has been dragged through several of the courts in the defence of his water right and for a time has faced ruin. Being successful in his defence and having enjoyed some years of peace, he does not propose to be a party to anything that will jeopardize his rights. The holders of one of the later rights takes the stand that he is not always sure of a share of the water, and, since it is hard enough for him to get along, he wants to be certain that in becoming a member of the Water Users' Community he is not taking upon himself a liability that may mean the loss of everything he has. The result usually is a request that the Comptroller attend one of their meetings, when an effort is made to explain the several points provided in the Act and then answer any questions. The first record holder is told that membership in the community will not affect the status of his rights. The holder of the last record has explained to him the limited liability provision. Administration is also carefully explained, reference being made to the laws on irrigation and the duties and powers of the water bailiff, attention being directed to the fact that the water bailiff is under the direct supervision of the district water engineer. This is an important feature, for, should the partners fail to agree on a system of rotation in use of water, the engineer prepares the order and sets the dates.

Another point with the prospective community is whether or not it is necessary to employ a lawyer. The majority is usually not in favor of having the lawyer because of the expense, and to meet their wishes the Department prepared a form which comprises the Articles of Partnership, which have been made as simple as possible that those interested may understand them.

The first district to take advantage of these provisions was Heffley Creek Valley. It did not take the men of this Valley long to come to a decision; in fact, they were ready to go ahead before the law became effective in the Railway Belt. Here it was realized that only by means of organization and co-operation would contention cease. The Heffley Creek Water Users' Community has been, and is, a success. It comprises about twenty farms, which, together, have about 1,000 acres under irrigation. As a result of all parties doing their share an excellent reservoir has been developed. The provisions in respect of irrigation and the water bailiff have demonstrated that order and reasonable system works to the advantage of everyone. Several incidents that have happened show that the problems of conservation of water, alienation of water to another watershed, and the granting of new rights which are of vital interest to the Valley are more fully appreciated, and the secretary of the community is making it his business to see that these problems are properly considered by keeping in touch with the departmental officers. In the old days these same problems were the business of everyone, yet of no one in particular, with the result that no united action was taken.

In another district a community is in process of organization. In this case it was necessary that an agreement be entered into with two of the prior record-holders for the use of their ditch. For some reason or other the prospective members at one time reasoned that the agreement should be first entered into, then the community formed. Finally, they were advised to see a lawyer, who confirmed the advice of the department. The difficulty in this instance is the agreement. The record-holders did not fully appreciate their status and the powers of administration under the Act. Under these powers the administrators take the stand that it is not in the public interest to permit construction of parallel ditches, even on Crown land, where one ditch will serve the same purpose. These record-holders have been given to understand that they must fall in line, and that any system of rotation in use of water ordered will be enforced. As the same time they are assured that this will work no hardship, since any order of rotation gives first rights their due consideration.

Co-operation under the Water Users' Community is proving of some assistance to the administration. To illustrate this: a short time ago a landowner in the Heffley Creek Valley wrote, enquiring if he could secure a water right on Heffley Creek. He was advised to confer with the Heffley Creek Water Users' Community. Their answer being favorable, he wrote accordingly, which the Water Rights Branch confirmed by writing the secretary of the community. The result was that in due course a right was applied for. Had this man applied in the days prior to the organization of the community there is not the slightest doubt but that there would have been objections from all who already held rights. The applicant and the objectors would have employed lawyers. It would also have meant considerable investigation by the department before any decision could have been arrived at. All the expense, litigation and delay that these proceedings would mean was put to one side by the community itself in one brief letter to the Comptroller.

There is just this to say in conclusion, that if the Water Users' Community plan of co-operation is proving a benefit to those who have taken advantage of it, it is likewise proving of assistance to the water administration of British Columbia in satisfactorily disposing in some cases of what have been contentious districts.

SOME MINOR PROBLEMS IN A HIGHWAY BRIDGE DESIGN.*

By L. M. Hastings.

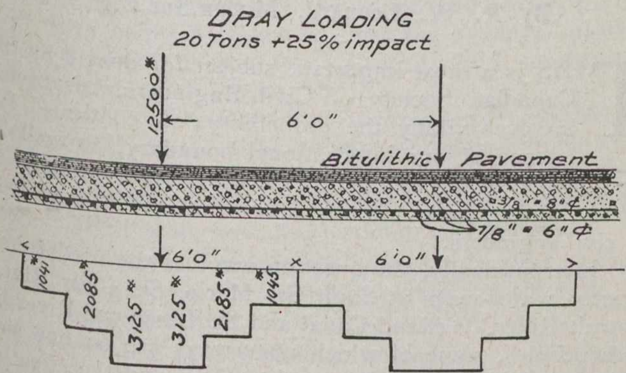
THE highway bridge at Walden Street, Cambridge, over the main line of the Fitchburg Division of the Boston and Maine Railroad, has a width of 42 ft. between sidewalk railings, and a length between abutment bearings of 61 ft. This bridge, as constructed in 1892, had two main steel plate girders with steel floor beams carrying the floor joists of hard pine. The floor was of 3-in. hard pine covered with 2-in. spruce. The sidewalks were carried on steel brackets.

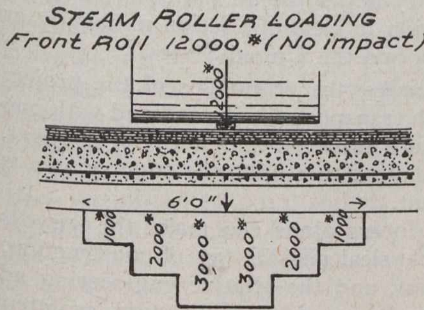
The railroad here has four tracks and is built on an ascending grade going west. The clearance between the rails and bottom chords of the bridge was only about 15 ft. 6 in. This brought the tops of the engine smokestacks very close to the lower members of the bridge, with consequent rapid loss of metal by the mechanical effect of the blast, besides the chemical action of the smoke and gases upon all exposed surfaces. Various means were tried to protect the more exposed portions of the steel members from these effects. A heavy coating of asphaltic paint, cement mortar held with expanded metal and heavy sheet lead, were tried with only indifferent success. Finally, the portions of the members exposed to the direct action of the blast from engines were covered with ⅞-in. plain oak sheathing, held firmly in place with iron clamps, the sheathing first being thickly covered on its upper side with a paste composed of red lead and Portland cement. This was found to work very well, the oak sheathing showing surprising resistance to the destructive action of the blast. Some pieces of oak taken from the bridge after ten or twelve

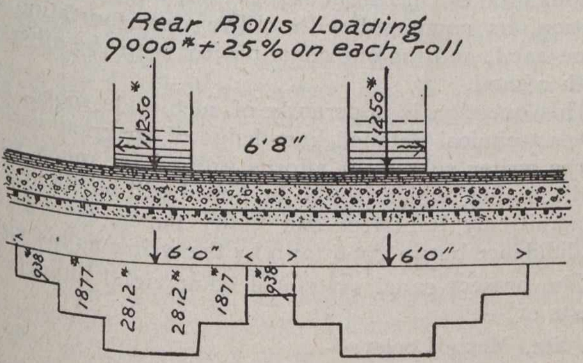
*Read before the Boston Society of Civil Engineers.

years' exposure showed a loss of not over ¼ in. in thickness.

