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PUBLIC SQUARE, TRAFFIC CENTER OF CLEVELAND, OHIO

THE paving situation in Cleveland is of unusual interest because that city stands high in the records of the United States Census in the percentage of paved streets in relation both to population and to the length of all streets. Furthermore, one paving material—brick—has been steadily growing in favor until last year over 90 per cent. of all the work completed was built of that material, and Cleveland has now more miles of brick-paved streets than any other city of the United States. The history of paving in Cleveland during the past fifteen years will show how brick has displaced other good paving materials and will also shed some light on the question as to the extent to which local conditions and the merits of the material have contributed to the result.

Before the year 1889, there had been laid in Cleveland three kinds of pavement—tar concrete, Nicholson wood blocks and Medina stone. The tar concrete was of the sort laid in Washington during the period from about 1870 to 1885, about all of which proved a failure there; and the Cleveland variety was poor of its kind, was a failure from the beginning and little of it was laid. The Nicholson pavements did not prove very satisfactory owing partly to the fact that the tar with which the blocks were treated was too volatile, and because not sufficient attention was paid to the maintenance.

Stone blocks made of Medina sandstone were also laid at an early period and, except for the fact that the blocks were not as well shaped as they were later, these pavements were very satisfactory, some of them giving fair service to this day. For a few years Medina was about the only paving material used in Cleveland. This stone, which occurs in Medina county and thereabouts in New York State, has great merits for paving purposes. The stone is gritty enough to give a good foothold to horses and is hard enough to withstand ordinary traffic. Moreover, it has the peculiarity of wearing flat and the blocks do not round off to a cobble-shaped top like most granite or chip off at the joints. The principal objection to the material is the expense, and of course, like all hard block pavements, it is noisy.

Asphalt was the first material to challenge the supremacy of Medina stone in Cleveland. The promoters of this material probably made the hardest, and in some respects the most picturesque, fight that has ever been made in any American city in behalf of any paving material. Committees were taken all over the country to examine and report on

asphalt streets, advertising space was bought in the papers and circulars were mailed to property owners and citizens generally in such abundance that after a while sensible people threw them in the waste basket as soon as their eyes caught the word asphalt. In time asphalt was introduced on a number of small streets and on one long one.

At about this same time, however, brick pavements were coming into use in the small cities. From the beginning this class of paving material had an advantage over asphalt in cost, a matter of almost controlling importance where pavements are laid on request of property owners who have the assessments to pay. As soon as a few years' trial removed the doubts as to durability, brick rapidly became the favorite paving material. At first small blocks were used, but these were increased in size later; and the year 1895, which is chosen for comparing the past and the present status of the paving question in Cleveland, marks the time when blocks five inches in depth came into general use. At the same time the

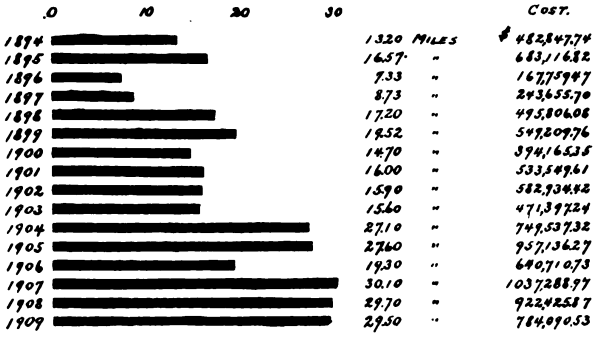
CLEVELAND'S FIRST ASPHALT PAVEMENT BEING REPLACED WITH BRICK

use of the tar filler in the joints was discontinued and cement grout filler was adopted. The first brick pavement, laid in 1889, had sand filled joints and a few other streets were laid this way, but in practically all of the pavements laid between 1889 and 1895 tar filler was used. In 1895 the total amounts of all kinds of existing pavements were as follows:

