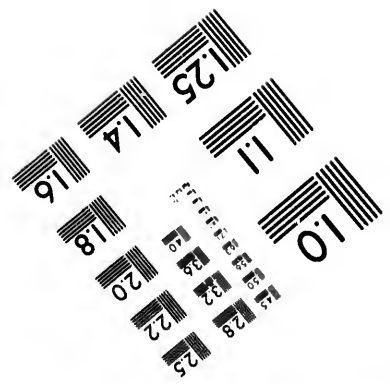
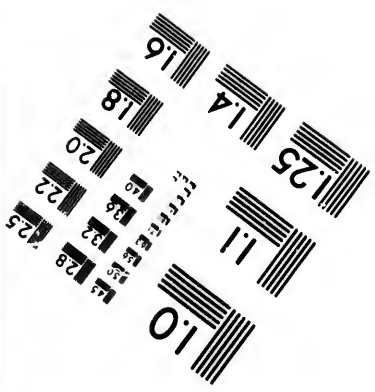
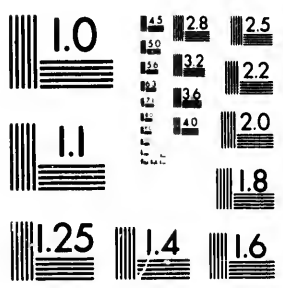


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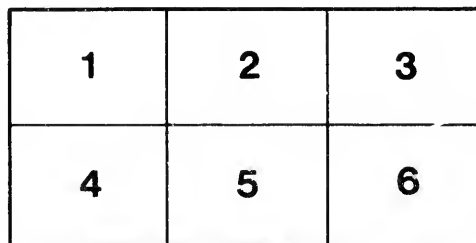
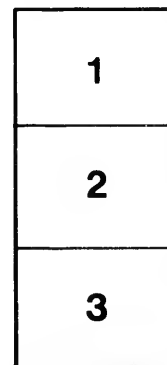
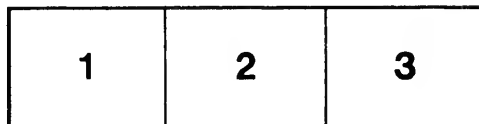
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THE STREETS OF SAINT JOHN.

REPORT OF MR. A. W. CAMPBELL, C.E.

GOVERNMENT ROAD COMMISSIONER FOR THE PROVINCE OF ONTARIO.

RADICAL DEFECTS IN STREET MAKING AND REPAIRING POINTED OUT.

HOW WORK SHOULD BE DONE.—MATERIAL TO BE USED.
STREET PAVING.—GENERAL RECOMMENDATIONS.

[PUBLISHED BY THE ST. JOHN CITY AND COUNTY GOOD ROADS ASSOCIATION.]

The following is the full text of the report made by Mr. A. W. CAMPBELL C. E., Road Commissioner for Ontario as a result of his visit to St. John in September last :

To His Worship Mayor Robertson and members of the Council of the city of St. John, New Brunswick:

Gentlemen,—In compliance with your request that I should prepare a report upon the streets and street system of the city of St. John I beg to submit the present document: The brief period of my visit, however, and the little time available for a careful examination of all work and departments prevent as detailed a statement of the matter as I would wish to give.

The accounts of the corporation show that from 1887 to 1896 inclusive, that is for a period of ten years, the amount spent on street improvement, including sidewalks, reaches over \$400,000. This includes the cost of the road to Indian-town and a portion of the Carleton improvement account. It does not, however, include the expenditure of Portland prior to May 18, 1889, or a period of a little more than two years; nor are scavenger accounts included. The estimated total of \$400,000 is not exact, but

is merely approximate, made up as follows:

1887—St. John and Carleton.....	\$12,083.87
1888—St. John and Carleton.....	26,625.02
1889—St. John and Carleton, Portland from May 18th.....	27,560.64
1890—St. John, Carleton and Portland.....	74,829.37
1891—St. John, Carleton and Portland.....	94,014.00
1892—St. John, Carleton and Portland.....	53,437.47
1893—St. John, Carleton and Portland.....	35,283.42
1894—St. John, Carleton and Portland.....	24,569.63
1895—St. John, Carleton and Portland.....	29,763.10
1896—St. John, Carleton and Portland.....	28,994.77

The foregoing estimate shows an average yearly expenditure of about \$40,000. Excluding the Indian town road construction and Carleton improvements the normal yearly expenditure appears to reach nearly \$30,000. I was informed that about one-half of this is spent on roadways, the remainder on sidewalks.

CONDITION OF THE STREETS.

The city of St. John is very compact, there being only about sixty miles of streets. There has been a considerable amount of work done on them, but, with the exception of some quarrying necessary in opening a few streets, very little of a permanent nature has been accomplished. The large expenditure noted above is entirely too great to be spent on work of a temporary character. There is really no good paving in the city and the general condition is below a good standard. A great part of the work already done, and further work done in a similar manner, renders the change to permanent plans more difficult; since the work and material now being placed on the streets will have to be torn up and carted away in order to grade the street properly. Expenditure as in the past, therefore, is not merely ill-advised as regards immediate results, but is wasteful with regard to the future.

In driving over the streets of St. John I noticed wooden block pavements on Main street, Charlotte street from Union to King, Prince William, Dock and Mill streets, all of which will soon have to be replaced. Main street is one of the principal thoroughfares of the city and receives a heavy traffic from the St. John river docks; and also the greater part of the travel from the western country passing over Douglas avenue.

Douglas avenue is the main entrance to the city from the west and is very heavily travelled, but is almost in a state of nature. Drainage is greatly needed and would be easily obtained through the adjacent property and ravine crossing it.

Water street (Duke street to Reed's Point), a much travelled street passing along the front of the wharves, is very heavily travelled and receives heavy loads from the wharves. It has been covered with rough stone, has no sewer, no curb, no crown, shape nor form. The soakage from the uplying land to the east is through the foundation of the roadway to the harbor; a sewer or drain on the upper side of the grade is necessary to cut off this soakage water. On this street from Duke street to the Market Square \$900 has been spent this year in improving the surface, which improvement consisted of a heavy coating of rough broken stone covered with soil; and this is already, under the very heavy traffic, being rapidly converted into mud. By next spring it will be an excellent

example of the fallacy of expending money in temporary work, entirely inadequate to the demands of heavy traffic. The ferry traffic also passes from Princess street along Water street to the Market Square.