The portions of the metal not so protected were, of course, exposed to the continued action of the smoke and gases, and continual repairs were necessary to keep







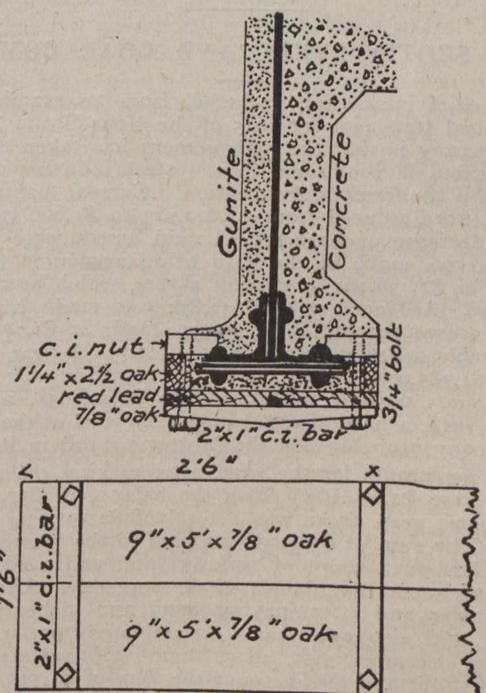
the bridge even fairly safe. The first cost of the bridge superstructure in 1892 was $3,063.80. The total cost of maintenance and repairs on the bridge from its erection to 1913 was $3,815.85. In 1913 the bridge had become so weakened that it was declared to be unsafe for travel, and in 1914 it was decided to build a new one in its place.

The new bridge is carried on three main plate girders, 63 ft. long and 42 ft. between centres of the two outer ones. The entire floor for roadways and sidewalks is of reinforced concrete slabs carried by steel beams so arranged that no slab shall be of more than eight feet span.

In designing the details of this bridge, two rather interesting problems were encountered. The first related to the distribution of the assumed concentrated live loads upon the floor slabs, from which the proper amount of steel reinforcement could be determined. The slab itself was assumed to be about 9 in. thick and to be covered with a bitulithic pavement about 4 in. thick. The usual live loading for that class of bridge was taken, namely, a four-wheeled dray weighing, loaded, 20 tons, with wheels 6 ft. apart and axles 12 ft. apart, or a steam roller weighing 15 tons with rolls 11 ft. apart, and with 20 per cent. additional for impact and vibration in computing stresses. No data as to the distribution of such loads on the floor slabs under these conditions being available, an empirical assumption had to be made. The conditions of loading producing maximum stress would be as shown on the accompanying diagrams. While it was clear that the slab had some degree of flexibility and must show deflection under loading, it was assumed that the concrete, bonded laterally by the cross reinforcing rods, would distribute the stresses over a considerable distance. After trying various assumptions for distributing the stresses, the one shown on the stress diagrams was finally adopted.

On the first, it was assumed that the load of 12,500 lbs. was carried equally by the reinforcement on either side of its point of application, and that the influence of one-half of this load, or 6,250 lbs., would be extended for a distance of three feet from its point of application in a diminishing amount, and that one-half of that amount, or 3,125 lbs., would be carried by reinforcement in the first foot, one-third, or 2,085 lbs., in the second foot, and one-sixth, or 1,045 lbs., in the third foot, making the entire load to be carried by the reinforcement in a strip of floor six feet wide.

In the second case, the front roll of the steam roller was considered. In this the entire load of 12,000 lbs. was assumed as applied at one point but without the 25 per cent. addition for impact, as it was thought that if impact was produced by the roll, as in passing over a stone, it could be only when the roll was returned to the surface, and the load was then automatically distributed by the roll itself. The flexible hanging of the front roll would also assist this distribution. The assumptions for



distribution were as before. The greatest load in this case would be 3,000 lbs. per foot.

In the third case, the rear rolls of the roller were considered, and the assumptions as to load distribution were the same as in the first case. The maximum loading in this case would be 2,812 lbs. per foot.

The loading used in determining the amount of reinforcement required was 3,125 lbs, per foot applied in the centre of the span.

Before the bridge was completed, the contractors for the paving rolled it with a fifteen-ton roller, passing it repeatedly back and forth over the bridge. The deflection was so small as to be unnoticeable.

The second problem related to the best method of covering the exposed sides of the two outer girders. They are seven feet high, and to cover them with cast concrete was difficult unless the covering was made rather thick. If the covering was cast thick enough to be practicable, the dead load was greatly increased. It was, therefore, proposed to use the "Cement Gun" and apply the covering only about two inches thick. When the bids were received, however, it was found that the price demanded for the use of this method was excessive, due to the unfavorable position of the surfaces to be treated over the constantly passing trains beneath. It was suggested that the "gunite" be applied to the girders at the shop after they were fabricated, and that then they might be shipped to the site on the cars. The contractors for the bridge finally adopted and carried out this plan with entire success. The two girders were given a covering of "gunite" in the yard of the shops and were transported on cars to the site and the bridge erected without starting a crack, so far as could be discovered. The "gunite" forms a dense, firm covering, which seems to adhere with great tenacity to even the smooth surfaces of steel plate.

Where the railroad tracks pass under any of the main or secondary members of the bridge, the bottom flanges are protected with the oak covering already described, and shown on the accompanying diagram. Twenty-four of these oak coverings, each five feet long, were used on the new bridge.

NOVA SCOTIA STEEL AND COAL COMPANY.

The chief impression gathered from an examination of the financial statement for 1915 of the Nova Scotia Steel and Coal Company is that the management has taken advantage of the favorable conditions in the steel industry materially to improve the company's position. Current liabilities, for example, were reduced from $2,622,723 to $1,866,378, a substantial decrease of $756,345. Liquid assets were increased by $3,000,000, much of the gain being accounted for by an increase of $2,238,284 in current assets, which now stand at $5,015,890. An increase of $633,874 was made also in the special reserve account, which now stands at $1,773,423. In bills payable a heavy reduction was made. A year ago, they totalled $1,785,000, and at the end of last year only $490,000. The accounts payable, amounting to $1,108,938, are double those of 1914, a natural development in view of the fact that the company probably has the largest payroll in its history.

The net profits for the year, after making the usual provisions, were $2,094,169. With the balance of $57,466, from the previous year, there was a total of $2,151,636 for distribution. The sum of $36,309 was paid to the trustees for the bondholders on account of sinking fund and used by them in retiring 5 per cent. bonds of the company. After making that transfer and after paying bond and debenture stock interest, and also one year's accumulated preference dividends to December 31st, 1915, there still remained at the credit of profit and loss account the sum of $1,510,609. This is a balance greater by $1,453,143 than that of a year ago. The statement is obviously the best in the company's history. It indicates that Colonel Cantley, the president, his directorate and staff have not allowed much to escape their notice during the past year.

The Nova Scotia Steel and Coal Company holds 51 per cent. of the stock of the Eastern Car Company. At the end of the fiscal year of the latter company it had an undivided balance of $250,455. Its profits since the end of its fiscal year have amounted to $230,000. This gives to the present time an undivided surplus of about $500,000. The company has recently closed an additional contract for 3,000 cars, to be completed in about five months' time.

ECONOMIC AND STRATEGIC ASPECTS OF ENLARGEMENT OF WELLAND CANAL AND OF CONSTRUCTION OF GEORGIAN BAY SHIP CANAL.*

By R. W. Leonard, M.Can.Soc.C.E.

THIS is a most important subject for debate by the Canadian Society of Civil Engineers, because it involves vitally the probability of continued existence of our international boundary, as well as the question of the economic expenditure of vast sums of money, and because it is a question that should be solved by civil engineers.

Internationally, the question involves the use of constricted water-ways at Sault Ste Marie, St. Clair River, Detroit River, Welland Canal and St. Lawrence River by both peoples, some of which waterways are on one side of the boundary and some on the other, and the effect of such a condition in case of friction unhappily arising between Canada and the United States.