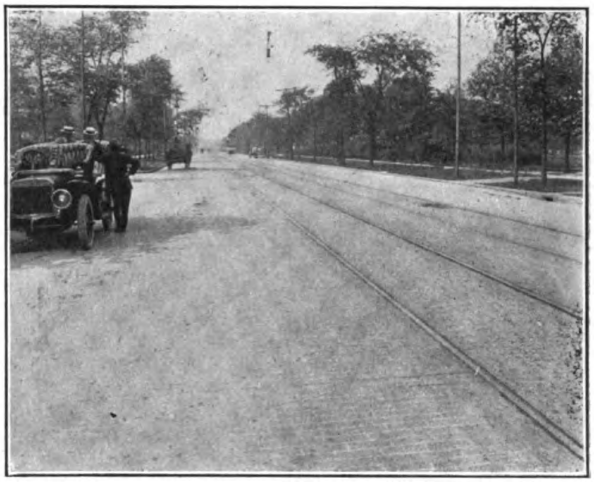
	Miles.
Asphalt	3.94
Medina stone	85.97
Brick	29.22
Wood	1.46
Cinder macadam	.73
Cobble stone	.05
Miscellaneous	.67
Total	122.04

The amount of work completed that year was: Brick 5.91; Medina blocks, 7.50; common Medina, 3.06; asphalt 0.1. The prevailing contract prices per square foot that year were: Medina blocks, 28½ to 31½ cents; Common Medina, 21 to 21¾ cents; Brick 10 to 11 cents; Asphalt, 33 cents.

At the close of the year 1909 the total amounts of all existing pavements in miles was as follows:



MILES OF CLEVELAND STREETS PAVED, BY YEARS



FIVE-INCH BRICK ON CONCRETE. FOUR YEARS OLD

Medina stone on concrete, dressed blocks	7.2	
Medina stone on concrete, common blocks	2.0	
Medina stone on sand, dressed blocks	50.0	
Medina stone on sand, common blocks	36.5	
		95.7
Sheet asphalt		24.6
Brick on concrete	30.0	
Brick on sand	231.5	
		261.5
Tar macadam		.7
Bitulithic		.4
Limestone macadam		1.5
Wood		1.1
Total		385.5

The mileage of streets completed during the year was as follows:

Tar macadam	.1
Asphalt	1.1
Medina stone	1.0
Brick	27.3
Total	29.5

The prevailing contract prices were about as follows: 5-inch brick on sand, 14 cents per square foot, 5-inch brick on concrete, 20 cents; Medina blocks on sand, 30 cents; on concrete, 36 cents; asphalt, 23 cents; Medina, common, 26 cents; bituminous macadam, 25 cents.

The low prevailing contract prices noted above are partly the result of the fortunate situation of Cleveland as regards

FIVE-INCH BRICK ON SIX-INCH CONCRETE. HARD-TRAVELLED STREET. FOUR YEARS OLD

local conditions and supplies, and partly the result of specialization. Where any one kind of paving material is used in a city to the practical exclusion of others, an opportunity is afforded for the development of a great organization with many ramifications tributary to the industry. In the first place, the soil in the part of the city where pavements were first laid made the usual concrete foundation unnecessary. The soil is a fine sand with some loam, but not enough to prevent it from being very pervious to water. Hence by the use of water for compacting the soil a sufficiently stable foundation was secured. If concrete had been necessary, the brick paving industry would have been handicapped, because concrete was then much more expensive to lay than it is now.