Brussels street is double tracked by the Street Railway and is curbed. The tracks in places are lower than the surface of the adjoining roadway; water is held between the tracks and having no provision for the disposal of this water it is obliged to course a long distance to the bottom of the grade. This current washes the material from between the tracks and leaves the rails projecting above the road to such an extent as to make this portion of the street useless and dangerous. This seems to be characteristic of the streets wherever the tracks are laid.

Marsh Road is a leading entrance to the city from the northeast. Traffic passes from it along Brussels and Waterloo streets to Union street, or it diverges along City Road to Garden, Coburg and Union streets. The provincial government of New Brunswick has macadamized the Marsh Road for a distance of about one mile outside of the city limits and the work reflects credit upon the department by which it was undertaken. The roadway is of liberal width and the crown is uniform and not excessive. This road, however, within the city limits, is very similar to the remainder of the city streets.

Garden street, leading from City Road, has a very steep grade. It was repaired this year, but the stone used was not coursed nor screened and was afterwards heavily coated with clay, thereby destroying the effect of the work.

City Road has this year been similarly treated, having been picked up, re-surfaced with stone and then buried under a coating of clay. The Street Railway tracks are in the centre of the roadway. The rolling has been very imperfectly done, not having been continued to the gutters, as the pressure disturbs the sidewalks. Curbing would have overcome this difficulty.

St. Patrick street, a residential street receiving a large amount of travel from the country, was repaired last year. The crown is too low, the gutters are cobbled, but there is no curb and the rolling could not be completed. The coating of loam used is now turned to dust and mud and the temporary character of the work is becoming apparent. Flat

stone for the gutters, or granite setts, are preferable to cobble stone.

Union street is an important business thoroughfare. At the east end the Street Railway track has been abandoned. The rails and ties are still in place, but are covered with stone and mud. In this way the centre is crowned to such an extent as to make it dangerous, while in places the rails are still exposed some inches above the surface of the street. This portion has cobble gutters, but no curbing.

On Pitt street, from Orange to Duke, the grade is very steep; the gutters are cobble-stoned, but the bottom of them is higher than the centre of the street. Earth is placed on the roadside of the gutters to keep the water from flowing out of the channels into the street, but this embankment also prevents the water from the surface of the roadbed entering the gutters, so that they do not serve the purpose for which they are intended. The surface of this street is flat and the water coursing down it has worn it into gulches.

On Germain street, from King to Church, the sidewalk on the east side is higher than on the west. The roadway is made level with the higher side, leaving the gutters on the west side in the shape of a ditch along a country road, deep and dangerous. The roadway is considerably higher than the west sidewalk.

St. James street is very narrow, the Street Railway track is in the centre and the grade of the track is a couple of feet above the sidewalk. The traffic passes on each side of this track. The sides of the roadway are made very steep, so as to conform to the grade of the Street Railway, and are dangerous.

Broad street is 100 feet wide, has a nine-foot sidewalk on each side and the roadway is about 60 feet in width. The traffic is light and infrequent, and were this roadway narrowed to about 28 feet, properly graded and paved, curbed and boulevarded, with trees placed on either side, it would become a desirable avenue and promenade, and prominent among the city's attractive features.

MANAGEMENT OF STREETS.

There is no department of municipal government so dependent upon systematic oversight, skilled and experienced judgment, as is the street department. There is no branch of municipal affairs

which will make so apparent the results of wise expenditure; no public work which affords so many opportunities for waste and mismanagement. The evil effect of loose management is heightened by the importance of rightly paved streets to the well being and progress of a city. Large expenditure produces a correspondingly high rate of taxation; when this is coupled with rough, badly-designed and constantly failing pavements the evil is not of a single, but a two-fold nature. High taxes and bad streets are a most undesirable union. This criticism is not directed with any emphasis toward the city of St. John, but is a general statement of the condition in cities throughout Canada. Nor is it intended to point to St. John as a marked exception to the rule.

The present Council and its predecessors, together with those at the head of street affairs, undoubtedly deserve the compliment due every public official who honestly seeks the public good. There evidently has been, and is, an earnest desire to obtain the best results with the least expenditure. But in common with other cities the importance of the street department has not been realized nor understood.

I cannot find that there has been any definite plan laid down which will ultimately provide for the improvement on a proper system of all the streets. There is no definite object to be reached as a result of the large annual expenditure. A plan for street improvement should be almost parallel with the construction of a system of water works. A system for the entire city is decided upon. The size of pipe needed on outlying streets is estimated, that of the lines by which these are supplied is computed, and so on until the size of the largest main is known and a complete plan for the entire town is framed, future requirements being always kept in view. The whole of this may not be constructed at one time, but definite provision is made and work is done in accordance with the plan when required. A plan of streets for the entire city should be considered and the best means provided for carrying it out.

While it may be very popular to look with skepticism upon scientific principles in street construction, and the necessity for the services of experts, the fact still remains that until this error is fully recognized money will be extracted from the pockets of the ratepayers by the hand of taxation and buried in the mud by

the hand of innocence. No clearer demonstration of this can be had than the common expression, "Give us more money and we will make you good streets," when after many years of effort and many hundred thousands of expenditure not a street or even a block in the city has been properly constructed. Increased appropriation would, therefore, mean increased waste. System and plans embodying the true principles of construction are certainly of first importance to ensure the full return of benefit for every dollar expended. A system of extensive patch-work and temporary surface repairs called "street construction," which tides over the year merely, is as shiftless as it is extravagant. It has cost St. John a great amount of money. By it no finished work can be expected. Streets will always be required and their construction in a permanent manner, consistent with development and requirements, is the most economical system. Skilled direction is the foundation of all great public works, and while we are delighted to admire the results of their employment in all the great works of the country, in none are they more needful than in street making. Surrounded by peculiar local conditions, as to material requiring careful preparation and application, nature and extent of traffic, treacherous foundations, changeable climate and limitation of cost, what work can be mentioned that requires more skill and judgment? Until this is realized failure is inevitable.