Commercially, the economics of the projects can be compared with transportation by rail and with one another. The expenditure involved and where it is spent, and the effect of the expenditure upon the country as a whole, are most important.

Civil engineers alone can make the surveys and determine the physical possibilities of construction, the cost of construction, and the relative engineering advantages or disadvantages in the construction, maintenance and operation, as compared with railway transportation on the one hand, and the one canal project with the other on the other hand.

This question is apparently of such wide scope, and involves technical detailed knowledge of so great variety that the writer submits it affords ground for much valuable discussion, which it is to be hoped will be elicited by this admittedly imperfect and faulty paper, contributed with diffidence but in good faith by the writer as his view.

The present canal system of commercial importance consists of:—

Sault Ste. Marie Locks:—

1—on Canadian side 900′ x 60′ x 19′ draft } being
1—on U.S. side 600′ x 100′ x 14′ draft } operated.
1—on U.S. side 800′ x 100′ x 19′ draft }
1—on U.S. side 1,250′ x 80′ x 24½′ draft, opened October 21, 1914.
1—on U.S. side expected to be ready in 2 or 3 years.
Channels in U.S. territory below locks in Sault.
Channels in Canada and U.S. in St. Clair River.
Channels in Canada and U.S. in Detroit River.
Welland Canal, including 24 locks, 270′ x 45′ x 14′ draft.

St. Lawrence canal system, 26 locks, 270′ x 45′ x 14′ draft.

After the War of 1812 the British Government—recognizing the necessity of having a line of communication for military purposes away from the boundary—canalized the Ottawa River from Montreal to Ottawa, and the Rideau and Cataraqui Rivers from Ottawa to Kingston for barges drawing five feet of water at a cost of $3,911,700, which system they subsequently gave to Canada free of cost.

The Department of Railways and Canals has since nearly completed the Trent canal system from Trenton on

*Paper prepared in 1914, and presented in 1916 to the Canadian Society of Civil Engineers.

Lake Ontario to Georgian Bay, for barges drawing about five feet of water at a cost to date (1914) of $13,611,035, exclusive of interest.

These last two systems—however interesting to the summer tourist as canoe and yachting routes—are not of great economic or strategic importance under modern conditions.

The cost, maintenance, operation and repairs for the year 1913 being $309,822.65, and the tonnage passing through (mainly pleasure boats, cord wood, lumber and sand) amounted to 227,023 tons.

About 1904 the Dominion Government (Public Works Department) started a survey of the Ottawa-French River route for the purpose of arriving at the cost of a 22-ft. ship canal. The result is embodied in a very voluminous report, dated 1908, including estimates as follows:—

Total length of canal, 440 miles, 22 ft. deep, including: Free navigation, 346 miles; improved channels, 66 miles; excavated canal, 28 miles. Cost, $100,000,000.

The system is estimated to be capable of developing 1,000,000 h.p. on the direct canal route, and this estimate might probably be doubled by figuring the power developed in regulating the tributary streams.

It is significant that about the same time the Department of Railways and Canals commenced to make surveys to determine the possibility of enlarging the Welland Canal from the present 14-ft. draft to 30-ft. draft. These surveys were completed in 1913 and the parliamentary estimate for that year included $2,000,000 for the enlargement of the Welland Canal and $500,000 for canalizing the French River from Georgian Bay to Lake Nipissing.

The total estimate of the cost of enlarging the Welland Canal (26 miles) is reported to be $50,000,000, probably two-thirds of which is expended in the United States for fuel and machinery, and in various foreign countries in the form of wages sent home by laborers.

The lift of 325 ft. is overcome by 7 locks of 46.5 ft. lift, 800 ft. long x 80 ft. wide x 30 ft. draft.

The St. Lawrence canals enlargement has not been surveyed and no information is therefore available to indicate whether corresponding enlargement to suit that at the Welland Canal is physically possible at *any* cost of construction, and the people of Canada have not been informed of any treaty with the United States sanctioning such deepening of international waters with the probable construction of international dams, etc.

During 1913-14 contracts were let for the construction of about 10 miles of the Welland Ship Canal, including all the locks, at a cost of probably $35,000,000, and the work of excavation is possibly half done.

Internationally considered, this question is of supreme national importance, as involving such questions as national defence and the very possibility of holding Canada for the Empire.

In this connection, it must be borne in mind that New York State is enlarging the Erie Canal from Troy to Oswego and to Buffalo, from 6 or 7 ft. draft to 12 ft. with a lock length of 311 ft., and width of 45 ft., to accommodate barges of 1,500 tons capacity,* and these canals will open Lakes Ontario and Erie to formidable United States war vessels, giving them absolute control of these lakes at all times, unless Canada be supplied with similar transport facilities apart from the boundary waters of the St. Lawrence River from Kingston to Prescott.

The enlargement of the Welland Canal will also carry a great preponderance of large United States steel freighters into Lake Ontario, thus giving to that country an undisputed control of that lake.

Canada has enjoyed a century of peace with her powerful southern neighbor, and it is the wish of all good citizens to enjoy another one, even avoiding in the coming century such incidents as the "Trent Affair," the Fenian Raids, Venezuela messages and the Panama Canal question, and serious boundary disputes, fishery disputes, international water power questions, etc., to say nothing of United States Senate reports, 1889-1890 (Testimony of Joseph Nimmo, Jr.), etc. Such questions having arisen in the past, however, they will naturally arise in the future, and the peaceful settlement of them depends largely upon the temper and temptations at the time. So long as an international boundary is to be retained, so long should the policy of Canada be to preserve peace while safeguarding her honor and interests.

It is not apparent to the public that this canal problem (probably Canada's most expensive commercial project under construction) has been considered by the Canadian people from the national point of view, though pamphlets have been published *ad nauseam* by Boards of Trade of various municipalities treating the subject in a spirit of parochial politics, each exaggerating the advantages of one route and the disadvantages of the other, the very apparent incentive in each case being the expenditure of public money on construction in the immediate vicinity of the municipalities interested.

If the question be approached from a purely economic point of view, it is probable that freight (and grain from the prairies to the Atlantic seaboard in Canada is the most important commodity at present) can most cheaply be handled by rail from Winnipeg to Fort William and Port Arthur, by ship to Georgian Bay, and by rail over a direct line with easy gradients to Montreal, than by any canal at present built or proposed. On this route the C.P.R. has a double track from the West to Fort William; the G.T.P. and the C.N.R. have each a single track between the same points. There is a large fleet of United States steamers engaged in the coal, grain and ore trade on the lakes, and the Canadian fleet is growing rapidly. The C.P.R. has a line with easy gradients from Port McNicoll, on Georgian Bay, where it has built large grain elevators, to connect with its Toronto-Montreal line, with a view to carrying grain in competition with the canals, and they probably have estimates of comparative cost warranting the expenditure, even under the unequal conditions that the traffic by the railway must pay interest, depreciation and upkeep, while the government assumes these enormous sums in the case of the waterways, making the canals free to all ships alike, Canadian and foreign.

The people are educated to demand water transportation "to regulate rail freights," and to what extent a larger canal than the present 14-ft. Welland-St. Lawrence system will result in a reduction of rates is a question that can be figured in many different ways with varying results. Figures have been prepared by competent authorities showing that the maximum saving in freight on wheat from Fort William to Montreal by the enlargement of the Welland Canal will be 3/8c. per bushel, which will amount to $187,500 per year on 50,000,000 bushels—at a cost in interest on $50,000,000 of, say, $2,000,000 per year plus depreciation, upkeep and operation.