Cleveland possesses another advantage, in that it is more favorably situated than any other city of its size so far as propinquity to the brickmaking centers is concerned. The first brick used in Cleveland were shipped in from considerable

ONE OF THE BRICK PLANTS WHICH SUPPLIES CLEVELAND

distances. Porter, Union and Canton brick figured largely in the early days. In recent years, since 1895, five companies have established brick making plants within the switching limits of Cleveland—that is within limits in which the freight rate is 25 cents a ton to any point within the district. These companies are the Deckman-Duty, at Collingwood; Metropolitan at Willow; and the Newburg Brick and Clay Co., the Cleveland Brick and Clay Co., and John Kline and Co. at Wychleff. The history of the Bessemer brick affords an interesting sidelight on the development of a source of supply as the result of a great demand. These bricks are made by a company in Youngstown whose principal business was the quarrying of limestone. Over the bed of limestone was a bed of shale that had to be removed and was a source of expense in the regular business. To utilize the waste, the manufacture of paving brick was undertaken and the bricks were shipped to Cleveland. In time the brick-making became a bigger industry than the limestone quarrying. Later, when the competition from plants nearer Cleveland became pressing, expensive continuous kilns were introduced and the cost of manufacture so reduced that the 65-cent freight rate was not prohibitive. Four-inch paving brick can be bought for about $16 per thousand in Cleveland and five-inch block for $20, both running about 40 to the square yard.

Cement, too, is low in Cleveland, water competition making railroad rates low, moreover Portland cement is made at Sandusky and other near-by points. Sand for grout and coarse sand for ballast or cushion is supplied by a company that dredges with pumps from the bottom of Lake Erie. This company has excellent facilities for unloading from the scows and transferring to cars. The third material used in concrete, stone, is not so cheap in comparison, but is no more expensive than in many cities. Limestone may be obtained from immense quarries owned by the Kelley Island Company, Sandusky, and a hard sandstone is obtained from a quarry near the city. Crushed stone costs about $1.25 per cubic yard on cars anywhere in the city. At the iron furnaces near the city slag is crushed, which also is used for foundation purposes.

In cost of maintenance and durability, brick pavements have made good in Cleveland. Since the first pavement was laid in 1889 only two streets have given out sufficiently to require resurfacing. Jennings avenue was one of these. This street was paved in 1890 with small bricks, probably Porter, laid on a sand foundation with sand joints. In spite of the inferior construction, this street held out until 1908, when it was replaced with a five-inch brick laid on a concrete foundation. The other street was Detroit avenue, laid by the village government in territory since annexed to the city. This street was pavd originally in 1889 with the same general construction as Jennings avenue. It also was repaved with five-inch brick on concrete in 1908.

FIVE-INCH BRICK ON SAND, CEMENT FILLER. SIX YEARS OLD

Regarding the cost of maintenance few details are readily accessible, but sufficient to bring out prominently the fact that the cost of maintaining the pavements in Cleveland is very low. In 1909 the Superintendent of Streets, who has charge of all repair work, spent $118,400 on paved streets. Of this sum $59,747 was recovered from plumbers and others who made openings in the streets, for which work they are charged cost plus 15 per cent. The balance, $58,653, is the total expenditure for maintaining about 7,000,000 square yards of pavements of all kinds. As the percentage of brick so greatly exceeds that of all others and the cost per square yard is so low, the error is not great in prorating this cost over the whole yardage and assuming the figure obtained to be the cost of maintaining brick. This amounts to less than one cent per square yard. It may be true that the maintenance ought to be more and an allowance made for renewals. But the same argument holds true of other pavements in other cities; as in New York for instance, where 15 cents per square yard is spent for maintaining pavements, and even that sum is not sufficient. It is true also in Washington, where a charge of from 5 to 10 cents per square yard does not keep the streets up to a uniform standard of excellence. However, a just comparison would require a consideration of the relative traffic on the streets of the several cities.

FIVE-INCH BRICK ON SAND, TAR FILLER. FOURTEEN YEARS OLD

Methods of constructing brick pavements in Cleveland have been influenced by the peculiar soil that is found in certain parts of the city, mostly the old part, where, in the vicinity of the lake front and of old stream beds, in ages past a fine sandy material has been deposited. The method of preparing the foundation is peculiar to Cleveland. After the rough dirt has been excavated, dams are built dividing the roadbed approximately into squares and these are filled with water. The water is usually turned on at night and by the following morning will have all disappeared. If there were any old trenches in the street not well settled they will be shown by depressions. The dams are then leveled, the depressions filled and the surface shaped and rolled in the usual way. A bed of ballast eight inches thick is laid on streets where the natural soil is not of sand. This has been the most general method of construction since five-inch brick were used. These brick, cemented with grout, perform practically the same service as a bed of the same thickness of concrete. Of course it is not claimed that this monolithic surface of five inches is as strong as a surface of four inches of brick and a layer of four inches of concrete besides. But the experience with this construction in ordinary streets has been eminently satisfactory.