The management of the street department in St. John appears to be on a very uncertain basis. The duties of those in charge do not seem to be rightly defined and responsibility shifts along very flexible lines. There seems to be also a lack of that unity necessary for the proper guidance of any institution. Regarding this branch of street affairs I could not obtain very positive information, and am, therefore, not in a position to make any direct recommendation. I judge, however, that the engineering of public work is in a measure subordinate to the business management. This, while unusual, is not in itself necessarily injurious. But the duties of the engineer should be in no measure curtailed. He should exercise full control over all matters of, and relating to, actual construction and should be held responsible therefor. It is becoming more and more recognized that the most necessary part of a municipal engineer's qualifications is an ability

to deal with street improvement in a skilful manner.

CHOICE OF PAVING MATERIAL.

The science of paving is not in an experimental stage. There are certain varieties of pavement which, with proper precautions, can be laid with considerable certainty of success. When failure results it can generally be traced to defects which could and should have been avoided under skilled management.

But experiments should not be conducted in a large way with material the wearing properties of which are not definitely proven by experience. Millions of dollars have been wasted by municipal councils jumping at new forms of pavement which promise a reduction of initial cost. Wooden block pavement has been one of the chief sources of wholesale experiment and waste. There are certain standard forms of pavement which should be retained until other materials have proven their utility beyond question.

And because a pavement is found to give good results under a certain set of conditions of climate and wear it is not to be inferred that it will be equally suitable for another set of conditions of climate and wear. A Victoria is a very useful carriage in which to go for a drive, but we do not use it for carrying building stone nor cord wood. Pavements, like vehicles, have to be designed and constructed according to the use for which they are intended. And very much as the bridge engineer calculates the strains to which a bridge will be subjected, the expert road builder will study the design for a pavement required to meet certain conditions.

There is no one variety or pavement suited to all degrees and forms of traffic, no one variety which can be used to advantage for all locations. Granite block pavement is the most durable which can be constructed, requires but little repair and is well adapted to steep grades. But it is too noisy, rather rough, and trying on the legs and hoofs of horses. Asphalt is a very smooth and agreeable pavement on which to drive, is handsome, sanitary and may be kept very clean, but it is less durable than granite and cannot be used on steep grades. Vitri-fied brick is fairly well adapted to steep grades, ranking next to granite in the foothold afforded horses, is smooth and less noisy than granite, is very agreeable for driv-

ing or wheeling, may be kept very clean, but is less durable than either granite or asphalt. Crushed stone (macadam) is the most agreeable of all for driving, is not noisy, is superior to all in safety, is adapted to steep grades, but under excessive traffic is very expensive to maintain.

CLASSIFICATION OF STREETS.

In arriving at a plan, then, whereby the paving of the streets may be undertaken systematically, one of the first steps is a consideration of the traffic over streets of the city with a view to the kind of pavement required. It will be seen that there are certain streets, such as Water street, Doek street, Mill street, Main street, which are most heavily travelled of all. They receive the traffic from the wharves, vehicles loaded are constantly passing over them. The strain on the pavement is evidently very great and the strongest form of pavement should be chosen. Mill, Doek and Water streets could well be paved throughout with stone blocks. For Main street, on account of the large amount of business on the street and the numerous retail stores, the noise created would probably be objectionable and asphalt could be substituted on the level portions, but stone blocks would necessarily have to be retained on the steep grades. To this list of heavily-travelled streets may be added others, such as Prince William and Smythe streets, Sidney, from Union to King Square, for which stone blocks would be very suitable. On Union street a rough pavement would be objectionable, so that asphalt might be substituted; also on Charlotte street, from Union to King, and on King street surrounding the square. On the Market Square so strong a pavement is not needed and vitrified brick would be well adapted to its requirements.

There is a second class of streets, residential streets very largely, but over which passes a considerable amount of traffic. Such streets as Waterloo, St. Patriek, City Road, Marsh Road, Garden, Coburg, Britain, Germain, Charlotte and Sidney from King street south, and Douglas avenue. These thoroughfares should be heavily macadamized with the trap rock available in the city of St. John.

A third class would include such streets as Pitt, Wentworth, Carmarthen and similar intersecting streets, on which a

lighter macadam could be used with good effect.

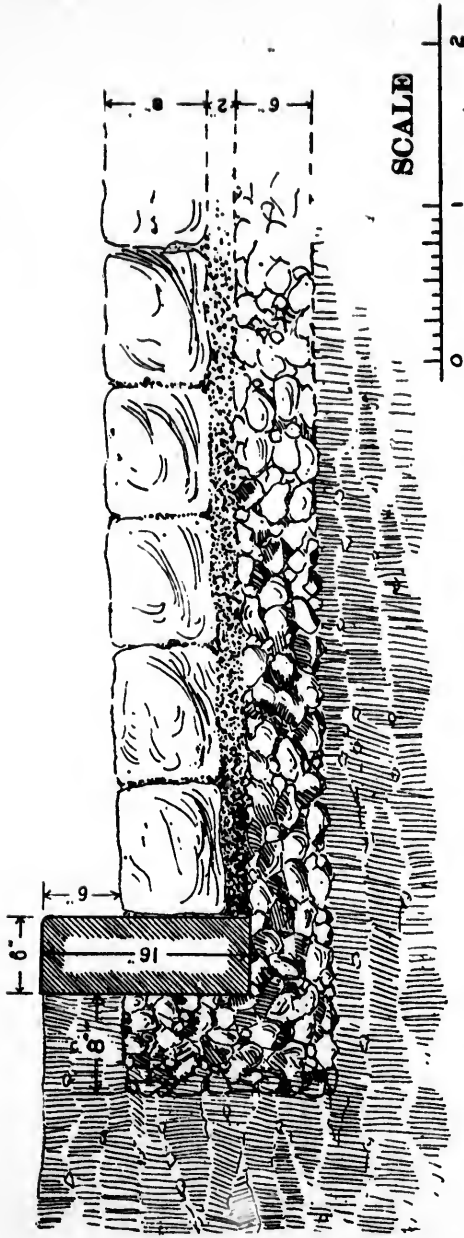
STONE BLOCK PAVEMENTS.