Return cargoes of coal are obtained in Lake Erie ports. Probably few will contend that 14 ft. draft ships are not economical for package freight from Lake Ontario or St. Lawrence points.

It will be of interest in this connection to have a report on the feasibility and cost from an engineering point

*Report of State Engineer and Surveyor, 1913.

of view of lengthening the existing locks on Welland and St. Lawrence canals 100 ft., and the economic results of such lengthening if it be practicable.

To analyze and compare the respective advantages and disadvantages of these two routes.

Assuming that the government enlarges the Welland Canal and proposes to canalize the French River to North Bay only:

The estimate for the enlargement of the Welland is generally stated to be $50,000,000; which amount at 4% interest, together with amortization, upkeep and supervision of the two existing canals and the proposed canal, may be estimated at another $1,000,000, or a total of $3,000,000 per year, which sum is probably under the mark unless all past experience in cost of government contracts be reversed.

Assuming the distance from Port McNicoll to Montreal to be 400 miles, and a paying freight rate to be four-tenths cents per ton-mile, or $1.60 per ton, or 5c. a bushel, then $3,000,000 per year would pay the rail freight from Georgian Bay to Montreal on 60,000,000 bushels, which is much greater than the amount of grain and flour shipped in the past from Montreal in any one year, and 50% greater than the greatest Canadian tonnage through the Welland Canal bound down in one year.

This enlargement of the Welland Canal will not materially increase the water power development, as that is regulated by international treaty and works out so that, though Canada owns two-thirds of the water flowing over Niagara Falls, she gets the use of only one-third of the power development therefrom, the United States getting two-thirds.

It is manifest that the only saving effected by enlarging the Welland will be that effected by the difference in freight rates between 2,000-ton ships from Port Colborne to Montreal *vs.* 8,000-ton ships from Port Colborne to Prescott, plus 2,000-ton ships from Prescott to Montreal, estimated above at ⅜c. per bushel on wheat.

Oswego is about 150 miles nearer (by Erie Canal) to Troy than is Buffalo, and, as the enlarged Welland Canal will be, by treaty, free to United States ships, their largest lake ships will deliver grain cargoes to 1,500-ton United States barges at Oswego, in the New York State Barge Canal for New York instead of into 200 or 300-ton barges at Buffalo as at present, and thus compete with large Canadian ships discharging into 2,000-ton barges at Prescott or Kingston for Montreal.

In the past the little Erie Canal boats taking grain from Buffalo to New York have been very keen competitors against the St. Lawrence route. What will be the result of the new conditions when in operation? It would appear that the expenditure on the proposed Welland Canal enlargement when completed will be quite as much to the advantage of the United States as to Canada, and during construction probably much more than half the cost goes to the United States for coal and machinery.

The canalization of the French River to North Bay to a depth of 22 ft., a distance of 82½ miles, is estimated to cost $14,275,000, and would develop 35,000 h.p.*

It could bring coal and coarse freight to North Bay for railway distribution, and return pulp-wood and probably ores from that district, and partially develop a lot of power for which there is probably no immediate market in sight, but the value of which will doubtless be very great in a few years, if we judge from the phenomenal increase in the use and value of hydro-electric power during the past 20 years. Probably this construction is warranted only in anticipation of the completion of the entire canal to Montreal.

Assuming that the appropriations in the estimates for the Welland and French River works are preliminary to the extension of each system through to Montreal:

The Welland-St. Lawrence system (unless an entirely new route inland to the north of the St. Lawrence can be found) passes through international waters from Kingston to Cornwall, and probably nothing can be done toward enlarging this portion without international agreement, including a natural demand by the United States for a share of the power development, (loosely estimated at 2,000,000 h.p. by some writers in the press).

Would the United States, having the free use of the enlarged Welland to carry their big ships to Oswego (the end of their Erie Canal) consent to the enlarging of the St. Lawrence system to divert the trade from Troy and New York to Montreal? What share of the expense would they bear? What share of the power developed would they demand?

Sufficient information is not available to indicate the nature or cost of such an enlargement of the St. Lawrence canals, to a depth of 22 ft.

In the case of the Ottawa-French River system, careful surveys and estimates have been made by the Public Works Department. The total length of the canal is 440 miles, of which 346 miles is free navigation, 66 miles in improved channels and 28 miles in excavated canal.* The cost is estimated at $100,000,000.*

The system is estimated to be capable of developing 1,000,000 h.p. on the direct route* and 3,000,000 h.p., including the tributaries† which probably within 20 years will (if carefully conserved and utilized by the nation) be worth from $20 to $100 per year per horse-power utilized over the cost of production from coal, depending upon the purpose for which it is used.

In the absence of authentic estimates and reports on the St. Lawrence route, it is impossible to compare the two routes as to practicability, cost, time of transit and economy of operation. It is not known whether the St. Lawrence enlargement is at all possible, due to international questions. If it be possible, then the two systems can be compared in regard to length and total height of locking only.

From Lake Superior to Montreal the Ottawa route is 661 miles long, and the total lockage up and down is 780 feet.

The Welland-St. Lawrence route is 943 miles long, and the total lockage is 578 feet.

Both routes pass through United States waters in the St. Mary River. The St. Lawrence route passes through contracted international waters at St. Clair River, Detroit River and St. Lawrence River.

The deepened Welland-St. Lawrence Canal would be found to have probably three times the length of actual excavated canal and about the same length of restricted river navigation, as compared with the Ottawa route.

Much has been written about fogs, rock-excavated channels and sharp curves on the Ottawa route. Any Canadian knows that the St. Lawrence probably suffers quite as much as the Ottawa from fogs. About half of the existing Welland Canal is in rock excavation and the new canal will not have less. It is not known how much of such channels the proposed St. Lawrence enlargement will include. The Ottawa route has sharp curves, so has

*Report of Government Engineers, 1908.

*Report of Government Engineers, 1908.
†Estimate of Government Engineers, 1908.

the Thames below London, and it is not known what curves will be required on the proposed St. Lawrence enlargement. There are, however, sharp curves in swift currents in St. Mary River at Neebish and other points.

Without surveys, the distances through restricted waters cannot be compared and therefore neither the time necessary to pass through, nor the dangers of navigation.

The St. Lawrence route is known to be longer and will demand greater fuel consumption per ton of freight, and probably more time in transit.

The weeks per year when they will be open for navigation will probably not greatly differ, although the St. Lawrence system would doubtless have a slight advantage in this respect.

If, as shown above, the annual expense of enlarging the Welland Canal alone would pay the freight on double the quantity of wheat and flour at present carried per year from Lake Huron to Montreal, it is unnecessary to prove that (commercially speaking) neither scheme can be defended as a canal solely. Without further information they cannot be compared physically, nor is the possibility of the St. Lawrence enlargement even sure.

Conclusion.—Pending the result of discussion the writer cannot avoid the following conclusions:—

(*a*) Neither canal system can be made, as a canal, a commercial success.

(*b*) On account of the geographical position and abundance of power capable of being developed along the Ottawa-French River system, that canal and power development (if undertaken by the government) can probably be made a commercial success in a few years and will be a very valuable asset in case of international disputes, giving Canada a chance for defence on the Upper Lakes that she can never enjoy without it. This canal might be considered by the Dominion Government on the same basis as colonization railways which have been freely encouraged all over Canada.

(*c*) The possibility of the enlargement of the St. Lawrence system is as yet undetermined, as it requires the co-operation of the United States.

(*d*) The cost and value of the power development thereon is unknown as no international agreement, surveys or estimates have been prepared.