Where concrete is used as a foundation, it may be four inches thick or, if the street is very heavily traveled or has car tracks, it may be six inches thick. Portland cement only is used. The mixture is one part of cement, three of sand

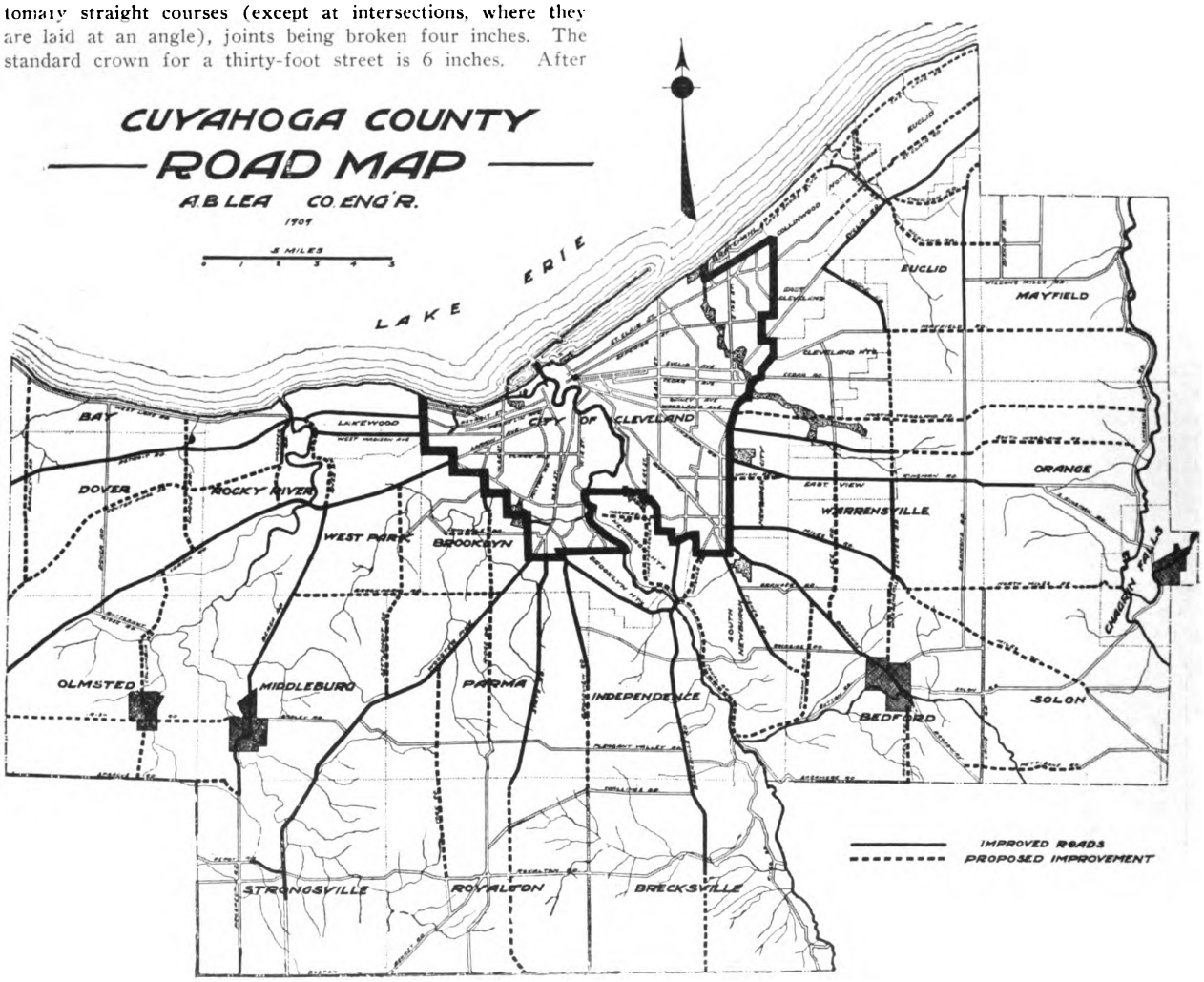
and six of broken stone. In the case of hand mixing, the mortar is made before stone is added. The large contractors as a rule use concrete mixers. A cushion coat of sand two inches thick is laid over the concrete.