Stone block is the oldest of paving materials; is extensively used in cities, and is the strongest and most durable that can be had. It is well adapted to grades up to ten per cent., yields little dust, requires little repair and suits all classes of traffic. It is, however, very noisy and is rather rough. It is, therefore, not suited for residence streets nor business streets on which there are retail stores and offices. It is best adapted to streets such as Water street, on which there is a large amount of slow, heavy traffic. It should be used also on steep grades in place of asphalt.

The stone generally used is granite or trap. Excessively hard stone wears to a smooth surface and becomes slippery. No examination or test which can be made of stone is perfectly satisfactory in distinguishing the best variety. Different kinds of the same stone, and even stone taken from different parts of the same quarry, have different wearing qualities. The trap rocks of Carleton Heights, the quartz diorites at the end of Sandy Point, will any or all prove satisfactory. Quartzites, of which varieties are found at the west of Lily Lake, on the slope of the ridge north of Douglas avenue and on the road to the Lake after passing Seely street, are apt to wear away too rapidly. White marble, of which some is found back of Lily Lake and elsewhere in the vicinity, is too soft.

The stone blocks should be cut into rectangular blocks about seven inches deep, three inches wide and nine inches long. The price paid for quarrying and making these blocks will average about thirty dollars per thousand. Slabs of a size which can be handled by one man are split out in the usual manner. These are sub-divided into sections corresponding to the size of the paving blocks, which are then trimmed and finished.

In constructing a stone block pavement the natural earth is first prepared by draining, grading and rolling with a steam roller. On this a layer of concrete is laid, say six or eight inches in thickness, according to the traffic to be supported. On this is spread a layer of sand about one inch in thickness, and in this the stone blocks are imbedded.



Granite Paving. — Granite blocks eight inches deep on a two-inch layer of sand over a six-inch bed of cement concrete, laid on earth surface that has been properly drained, graded and rolled.

The blocks are laid stone to stone in courses at right angles to the street line and so that the joints will be broken. A slight variation in the size of the blocks is permissible as regards depths and length, but the width (if three inches as previously specified) should be exact.

On hills and grades a better foothold for horses may be obtained by using rough-finished blocks, or the blocks may be so imbedded in the layer of sand on a slight incline in such a way as to present a series of steps. At street intersections the blocks are laid obliquely in what is termed the "herring bone" fashion so as to give a secure foothold to horses turning the corners.

The joints between the blocks are filled with sand and tar cement.

The State of Maine, adjoining New Brunswick, is one of the largest producers of stone paving blocks.

ASPHALT.

The materials of which asphalt pavements are composed may be either natural or artificial. Natural asphalt is obtained by grinding to powder bituminous limestones found in Texas, Utah and elsewhere, or the bituminous sandstones found in California, Kentucky, Texas, etc. This powder is then heated until soft and is spread while hot on the roadway. The chief source of artificial asphalt is the Island of Trinidad, W. I., where crude asphaltum is obtained, is then refined and mixed with sand and stone dust; is heated and applied to the roadway.

Owing to the skilled labor and machinery needed in laying this pavement it is, in the great majority of cases, laid and kept in repair by contract. When properly laid its durability cannot be questioned, but there is some difficulty in surrounding a contract with such safeguards as will ensure first-class material and workmanship. A reliable company should be employed and the maintenance of the pavement guaranteed for ten or fifteen years. A common guarantee is for a term of five years, but this is not sufficient. Breaks in asphalt pavement must be immediately repaired, otherwise they quickly shear off under wheels, and the size of the hole increases with great rapidity.

On the business streets of St. John, where the traffic is severe, where noise is

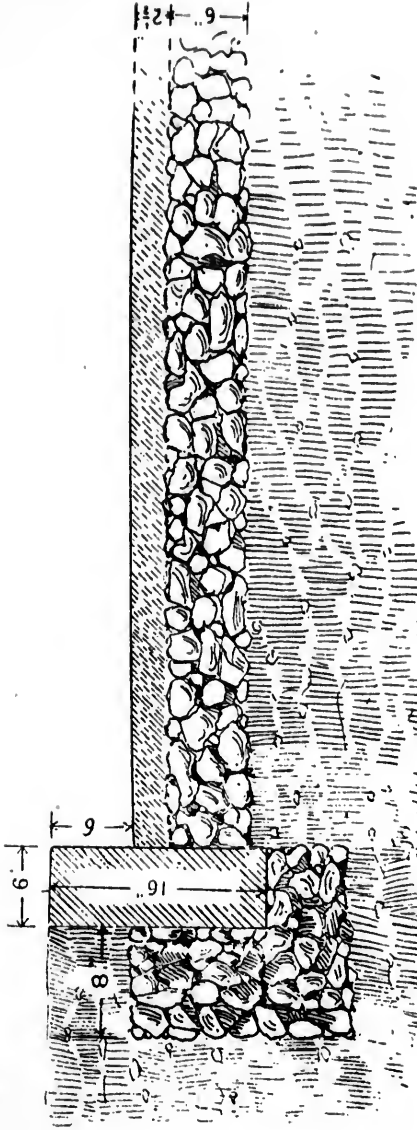
objectionable, and where smoothness, cleanness, ease of travelling are desirable, stone blocks are not suitable. Asphalt is the most durable material filling these conditions. It is not, however, suitable for steep grades, and stone blocks would necessarily be retained for grades greater than three per cent. Nor can asphalt be used between and adjacent to street car tracks. The gutters, too, should be formed of concrete or flagstone, as asphalt decays rapidly from the effect of moisture.

VITRIFIED BRICK.

Vitrified bricks for street paving are different in composition and manufacture from the ordinary building brick. They are made from shale, or clay, or a mixture of the two, which is heated to the point of vitrification and then slowly and gradually cooled. The size of each brick is about 2 1-2 x 4 x 8 1-2. They are laid in the same manner as stone blocks, viz., in courses at right angles to the direction of the street, with broken joints, etc. The durability is not equal to that of asphalt or stone blocks. But they are less noisy than stone blocks. The pavement is adapted to business or residential streets on which the qualities, but not the strength, of asphalt are required. They are manufactured in the Province of Ontario, in the States of Ohio, New York, and Pennsylvania and elsewhere. There is room for much variation in the quality of brick. The process of manufacture is one which requires an expensive plant and much skill in burning. The composition of clay or shale used is of great importance. It may contain, for example, too much lime, which will destroy the brick on exposure to moisture. Care must therefore be taken in selecting the brick to be used.