(*e*) The enlargement of the Welland Canal without a corresponding enlargement of the Welland-St. Lawrence system will at least benefit United States quite as much as Canadian interests, and it is questionable if it will not divert trade from Montreal to New York.

(*f*) It will give the United States control of Lake Ontario in case of international trouble, and be an important factor contributing to the probable loss of the wealthiest and most populous part of Canada.

The Dominion Government has recently appointed a commission to report on the proposed Ottawa Ship Canal, which doubtless will add much to the present knowledge of the commercial feasibility of this project, and it is to be hoped of an alternative project of a 14-ft. barge canal.

It is to be hoped that it will also give some similar information regarding the enlargement of the Welland Canal and the proposed extension of the enlargement to Montreal that will guide the government in deciding on the wisdom of such vast expenditures of public money before the projects are actually undertaken.

It is to be regretted that a similar commission had not been appointed before the government committed the country to the expenditure of several hundred millions, on the simultaneous construction of two additional transcontinental railways, and numerous other expensive projects.

NOTE—The following figures are added for reference. They have been taken from Canal Statistics, Department of Railways and Canals, 1911, and Report of Government Engineers on Georgian Bay Ship Canal, 1908. It is very difficult to get definite and accurate information regarding water transportation costs, which heretofore have not been obtained by the government, and some of these figures are subject to correction; especially those relating to freight rates, insurance charges and interest, which are liable to change from year to year.

Distances.—Fort William to Montreal (via Georgian Bay Canal), 934 miles; Fort William to Montreal (via Welland Canal), 1,216 miles; Fort William to New York (via Erie Canal), 1,358 miles.

Proposed Georgian Bay Canal (length) 440 miles—French River village to North Bay, 82½ miles; North Bay to Montreal harbor, 357½ miles. Free navigation, 346 miles; improved channel, 66 miles; canal excavation, 28 miles.

Canal Depths.—Proposed Georgian Bay Canal, 22 ft.; Welland-St. Lawrence Canals, 14 ft.; proposed Welland Canal, 24 ft.; Sault Ste. Marie Canal (Canada), 20.2 ft.; Sault Ste. Marie Canal (U.S.), 16 and 20.5 ft.; Erie Canal, 7 ft.; New York State Barge Canal, 12 ft.

NOTE—Excavation in St. Mary River, below the locks, has materially reduced depths over lower sills below figures in the above table.

Lockage.—Proposed Georgian Bay Canal, 27 locks, 758 ft. up and down; existing Welland Canal, 26 locks, 326 ft.; proposed Welland Canal, 7 locks, 326 ft.; St. Lawrence Canals, 22 locks, 207.5 ft.; Erie Canal, 72 locks, 660 ft.

Rates.—Water rate on grain, Fort William to Montreal, 4½c. bushel. Water rate, Fort William to Buffalo, 3½c.; rail rate, Buffalo to New York, 5½c.—9c. bushel. All water rate, Fort William to New York, 5.3c. bushel.

NOTE—Water rate Fort William to Buffalo is at times as low as 1½c. per bushel.

Although distance and rates are in favor of Montreal, diversion to American ports is due to the following reasons: Availability of ocean tonnage at New York; lower ocean rates between New York and foreign ports; lower insurance rates from New York.

Insurance.—Montreal, 65c. to $1.10 per $100; New York, 12½c. to 15c. per $100.

Cost of existing Canadian canals, Fort William to Montreal, $80,000,000; interest at 3½%, $2,800,000; maintenance and operation, $1,400,000; total, $4,200,000.

Water freight rate per ton-mile, Fort William to Montreal, .163c.; interest and maintenance, .135c.; total, .298c.

Government contribution, .135c. per ton-mile.

Welland Canal traffic, 1912, 2,537,629 tons, of which 51% was Canadian and 49% American.

On the 51% of Canadian traffic the government contribution would amount to .265c. per ton-mile, as compared with a freight rate of .163c. per ton-mile.

Rail freight, Fort William to Montreal, on grain 0.421c. per ton-mile; water freight, Fort William to Montreal, including interest and maintenance, 0.428c. per ton-mile.

It will be seen that the all-water rate from Fort William to Montreal, including interest and maintenance of canals, would exceed the all-rail rate by .007c. per ton-mile, based on the amount of Canadian traffic passing through the Welland Canal, but in case tolls were charged to meet these interest and maintenance charges, the United States traffic would also have to contribute towards this revenue, and the ton-mile charge for the all-water route would be reduced to .295c. per ton-mile.

Government contribution does not include cost and maintenance of harbors, lighthouses, buoys, etc.

THE CARE AND OPERATION OF QUARRYING AND CRUSHING EQUIPMENT.*

By R. M. Smith, B.Sc.

THE writer, in presenting this paper, wishes to deal with the care of modern portable quarrying and crushing outfits and the manufacture of road metal as applied to county road systems. The first operation that confronts the superintendent in moving the crushing outfit to a new location or opening a new quarry is the stripping. If this is of considerable depth it demands consideration. Earth is generally removed at prices varying from 25 to 30 cents per cubic yard. Very often, however, the work is exposed and no stripping is necessary, and in this case the stone on the surface has been subject to varying conditions of the weather, and as a result should be culled from road metal.

Crushers are either of jaw or gyratory type; those used in Ontario are practically all of the jaw type and particularly in portable outfits. Of first importance is placing of crusher; all other equipment depending upon its location. Providing it is intended to work from surface downward some arrangement must be made for draining of quarry. If dump carts are being used, an incline plane is necessary that material may be conveniently moved to crusher. However, if quarry is on side hill and can be opened from a face, the drainage problem is of little importance. Material is moved from quarry face to crusher along bed of quarry with little or no tractive resistance. Operating a quarry on side hill from a face is probably less expensive and more efficient than any other method. Work down hill, not up, should be the motto in quarrying operations. Several quarries somewhat of a permanent nature operating in the province have the crusher below elevation of quarry face; narrow-gauge tracks have been laid and stone is moved by gravity from quarry face to crusher in small cars holding from one to two cubic yards. The tracks are placed so that crusher can be fed from both sides at once or alternately, and as a result jaws are always full. The crusher should be placed as near quarry face as possible, but at sufficient distance to prevent damage to equipment from flying debris. It is well to emphasize setting of crusher on timbers, making it absolutely rigid. A crusher allowed to operate while standing on its wheels is being hurried to the scrap pile, and not only does not work efficiently, but, due to axle bearings wearing, increases the traction power necessary to haul along road. Equipment of all kinds requires careful attention and good treatment. The life of machinery depends upon repairs quickly made, lubricants and oils not too sparingly used, adapting the latter to the degrees of temperature—heavy oils in summer and light in winter. This demands particular attention, as the heavy oils will not run in cold weather, with the result that bearings are soon liable to be destroyed. The prospective purchaser will do well to bear in mind that bearings wear rapidly with the best of care and the ease with which they are removed is a consideration. Many manufacturers supply replaceable babbit bearings which can be changed in a few minutes. Other facts that should be borne in mind is the composition of jaws in crusher; manganese steel jaws are preferable, although costing several times the price of ordinary jaws, but outwearing several sets of the latter and demanding practically no attention. The size is also very important; a crusher running one hundred yards per day is absolutely essential. Manufacturers often insist that small size crusher will run this amount, but generally the opposite has been the result. Jaws approximately 12 in. x 16 in. to 10 in. x 18 in. have been considered correct size.