The paving brick which are allowed to be used are described in the specifications as "the best quality of sound, hard burned, vitrified, machine pressed paving brick, made and burned expressly for street paving purposes." The surface dimensions are 3 by 8½ inches and the depth 5 or 4 inches. The usual indentations are made at the ends of the brick and quarter inch projections on one side, one near each corner, for the purpose of keeping them apart. Brick with square rather than rounded edges are used. Any brick when subjected to the standard rattler test of the National Paving Brick Manufacturers Association for one hour must lose not more than 20 per cent. in weight. Bricks equivalent to eight per cent. of the volume of the rattler (which is 12,300 cubic inches), are put in the machine with a shot charge of 75 lbs. of 2¼ by 2½ by 4½-inch cast iron blocks, and 225 lbs. of 1½-in. cast iron cubes. The amount of water absorbed in a 48-hour test after 24 hours baking must not exceed 4 per cent. In a city like Cleveland, where brick have been laid for so many years and the engineering force has been permanent, being unaffectd by changes of administration, there will naturally have grown up a corps of engineers and inspectors who are good judges of brick and can reject the poor ones at sight. Practically they do this, but condemned brick are of course subject to test.

Before laying the brick, a board is laid alongside the curb and a row of brick laid lengthwise next to it. Before the rest of the roadway is grouted this board is removed and the joint filled with bituminous filler. The bricks are laid in the customary straight courses (except at intersections, where they are laid at an angle), joints being broken four inches. The standard crown for a thirty-foot street is 6 inches. After

PAVED WITH BRICK IN 1904. SHOWS LONGITUDINAL BRICK ALONG CURB. CLEVELAND

laying, the bricks are rammed and rolled. Care is used throughout to avoid chipping. The contractors as a rule use tongs and conveyors in handling the bricks both from cars to wagons and from the piles alongside of the street to the work. The conveyor most used is simply a frame carrying roller whose axles have roller bearings. Another type of conveyor used, an invention of a Cleveland foreman, is a trianguiar framework, two of the sides being approximately level, one of which carries a trolley by which the tongs with a load of bricks is carried to the point of delivery by gravity, and the other leg carrying the empty tongs back.



IMPROVED ROADS IN CUYAHOGA COUNTY, OHIO

The final process of paving is the grout filling of the joints. This is made one part Portland cement and one part of sharp lake sand. The sand and cement are mixed dry first and after the water has been added is kept in agitation constantly. The grout is swept into the joints with brooms, each portion of the surface being gone over twice and if necessary three times or more. Traffic is kept off the street for seven days.

Particular attention is paid to the details of construction, such as the application of the cement grout. On most of the pavements Cleveland uses the cement grout in preference to the bituminous filler, as they find the brick chip less at the edges; although a few streets have been filled with the latter.