WOOD PAVEMENTS.

Cedar blocks and pine pavements have been used in St. John to some extent. In Canada and the United States wood-pavements are very much in disrepute. They have been found to decay rapidly, settle unevenly, become rough and are unsanitary, absorbing filth and giving off bad odors. Much of this is unquestionably due to the methods of constructing these wooden pavements in this country.



Asphalt Pavement. — Two to two-and-a-half inches Asphaltum or Bituminous Rock Asphalt on six-inch cement concrete laid on earth surface that has been properly drained, graded and rolled.

In England and France they are regarded with favor, but the timber used there is carefully selected, so as to exclude any blocks showing signs of decay. Oblong blocks are cut all of equal size. They are treated with creosote, tar, and other preservatives and are laid on concrete foundations. Some soft woods are used, and the life of such pavements are about ten years. The best wooden pavements are made, however, from Australian hard woods, particularly the jurrah, karri and other of the eucalyptus woods of South Australia.

In the absence of actual experience in this climate with wooden pavements constructed in the careful manner outlined in the foregoing paragraph, their use cannot be recommended. Certainly cedar block and pine pavements as commonly laid in this country are not a success and should not be tolerated.

BROKEN STONE

Broken stone pavements (macadam) are in many respects the most satisfactory that can be had. This is especially so where, as with St. John, first-class material for their construction is to be found in the immediate vicinity. Trap rock is the best and most durable stone which can be employed, and it is to be had in Carleton Heights. Roadways of this material cannot be excelled, except for immediate business sections, or for streets where the traffic is so excessive as to render their annual maintenance very costly. The limestone at present used on the streets is too soft and its use should be discontinued except for the foundation layer. The stone quarried from certain streets in opening them up might also be used in the foundation of roads, but not on the surface.

Macadam roadways for residential streets are regarded with very great favor. They are pleasant for driving, for wheeling and their appearance is in keeping with shady boulevards and well kept lawns. Their only rivals in this respect are asphalt and brick, which, however, need only be resorted to in case of heavy traffic. Crushed stone is better adapted to hills and steep grades than are other pavements, a feature of importance to the city of St. John.

On business streets the traffic is usually very heavy, and with horses standing constantly in the gutters in wet weather as well as dry, and drays heavily loaded with merchandise constantly using

the street, a pavement which can be more readily cleaned, which will not easily rut and which can always be crossed by pedestrians at any point, is more desirable.

Satisfactory results from this pavement have not been had in St. John by reason of the imperfect construction. The life and utility of the roadways thus improved has been largely destroyed by the use of a clay "binder" placed in a heavy coating over the surface of the stone. A screen has not been used in connection with the steam crushing plant to grade the metal. Drainage, grading and similar details have not received sufficient attention.

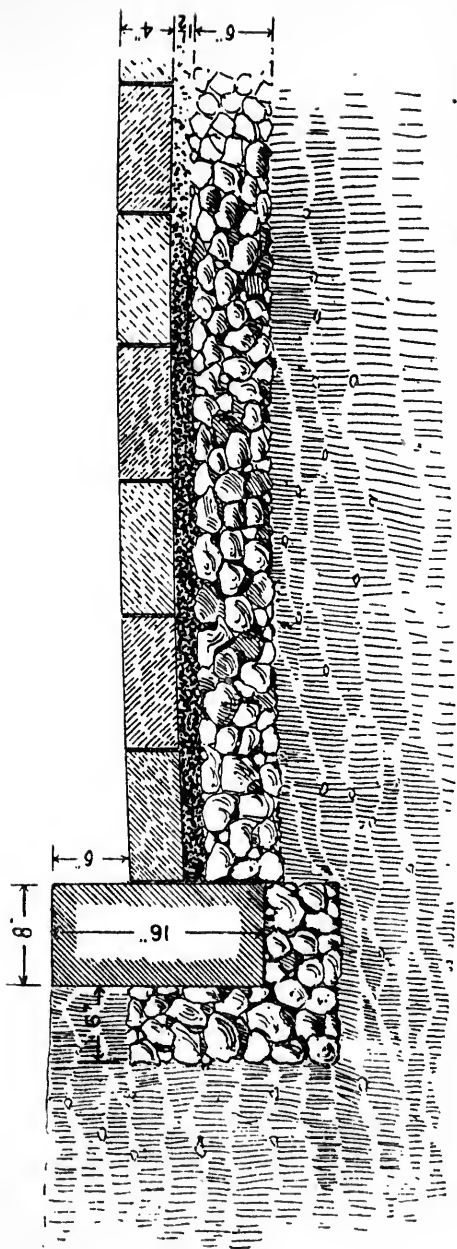
DRAINAGE OF ROADWAYS.

Good drainage is essential for all classes of pavement, and none more so than macadam. It must be understood that it is the natural soil which really sustains the weight of traffic; and that broken stones piled on a wet soil cannot be sufficiently strong to support heavy vehicles. Water permitted to accumulate and stand on the surface of the roadway will cause the pavement to be rapidly churned into ruts and mud.

Under-drainage by means of common field tile is very often necessary. Water falling in the form of rain passes at once through the soil until it reaches a strata of rock, compact clay or other impenetrable layer. If there is an outlet along the strata of rock or clay it will issue in the form of springs. If not, it will rise higher and higher in the soil above the strata through which it cannot pass: just as water poured into a vessel will rise higher and higher until it reaches the top, when it will overflow. Tile drains provide an outlet for this water before it reaches the surface of the soil, and thereby maintain a firmer foundation of earth on which the broken stone may rest. These tile drains should be placed at a depth of about three feet.

Surface drainage is provided by rounding up (crowning) the surface of the roadway, thus draining the water to the gutters at the sides of the road, which latter are so graded as to permit the water to flow along them to suitable outlets.