From the crusher, stone is carried to screen by bucket elevators. Little trouble has resulted with these; generally with attention and proper application of lubricant to keep running smoothly they will last as long as other equipment. The screen demands consideration and attention. Engineers and superintendents have in many cases purchased screens having three sizes of perforations, in ¾ in., 1½ in. and 3 in. This gives a ¾-in. to 1½-in. stone which, when applied alone, seems more detrimental than useful. The screen for limestone should contain two sizes, 1¼-in. and 3-in. respectively. Screens for trap should be somewhat smaller, approximately 1 in. to 2½ in. On many portable outfits the screen plates and elevator buckets are made of too thin material to wear well, the elevator buckets rusting quite rapidly. It is suggested that sprocket wheels and bevel gears should be made of manganese steel. The bin either of wood or steel with wood lining, should have a capacity of about 20 cubic yards, with three traps for loading stone into wagons.

The method of quarrying is particularly interesting. Often stone in limestone quarry may be removed a number of layers in depth with little or no blasting, then rock becomes firmer and powder or dynamite as a result becomes a necessity.

Drilling may be done either by hand, with steam or compressed air. Probably the two first named are methods most used in Ontario, although portable air compressor plants must soon make their appearance. The cost per foot of hole drilled by mechanical means approximates from 15 to 20 cents, using the ordinary tripod drill with 1⅛ and 1¼ bits, that by hand, from 35 to 45 cents.

Drills should be changed approximately every 15 ins., depending upon hardness of the rock. Dull steel makes a poor cutting implement.

Steam or air is not only cheaper than hand, but saves considerable man power, and work is carried on at much faster rate. The amount of road construction work to be done governs the size of plant and equipment that it will be required to purchase. Providing steam or air is used for drilling a portable boiler or air compressor is a necessary part of equipment. Sometimes the tractor providing power for crusher is of sufficient horse-power that it can also run the drill and probably hoist as well. The objection to this is, however, that it increases weight of tractor to an extent where it becomes cumbersome.

The explosive used to break up the rock which seems to give the best results is gunpowder or low freezing dynamite; they have a spreading and heaving action. Mistakes are often made in regard to producing rock for macadam. If the rock is hard and flinty a high explosive breaks it into pieces or spalls full of flaws, and then additional fractioning in a stone-crusher renders it unfit for heavy traffic, as it grinds down too quickly. A milder ex-

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*Read before the Conference on Road Construction, Department of Highways, Ontario, 1916.

plosive causes fewer small fractures, and the life of the road is much prolonged.

Stone is generally moved from quarry face to crusher, either by dump cart, hoist or the old-fashioned wheel-barrow. The hoist is probably the most efficient, but in most portable outfits this does not exist and dump cart or wagon takes its place. Considering the latter two, the dump cart is certainly to be preferred; one horse will do the work of a team. Two or three dump carts at most can keep a crushing outfit working full capacity, with one man driving carts and two men feeding crusher. Dump carts are handy to handle in quarry, quick to unload, no time being lost on crusher platform, and generally more efficient than any other method of moving material, except probably in case of gravity method explained previously.

A raised platform should be built, slightly elevated above the crusher mouth, making it convenient to shovel in loose material and allowing the men to move stone from platform to crusher jaws without being required to lift it. The crusher should be run to its full capacity at all times and special care should be taken to arrange outfit that material may reach crusher and be taken away with the same speed. The efficiency of the operation of the outfit depends upon crusher, and as a result it demands greatest attention.

The traction engine to run the crusher will be required to develop approximately 20 h.p. and probably more, providing it is required to run the drill and hoist as well.

We must not think when speaking of the portable crushing outfit that its sphere of usefulness exists only in the quarry; far from it. Probably over 50 per cent. of the metal being applied to roads at the present time consists of crushed field stone or gravel. Field stone is used extensively in parts of Eastern Ontario and the northern counties, this stone being piled in winter convenient to the road. This is an economical method; labor is cheap and teams more easily obtained at that time. The stone should be piled in two rows, between which the outfit operates, the crusher being fed from both sides. Granite or trap boulders should never be broken with sledge after they have been placed in jaws of crusher; this not only has a detrimental effect on machinery, but helps to decrease the output. Crushed field stone makes good road metal, the only objection being its lack of uniformity. Crushed gravel is a metal which may give excellent service under medium travel. Pits containing coarse gravel which would not be used in its natural state on the road may be put through the crusher, fine and coarse together, and separated in screens, as other metal. The only extra equipment required is a wire dust jacket wrapped around part of the 1¼-in. section of the screen. This wire jacket of ⅜-in. size removes sand, dust and loam. This fine material should not be used on the road surface.

A method of feeding crusher operating in gravel pits which has found considerable favor in Western Ontario is by elevator buckets as used in ordinary crushing outfits. These bucket elevators are placed against bank of gravel pit and operated from crusher, material being fed directly into crusher jaws. Wheel scrapers are also used to bring the gravel on to the elevated platform and are probably as efficient as any other method. In this case, platform is built over jaws of crusher, and only one man is required to regulate the feeding.

The life of a quarrying and crushing outfit depends partly upon the local conditions, but principally upon the kind of material it has to handle. Field stone generally contains varieties of trap rock, limestone, sandstone, etc., all of varying hardness. The crusher operating under these conditions would be subject to greater wear than one working in quarry under practically no change. A crusher working in limestone would have much longer life than one in trap rock. Regardless of kind of material a crusher will depreciate rapidly if not properly handled; careful management will practically double the life. It has been estimated by some engineers that crushers will depreciate probably 16 per cent. and entire plant about 10 per cent. per season, but this, as stated above, depends entirely upon conditions under which plant operates, and no hard and fast rule can be made.

In conclusion, the different stages of quarrying operations have their own importance; stripping, drilling, conveying material to crusher, operating crusher with its equipment, all are a special problem in themselves. It is only after years of experience that a man becomes acquainted with all the kinks in quarrying and manufacturing stone. Efficiency in loosening material, in getting it to crusher and to wagons, mean low cost of road construction.

MONTREAL SEWAGE SUIT SETTLED.

In connection with city drainage into the Little St. Pierre River, a long-standing controversy between the city and the Harbor Commissioners has been settled in which the former's claim against the Harbor Board for $150,000, representing the cost of a new sewer, was dismissed.

The city, in its plea, submitted that it had, by law, an absolute right to conduct its sewers to the river; that the works executed by the Harbor Board, since 1890, were the sole cause of the nuisance leading up to the present case, and that in consequence the harbor authorities were responsible for the costs of effecting a remedy.

The Harbor Commissioners on their side denied that the city, either by common or statutory right, had authority to drain the waters from its territory into the river, and urged that if a nuisance resulted from this being done, it was the city's responsibility to effect a remedy. Even if it were to be admitted the city enjoyed the rights claimed, and even though the nuisance might have resulted from alterations in the harbor, the Harbor Board could not be held responsible, inasmuch as the works had been executed under the orders of the Federal Government.

Justice Martineau said the city had the right to drain into the River St. Peter, and from thence into the St. Lawrence, sewage from its territory; but, at the same time, it was within the rights of the Federal Government, which controlled the harbors, to execute in the port of Montreal all the works it believed necessary, and even if these works rendered the city's drainage impossible in those places, neither the Government nor the Harbor Board, to which it delegated the execution of these works, would owe any indemnity to the city. It devolved upon the city, and the city alone, to effect a remedy to any existing nuisance by placing the outlet of its drains lower down the river. Therefore the city's action was dismissed.