ROADS OF CUYAHOGA COUNTY

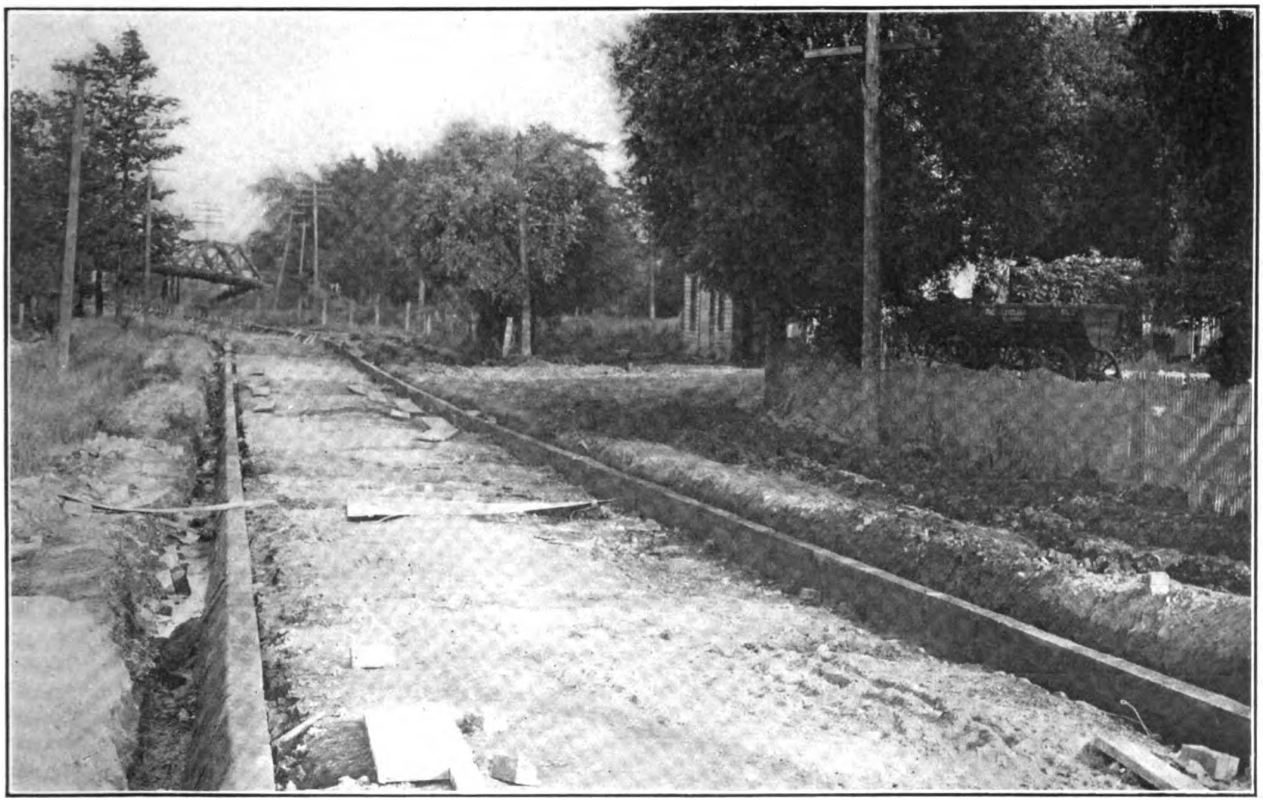
Cuyahoga County, Ohio, is said to have more miles of permanent pavement than any other county in the United States, and excepting counties that are included wholly within city limits, the statement is probably correct. However, the fact that the city of Cleveland, with its half million inhabitants and its high valuation is located within the county, is an important factor in bringing about this condition, for Cleveland paid 85.7 per cent. of the county road tax in 1909. As the county extends over a territory 31 miles in length by 16 miles in width, many of the roads are of the usual character of county roads, and the methods adopted in improving them are similar to those used in hundreds of other countries.