These drains (tile drains and open gutters) may have independent outlets or they may empty into the sewers. Surface water is now, in St. John, emptied



Vitrified Brick Paving on one-and-a-half inch layer of sand over a six-inch bed of cement concrete laid on earth surface that has been properly drained, graded and rolled.

into the sewers through gutters and catch basins. These, however, are not placed at sufficiently frequent intervals, especially on some of the steep grades, to properly intercept the water, having been put at street intersections only. The rush of accumulated water on these steep grades is the cause of considerable injury to the roadways. Water should always be disposed of in small quantities before it obtains any power and headway.

PLACING METAL ON THE ROADWAY.

The city possesses a steam roller and rock crusher, both of which are necessary in the construction of broken stone roads, the former necessary for all classes of pavement.

In the construction of broken stone roadways the use of the roller is to first thoroughly compact the earth subsoil on which the broken stone rests. On this earth foundation is then placed a layer of coarse broken stone, which in turn is consolidated with the roller. The stone is placed to the required depth in successive layers and each layer thoroughly consolidated. Rolling should commence at the sides of the road and should approach the centre gradually; otherwise the loose material is crowded outwards and the crown of the road flattened.

In securing consolidation resort should not be had to clay for a binder, but dependence should be placed on the roller. The vacuum between the stones should be filled with the fine stone dust and chips made in crushing the stone. This may be flushed down into the interstices by the use of water from the street hydrants. Clay or sand on top of or mixed with the stone, merely turns to dust and mud, is forced up from between the stones and has to be scraped up and carted away every spring. The bond thus produced, moreover, is merely temporary. In wet weather moisture is absorbed and the roadway becomes rough and slushy on the surface. But where the roadway is thoroughly hardened by rolling, the stones take a mechanical clasp, the one of the other, which will not yield in wet weather nor retain moisture to at all the same degree.

The stone crusher should have a screen attached whereby the stones could be separated into various grades according to size, the larger stones to be placed

in the lower layers of the roadway and the finer on top. The grades frequently adopted are:

- 1st. Such as will pass through a 2 1-2 inch ring.
- 2nd. Such as will pass through a 1 1-2 inch ring.
- 3rd. Such as will pass through a 1 inch ring.
- 4th. Chips and dust screenings.

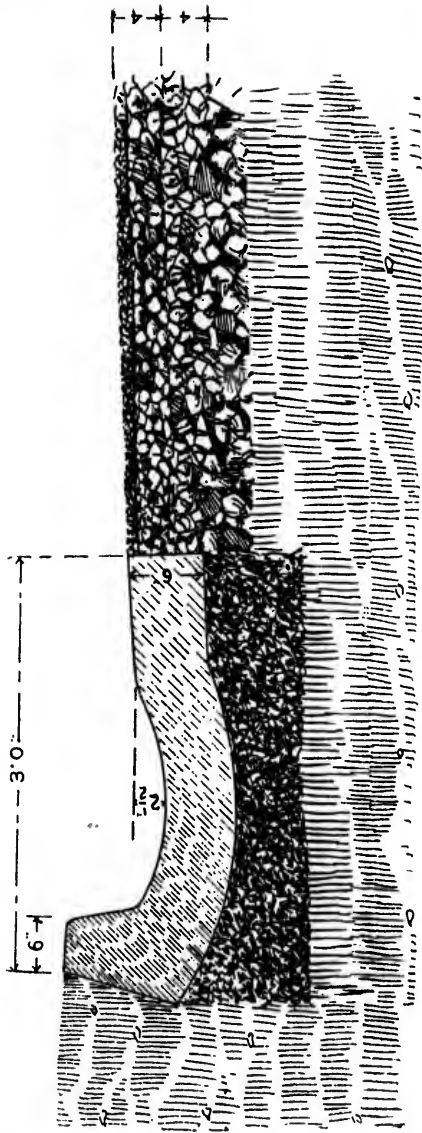
When stones are laid on the roadway large and small indiscriminately, the smaller wear more quickly than the larger and a rough surface will result. The larger stones have a tendency to loosen, as their bearings are not so perfect, and they will be found rolling under the feet of horses and under the wheels of vehicles. A rotary screen should be secured by your city without delay.

PREPARATION OF ROAD-BED—WIDTH OF STREETS.

The present practice in St. John is to merely spread the crushed stone over the surface of the travelled roadway, without previously preparing the road to receive it.

The first step in constructing a macadam roadway is for the engineer to take a series of levels on the street so that a suitable grade may be decided upon and the street properly levelled as regards both cross-section (from side to side) and from end to end.

This grade having been decided upon the width of the metalled roadway can be staked out. This width on the majority of residential streets need not exceed twenty-six feet. It has been the custom to place sidewalks at the edge of the street line, and to devote the remainder to roadway and ditches with just enough space for a row of trees. This on a sixty-six foot street allowance sometimes leaves forty feet of roadway to construct and maintain. This excessive width merely creates additional expense in first cost and subsequent maintenance. Twenty-six feet of roadway is found in many cities to afford ample accommodation for the traffic on some of the best residence streets, and the width on some is even less. This will afford room in some cases to place the sidewalks outside the row of trees, and at the same time leave a strip of sod, two to four feet in width, between the



MacAdam Roadway with three feet granitoid curb and gutters; earth excavated, graded, drained and rolled; broken stone screened so as to separate into different sizes; placed in layers, largest size at bottom, smallest at top, each rolled to place. The upper layers of hard trap rock, such as may be seen at Blue Rock, Carleton.

walk and the roadway. This strip of sod, like a curb, prevents the sidewalk being disturbed when the edge of the roadway is being rolled. A broad roadway is certainly very handsome, but so also are wide stretches of sod. The space originally occupied by the sidewalk may be added in appearance to the original depth of the lawn if the fences on the street line are removed. This narrow width of roadway is suitable for residential streets only. Business streets usually require pavements for sidewalks and roadway extending over the entire street allowance.

The width of roadway having been staked out, it should be excavated in accordance with the required grade so as to form a receptacle for the stone. To properly grade the roadway and excavate will frequently necessitate the handling of a good deal of earth. This earth should be used as far as possible in levelling the sides of the streets, filling in low lots adjacent to the roadway, disposing of the remainder as policy may dictate, usually in the same manner as street sweepings.

GRADES.