Incidentally, the harbor commissioners questioned the legal right of the city to drain into the river, but on this point the judge's ruling favored the city. Municipalities bordering on a river, he said, could conduct their sewers into navigable rivers in virtue of the right which every subject enjoyed of making such use of these waters as was not incompatible with their natural and public destination. But when it came to a question of conflict between the municipal and harbor authorities, as had arisen in the present instance, his Lordship found that the Government, as the controlling authority over the harbors, had the right to carry out such works as were deemed necessary without considering what effect they might have upon the city's drainage system in that harbor. If any nuisance resulted the city must effect the remedy and pay the entire cost.

COAST TO COAST

Toronto, Ont.—The Hydro-Radial Commission completed plans for a Toronto to Niagara Falls line.

Vancouver, B.C.—A prominent engineering firm is investigating the possibilities for the establishing of a modern steel producing plant.

Port Arthur, Ont.—The waterworks system has been transferred from the city council to the Utilities Commission as a measure of economy.

St. Thomas, Ont.—The annual report of the Hydro-Electric Company shows a surplus of over $9,000 after deducting depreciation charges.

Fredericton, N.B.—The St. John's River International Commission report, which has been in preparation intermittently since 1909, is completed.

Victoria, B.C.—The Saanich waterworks are now in possession of the council. The water was turned into the Saanich mains for the first time on February 18th.

Edmonton, Alta.—According to statements just compiled by the provincial government, the province has had 326 miles of railway constructed during the year of 1915.

North Vancouver, B.C.—The co-operation of Vancouver is sought by the Board of Trade in efforts to secure the establishment of copper and zinc smelters on the north shore.

Quebec, Que.—The Civic Health Committee, after investigating schemes for the purification of the city's water supply, recommended the adoption of a sterilization system.

Toronto, Ont.—At a meeting of shareholders of the Consolidated Mining and Smelting Co. it was decided to purchase the entire stock of the West Kootenay Light and Power Co.

Winnipeg, Man.—The sixth annual report of the Manitoba Good Roads Association shows that 265 miles of roadway were constructed under the Good Roads Act in 1915.

Edmonton, Alta.—At the convention of the Alberta Association of Local Improvement District and Rural Municipalities the formation of a Good Roads Commission was urged.

Calgary, Alta.—It is expected that when the auditors have gone over the accounts of the municipal plant the cost of paving done last year will be $2.50 or more per square yard.

Edmonton, Alta.—It is announced that the last spike in the construction of the Grande Prairie branch of the Dunvegan and Fort McMurray Railway will be driven on March 15th.

Winnipeg, Man.—Legislature proposes spending $25,000 investigating road conditions in the north. Dauphin will be the headquarters of the engineer in charge of the work.

Hamilton, Ont.—It is announced that the Canadian Northern will build a fast steam line from Toronto to Hamilton, and will drop its electric railway scheme, provided it is given greater bonding power.

Victoria, B.C.—The Department of Lands, Forests Branch, recently sent some fir and cedar ties to the Great Eastern Railway Company of England, who carried out tests which demonstrated the superiority of Douglas fir.

Mimico, Ont.—A joint meeting of ratepayers of Mimico, New Toronto, and Etobicoke will be held at which the municipalities will endeavor to decide on what terms they will agree to the completion of the Toronto-Hamilton highway.

Hamilton, Ont.—Although no action was taken by the Board of Trade at their special meeting, the arguments presented would indicate that the consensus of opinion strongly favored building an up-to-date steel bridge in place of the proposed fill over the marsh, connecting up the Toronto-Hamilton highway.

Sarnia, Ont.—F. A. Dallyn, provincial sanitary engineer, Toronto, reported to the council on Ald. Thomas Langan's scheme for supplying the city with a pure water supply. It was pointed out that the changing shore line and the high temperature of the water where Ald. Langan had planned to have the intake, would condemn the plan from a sanitary standpoint.

St. Thomas, Ont.—The Elgin County Council decided to pass a by-law to take advantage of the provision of the Highways Improvement Act in order to build good roads throughout the county. The by-law is not to become operative until January 1, 1917, and in the meantime a comprehensive plan will be prepared for designating the roads and the amount of improvements required.

THE WORLD'S SUPPLY OF POTASH.

For many years past the world's supply of potash has been in German hands owing to the fact that Germany possessed the enormous potash deposits of Stassfurt, which could produce potash more cheaply than any other locality in the world. The seriousness of this position is evident, since potash is an indispensable constituent of manures, without which modern agriculture could not be continued. In this respect the supply of potash is a matter which concerns everyone. Similarly, many British chemical industries, such as the manufacture of soft soap, alum, bichromates, glass, etc., depend for their continuance on supplies of poatsh.

In spite of the German potash monopoly the manufacture of potash compounds from other sources has lingered on in a small way in Scotland, Norway, France, Japan, Russia, and elsewhere, and in the last few years Italy and the United States especially, have endeavored to utilize new sources under their own control. Quite recently new deposits of salts somewhat of the Stassfurt type have been discovered in Spain and India.

The chief characteristics of manganese steel were summarized in a paper read before the International Engineering Congress, as follows: This steel usually contains 10 to 13 per cent. of manganese and approximately 1 per cent. of carbon. It is practically nonmagnetic and has a peculiar hardness, to which it owes a remarkable resistance to abrasion. It is extremely difficult to machine. It has high strength and toughness, but relatively low elastic limit. With care it can be forged and rolled. It has found its principal application in castings for crushing and grinding machinery and railroad crossings. Manganese steel has the peculiar property of being toughened and softened by quenching in water, resembling copper in this respect. All manganese steel castings are subjected to this treatment to remove brittleness.

Editorial

NEW ESTIMATE FOR CONSTRUCTION OF THE TORONTO-HAMILTON HIGHWAY.

Going into the history of the question as far back as the inception of this great work in the autumn of 1914, we find that the main object of the undertaking was at that time to give work to thousands of unemployed who otherwise would, to a greater or less extent, become a public charge. It was also thought that the work, which had been talked of for some time, could be done much cheaper at this stage owing to the abundance of labor. The latter, however, proved a fallacy, as the cost of labor, which was expected would have been less than 20 cents an hour, amounted to much over this.

The type of construction chosen originally was a two-course concrete centre, 16 feet wide, with shoulders of stone 4 feet wide on each side, making 24 feet of roadway.

The estimate of $600,000, as called for in the original pamphlet, did not take into account expenses of management, and plainly stated so. This item has been estimated at $56,000. In reference to the original pamphlet, one also notes the extremely low estimate for grading and ditching. Such an estimate could only have been approached in actual construction cost by a mere skimming of the surface.

The provincial highways engineer, when reporting on the original scheme, stated that the road could possibly be built for $650,000, exclusive of the cost of bridges and culverts, which item in the new estimate amounts to $88,000.

The Workmen's Compensation Act, which came into force since the work was started, is responsible for an additional $14,000. An item of $90,000 due to the employment of relief labor has been the cause of considerable discussion in the daily press, which is entirely uncalled for and not fair to either the employers of the labor or the laborers themselves, who for the most part were men who had been used to almost any other kind of work than pick and shovel work, and who, as before stated, would have been receiving help from the municipalities and not doing any work in payment if they had not been employed on the construction of the road. This item for $90,000 also accounts for the extra grading occasioned by cutting down the gradient and eliminating curves. Losses due to the inclemency of the weather are also chalked up to this account. Such additional costs as these would have been incurred by any contractor.

It was decided, after careful investigation and study, to change the concrete centre of the road to 18-foot width in place of 16 feet, as originally allowed for, and to substitute a 3-foot earth shoulder in place of a 4-foot stone shoulder. For this the commission accept the full responsibility. The estimated cost of this increase of 2 feet is $72,000.