The irregularity of the street grades in St. John is very noticeable. The roadways and sidewalks appear to follow the natural undulations of the ground, with little attempt at doing away with knolls and hollows. On side-hills, too, the cross sections of the street are frequently awkward and could be very much improved by lowering and raising sidewalks and roadways, thus tending to equalize the slope. On some streets, especially business streets, this is sometimes very difficult to correct after the street has been built up and street car tracks laid. The grades of all new streets should be established by the city engineer and plans kept on file. Residences or stores placed on the adjacent property could thereafter be built with this in view.

CURBING.

Very little curbing has been used on the streets of St. John. Curbing defines the roadway, forms the gutters, protects boulevards and sidewalks and keeps the road metal in place. As pointed out previously the absence of curbing prevents rolling the roadway at the side, because of the injury done to sidewalks, and consolidation is thereby very imperfect.

The best material for curbing is flag-stone four or six inches in thickness. Each stone should be not less than three feet in length and should be about eighteen inches in depth. The curb should not be set so high that water cannot flow readily over it from the sidewalk and boulevard into the gutter. A good substitute is cedar plank. It should be spiked to six inches in diameter cedar posts two and one-half feet in length, which are placed at intervals of eight feet and bevelled at the top with an incline from the roadway so that the curb will slope toward the boulevard. While wood is extensively used for curbing in most cities of the Dominion, on the less important streets, yet where stone is plentiful and easily obtained, as in St. John, its greater durability and better appearance will recommend its general use.

FOUNDATION.

A firm unyielding foundation is an absolute necessity for any kind of pavement. This is one of the chief defects in roadways in St. John. All road coverings, whether broken stone, asphalt, stone blocks, vitrified brick, wooden block, form merely a wearing surface. The weight of the load must be borne by the foundation beneath.

The natural soil if kept in a dry state will support any load. For this reason, careful drainage is necessary. The practice in St. John appears to have been an effort to cover and fill up places by dumping into them loads of broken stone rather than by removing the water in drains. In this way the roadways on many of the streets are raised away above the elevation of the sidewalks and adjoining property.

A foundation for a macadam road is obtained by drainage of the roadbed and thoroughly consolidating it with the steam roller. In certain cases, especially on clay soils, and for the most durable class of broken stone roads, a foundation layer of large stones may be placed on edge, the projection points being chipped off and wedged into the interstices. But for ordinary cases the layers of crushed stone may be placed directly on the natural earth.

With stone block pavements, vitrified brick and asphalt a bed of concrete placed upon the earth foundation is necessary. In some cases vitrified brick and stone blocks have been laid directly on the natural soil or a layer of sand with ap-

parently good results. This can only be done where the soil is porous and has good natural under drainage. Even then the tendency invariably is for the bricks or stone blocks to settle irregularly and the pavement becomes in the course of a few years very rough and uneven. This is especially the case in such a climate as that of New Brunswick, where alternating frosts and thaws keep the ground in a moist condition for a considerable part of the year. The upheaving action of frost alone will in time unsettle a pavement thus laid. The advisability of a bed of concrete on which to place the stone blocks or brick cannot be too firmly impressed. With asphalt the greatest enemy is water, and a bed of concrete is absolutely indispensable.

STREET RAILWAY TRACKS.

Street railway tracks on a street are always objectionable so far as travel with carriages and wagons is concerned and are a source of difficulty and expense in paving. This may be lessened by the use of grooved girder rails in place of the T rails at present used on the streets of St. John; since, with the former, the pavement may be kept flush with the top of the rail.

The wear of wheels at the side of the rails will show itself on the most durable of pavements. Wheels of vehicles travelling in the roadway on the tracks pass in a line at the edge of the rail. These wheels, when going off the track, frequently catch on the rail and slide some distance, thus wearing the pavement rapidly.

On broken stone or macadam roadways constant care must be taken to repair the effect of this wear. Hollows appearing at the edge of or between the rails should be at once attended to. In laying macadam between and around tracks the first layers have to be thoroughly rammed between the ties. The stone must be placed in this way until higher than the rails before the steam roller can be used to complete consolidation.

Stone blocks (or setts), vitrified brick or wooden blocks may be used, but asphalt is very unsatisfactory between car tracks, as the constant vibration to which it is subjected cracks and destroys it very rapidly. Stone blocks or vitrified brick should be used between the track on streets paved with material other than macadam. The remainder of

the street, the sides, may be paved with asphalt; and this combination makes one of the best forms of pavement for busy streets; but a course of stone blocks set in concrete should be fitted closely to the outside of the rail, the stones being laid alternately lengthways and across so as to form a toothed junction with the asphalt.

In order to intercept the water, gullies connected with the sewers should be placed between the tracks wherever the nature of the grade indicates a suitable location. The best form of gully for this purpose is oblong, making an opening from rail to rail, protected by a grating. On steep grades there should be places at frequent intervals so as to arrest the flow of water.

ROCK AT THE SURFACE.

Where rock comes to the surface it is necessary to quarry enough to permit placing a body of crushed stone sufficiently deep to secure consolidation.

The drainage of such portions requires some modification. When the outcrop of rock is horizontal, or nearly so, it is merely necessary to provide channels filled with gravel or other porous material so that the water will not lie in pockets. In St. John the roadways passing over the hillsides frequently have ledges of successive strata outcropping. From between these strata water forces its way into the roadbed, making soft, spongy, springy spots. Such cases require careful attention. The water can usually be intercepted readily by tile drains laid across the road diagonally from the point where the moisture appears. Some quarrying and rock cutting may be necessary to provide a proper channel.

KING STREET.

King street, from the square to Water street, is paved with broken stone. As pointed out in discussing macadam (broken stone) pavement it is not suitable for an important business thoroughfare, such as King street. The steep grade, however, renders the use of asphalt, otherwise the most suitable pavement, impossible. A secure foothold for horses is a necessity and stone blocks are for this reason most suitable. Traffic up and down this excessive grade must necessarily be slow, so that the objectionable features, roughness and noise, are reduced to a minimum.

COST OF PAVEMENTS.

In the matter of cost most pavements, including macadam, require pretty much the same expenditure up to a certain point—the completion of the grading, under-drainage, curbing and excavating, preparatory to receiving the paving materials. Up to the layer of concrete the cost, excluding macadam (that is for asphalt, stone block, vitrified brick and wood pavements), is very much the same, but may vary according to the depth of concrete used and the material for curbing, whether stone or wood. As I have no data for calculating the amount of grading, excavating and drainage needed in St. John, it becomes impossible for me to make an estimate of the cost of the work applicable solely to your city.