These added items bring the estimated cost of the road up to $920,000. Admittedly it is high, being approximately $23,000 per mile, but if it means a really good road, and there is no good reason to doubt that, then it fulfils its purpose, and all interests should be satisfied.

The foregoing briefly accounts for the added cost of the road.

Up to October 31st, 1915, over $275,000 was paid out for labor, of which almost 50 per cent. went to citizens of Toronto. It is altogether likely that a goodly proportion of this is money that otherwise would have been expended in relief to these same citizens, not only of Toronto but of all the interested municipalities.

The commission has proposed a deviation of the road through part of York county. The reason for this is to leave undisturbed a 2-mile section of concrete roadway which would have to be torn up, as it could not withstand the heavy traffic of an inter-city road. Another reason is that the Lake Shore Road is not wide enough between the Humber and Etobicoke, being only 38 feet wide in some places where a width of 66 feet is required. This was not known at the time the Lake Shore route was decided on, and it would not be fair for the citizens of other municipalities to have to pay for this extra land. If the municipalities interested do not purchase the extra land then the commission should be allowed to choose an alternative route.

HYDRO-RADIALS IN PERIL.

The success of the hydro-electric railway scheme which was voted on this year seems to be somewhat in jeopardy, at least it will be if bills for extension of franchise of several Ontario electric railways are passed. One of these roads—the Toronto and Hamilton Railway—was incorporated in 1903 with a capital stock of half a million dollars. The company was given the right to construct a line of railway from a point in or near the city of Toronto to a point located near Hamilton. Among other concessions, the road was given power to buy or make agreements with a number of smaller companies. The road had bonding powers of $35,000 per mile.

The time for completion of the road was later extended to two years to commence and five years to complete. In 1906 the name was changed to the Toronto, Niagara and Western Railway, and capital was increased to six million dollars. It was given further power to enter into agreement with the C.P.R., G.T.R., and half a dozen Mackenzie lines. Time for construction was extended two years and again in 1909 a further extension of five years to complete the road was granted.

Another road—the St. Catharines and Toronto Railway—was incorporated in 1899 with a capital of one million dollars. In 1902, extensions of time were granted to several of its branches, and in 1905 the Toronto end of it was granted a further three years. This company also increased its capital to three million dollars and several more extensions were granted, bringing the time of completion up to 1915.

Now both companies are pleading for further extensions, their arguments being that they are unable to commence construction owing to the financial depression. But the same government granted them extension after extension before the war was on and they had no such excuse, so why should they be granted it now? The rights of the people should be respected; they have voted for hydro-radials and they are entitled to them. If the companies had built their lines as empowered by their franchises it is altogether likely that the hydro-radial scheme would never have been brought up.

PERSONAL.

J. D. McARTHUR, railroad contractor of Winnipeg, will join the board of the Winnipeg Electric Railway.

P. D. ROSS, of Ottawa, was named by the Provincial Hydro-Electric Commission as its representative on the Ottawa Hydro-Electric Commission.

W. G. MACKENDRICK, until recently with the Warren Bituminous Paving Co., is now a captain in the British army doing roadway work at Canadian headquarters.

H. P. BORDEN, C.E., has been appointed a member of the government commission in charge of construction of the new Quebec Bridge in place of C. C. Schneider, of Philadelphia, deceased.

M. M. INGLIS, of Winnipeg, has been appointed manager of the Port Arthur Electric Railway system and entered upon his new duties on February 1st. Mr. Inglis was formerly superintendent of the electric light plant at Yorkton, Sask.

H. F. WARDWELL, formerly home office manager, has been appointed general sales manager of the Detroit Steel Products Company, effective February 1st. He succeeds Mr. P. A. Smith, who recently resigned to enter another line of business.

CHAS. J. CROWLEY, well known in Toronto as a railroad engineer, and E. H. FITZHUGH, formerly vice-president of the Grand Trunk Railway, announce the formation of the Fitzhugh-Crowley Corporation, engineers and contractors, specializing in railroad work, with offices in New York.

OBITUARY.

ARTHUR P. SCOTT, engineer for the Snider Electric Furnace Co., died in Montreal recently. Mr. Scott was a graduate of McGill University in both arts and engineering. For some time after graduating he served on the staff as a demonstrator in science. Other firms with which he has been connected are: the Dominion Iron and Steel Co., and the the General Electric Co. He was 39 years of age. The news of his death has caused widespread regret in engineering circles.

ONTARIO LAND SURVEYORS.

Following are the officers elected for 1916 for the Association of Ontario Land Surveyors at their recent meeting in Toronto: President, Mr. C. J. Murphy; vice-president, Mr. James J. MacKay, of Hamilton; secretary-treasurer, Mr. L. V. Rorke; member of council and management, Mr. T. D. Lemay (two others to be elected by ballot); auditors, Messrs. A. E. Jupp and D. D. James.

EDMONTON BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the last meeting of the branch, held on February 16th, Mr. L. A. Thornton, C.E., addressed the members on "The Development of the Mountain Park Coal Fields." Mr. Thornton described the development of this field, which is situated 75 miles south of Edson on the G.T.P. He illustrated by numerous slides the various interesting features at the collieries as well as the wonderful natural scenery of the Rocky Mountains in that vicinity.

OTTAWA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a recent Managing Committee meeting of the Ottawa Branch of the Canadian Society of Civil Engineers, the following names were selected for submission to the Council of the Society at Montreal, in connection with representatives for district No. 4 on the special committee authorized at the recent annual meeting to consider ways and means of advancing the prestige and usefulness of the Society: Messrs. John Murphy, G. A. Mountain, James White, J. B. Challies, Col. W. P. Anderson, J. B. McRae, C. R. Coutlee, S. J. Chapleau, R. deB. Corriveau, and G. B. Dodge.

Of these names Messrs. White, Challies, McRae and Coutlee were unable to act, so that the three representatives for district No. 4 will be selected from Messrs. Murphy, Mountain, Anderson, Chapleau, Corriveau and Dodge.

At the request of the Managing Committee of the Ottawa Branch, Col. Maunsell, Director-General of Engineering Forces in Canada, has arranged a provisional school for officers desiring to qualify in military engineering.

The course consists of infantry training on two afternoons and one evening and lectures on military engineering on one evening each week. As a majority of the members are taking advantage of the course, it has been decided to discontinue the evening meetings of the Society.

Lectures delivered so far have been on "Military Bridging," by Lieut. Fellowes; "Duties of an Engineering Corps in the Field," by Col. Maunsell, and a paper on "Military Discipline," by Capt. Parker, who has been invalided home for some time.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

H. B. Muckleston, M.Can.Soc.C.E., has been nominated by the Calgary Branch and endorsed by the Edmonton Branch as one of the members representing district No. 6 on the committee to consider ways and means of advancing the prestige and usefulness of the Society, in accordance with a resolution adopted at the last annual meeting of the Canadian Society of Civil Engineers. Mr. Muckleston is a past chairman and at present member of the Executive Committee of the Calgary Branch. He has always taken an active interest in the affairs of the Society and will, if elected, make a valuable member of the committee.

VANCOUVER BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At the regular monthly meeting of the branch, H. K. Dutcher addressed the members on the construction of the power plant at Kamloops. Lantern slides showing the character of the country and progress of construction of the plant explained more about this work.

COMING MEETINGS.

THIRD CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS AND EXHIBITION to be held at Sohmer Park, Montreal, March 6, 7, 8, 9 and 10, 1916. General Secretary, Geo. A. McNamee, New Birks Building, Montreal.