The following indicates the basis for a strong form of pavement, on which the cost of a macadam roadway 27 feet wide, for a residence street, may be estimated per lineal feet:

Excavating and grading roadway.....	.30
Grading boulevard.....	.06
Water and sprinkling.....	.04
Rolling.....	.10
Crushed stone in the street at \$1.00 per cubic yard.....	1.00
Drainage.....	.10

Total per lineal foot of street.....\$1.60
Total per lineal square yard.....\$0.53 1-3

With cedar curbing, 4x12, the cost would be \$1.72 per lineal foot or 57 1-3 cents per square yard; with stone curbing, \$2.80 per lineal foot or 86 2-3 cents per square yard.

In estimating the cost of an asphalt pavement to replace the cedar block on such a street as Main street, with a roadway 40 feet wide, the actual cost would be about as follows:

Removal of cedar blocks and excavation per lineal foot.....	44 4-9
Drainage per lineal foot.....	.15
Concrete, 6 in. layer, per lineal foot.....	2.22 2-9
Asphalt surface, per lineal foot..	4.44 4-0

Total per lineal foot.....\$7.26 1-9
Total per square yard..... 1.63 3-8

The maintenance is usually estimated on a basis of eight cents per square yard per annum. The cost, therefore, for a five years' guarantee is 40 cents; 10 years, 80 cents; 15 years, \$1.20. The total cost then under a five years guarantee is

\$2.03 3-8; under a ten years' guarantee, \$2.43 3-8; under a fifteen years' guarantee, \$2.83 3-8. In the above estimate the profit of the contractor on initial construction is not included and is regulated by competition.

Asphalt pavements, as previously stated, are laid by contract. This material is one which can be greatly adulterated and it will usually be advisable to have the work done by a reliable company under a long term in guarantee. Recent inquiry shows that Ottawa has had rock asphalt pavements laid, with maintenance guaranteed for 15 years, for \$3.10 per square yard; Montreal has had rock asphalt pavement laid, guaranteed for a similar term, for \$3.09. Trinidad asphalt, maintenance guaranteed for 10 years, has cost in Montreal \$3.43 per square yard; Toronto, \$2.60; in Hamilton, \$2.15. Montreal paid \$2.85 for Trinidad asphalt on a five years guarantee. The apparent disparity in these prices may be accounted for in part by differences in specifications regarding drainage, concrete foundations, and as regards special work on gutters, curbing, etc.

For a roadway of the same description as that on which the cost for broken stone was computed, 27 feet wide, an estimate for brick pavement would be as follows:

Excavation and grading roadway, per lineal foot.....	.30
Grading boulevard.....	.06
Concrete, 6 in. layer.....	1.50
Drainage.....	.10
Brick surface laid.....	3.45

Total per lineal foot.....\$5.41
Total per square yard..... 1.80 1-3

The following is an estimate of the actual cost of laying one square yard of stone block pavement, on a basis of the whole of the work being performed by the city. Labor on street railway allowance would be slightly more expensive:

Stone in quarry.....	.10
Quarrying stone.....	.25
Making blocks.....	1.20
Hauling.....	.10
Laying and grouting.....	.75
Removal of old pavement, excavation, grading, etc.....	.13
Drainage.....	.05
Concrete, 8 in. layer.....	.67
Sand coating.....	.05

Total per square yard.....\$3.50

MUNICIPAL IMPROVEMENTS.

The substantial growth of St. John since the disaster of twenty years ago, which laid the city in ruins, is a matter which cannot but impress the visitor. Much of this is due to the splendid location. On one side the rugged grandeur of the Bay of Fundy, on another the magnificent St. John River, the eastern sea-board terminus of the Canadian Pacific Railway, the terminus of a branch of the Intercolonial, the situation is one which combines an attractive residential location, with the advantage of a commercial and shipping centre. That this has been appreciated by your citizens is evidenced by the manner in which the city has been rebuilt. It is characterized by dwellings of modern design, well-kept and tasteful lawns, handsome churches and public buildings. To this is added pretty public squares in the central part of the city and the large recreation park surrounding Lily Lake on the outskirts of the city. There has been installed excellent systems for sewage disposal and water supply. Very large expenditure, approaching \$700,000, is being made for harbor improvements in order to develop the splendid natural opportunities of the situation as the leading winter port for Canada.

That so much enterprise has been shown in thus developing your city and adding to its prominence among the metropolitan centres of Canada is certainly good ground for believing that when the advantages of well-paved, well-designed streets are rightly understood the means adopted for their improvement will be equally energetic with those which have already so greatly enlarged the city's possibilities commercially and otherwise.

GOOD ROADS ASSOCIATION.

The formation recently of a Good Roads Association in your city indicates the awakening of public opinion in this regard. The movement has received the

support and approbation of the members of the Provincial cabinet, as well as many other influential citizens. This improvement of common highways as an aid to traffic should be well understood in a city where so much has already been spent in smoothing the machinery of travel and transport along the line of harbor improvement and railway terminal requisites. It is from the centres of thought, the cities and towns, that should spring the desire for general highway improvement—this more by example than by precept. While street improvement need not be undertaken with this object in view it is, nevertheless, one of the results, that a model is furnished to the rural communities and the cause of "Good Roads" thereby greatly aided. By no means can the towns so assist the Good Roads movement as by constructing their own streets properly.

In conclusion, I wish to again point out that the purpose of this report has not been to make direct recommendations regarding the construction of particular streets, but rather to outline in a more general way the defects of the present system and the means whereby they may be remedied. If it merely arouses a more lively interest in these matters it will, I believe, be of service to your city.

It is a pleasure to acknowledge the courtesy extended me while in St. John by the Mayor, members of the Council, members of the Provincial Legislature, promoters of the Good Roads Association and others, for which I am much indebted.

I have the honor to be, gentlemen,

Your obedient servant,

A. W. CAMPBELL,

Civil Engineer,

Prov. Road Commissioner for Ontario.
Dated at the Department of Agriculture, Ontario, this 19th day of November, 1897.