Public work began on a large scale eight years ago, and in the season of 1909 the engineering department had under its supervision the construction of 165 miles of pavements, besides that of two large bridges and a number of smaller improvements. To manage all this work requires an organization of unusual size, and during the busy season the engineer's office employs as many as one hundred men. The County Engineer is elected by the citizens, and he appoints two assistant engineers, one to have charge of bridges and the other of roads. During 1909 A. B. Lea, who has since been appointed Director of Public Service for the city of Cleveland, was County Engineer. Assistant engineers, draughtsmen and experienced inspectors are also included in the force. Daily reports are made by the inspectors and mailed to the engineer's office. All records are filed in accordance with an excellent system in charge of special filing clerks.

The system adopted for carrying out the plans of permanent paving contemplates, first, the paving of the main thoroughfares leading out of the city, and afterwards the cross-roads, thus forming a network of roads spreading over the whole county. This method best meets the needs of the two classes of citizens who use the roads—those who carry farm products to the city and those who travel from the city to their suburban homes or for pleasure. The benefits derived from the improvements also are two-fold, and they are not imaginary but are very practical matters well recognized by citizens generally. The farmer or market gardener, not hampered by the former difficulty of getting to market over bad roads in wet weather, can choose his own time for carrying his produce to the city. This has a tendency to equalize prices in the city market, as the supply is made to meet the demand. The other marked advantage is the enhancement in real estate values, particularly in the demand created for house lots on the part of city-dwellers desiring to escape the evils of congested population.

The presence of a trolley line alone is not sufficient to induce town-dwellers to move to the country, but they demand paved streets as well. County Commissioner Fisher says that the improvement of Bedford road, shown in one of the illustrations, increased the value of property from 50 to 75 per cent. The improvement of North Ridge road, according to the same authority, increased the value of adjoining property fully 100 per cent.

The natural soil of Cuyahoga county is clay of such a sticky nature that before the recent improvements the city was practically cut off from the country in wet weather. There were, it is true, some forty miles of plank roads which alleviated conditions to a limited extent; and an attempt at road improvement had been made by macadamizing, the clay foundation being rolled, a six inch layer of 2½-inch broken stone being laid first, covered with finer stone to a depth of four inches, and finally screenings being sprinkled over



MILES AVENUE, SHOWING TYPE OF CONCRETE CURB WITH SLANTING OUTER FACE, COUNTY WORK

the surface to fill the voids. These roads were failures because the stone used was not of a good quality for road making, questions of drainage had not been given proper attention and maintenance was neglected.

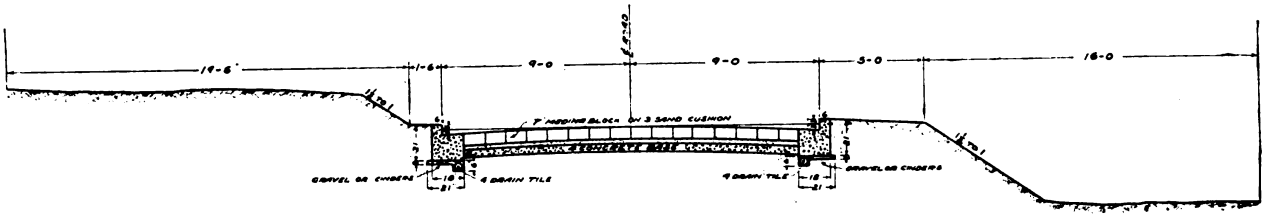
Thirteen years ago the county decided to experiment with brick, and two roads were built of a width of only eight feet, as they were built without proper drainage and without proper inspection during construction, these roads were not as successful as it was anticipated that they would be. They have been repaired recently and are now serviceable, although too narrow. Six years ago bitulithic was tried, but, probably from the lack of proper drainage, it has broken up to some extent.

The class of paving that is now being laid in Cuyahoga county, brick on concrete, is laid in accordance with the provisions of the Dodge law, which requires that the owners of a majority of the frontage on the proposed improvement petition for the grading, draining and improving of the road. The selection of the kind of paving is left to the decision of the County Commissioners. Included in the petition is a waiver of damages which the property-owners are requested to sign, releasing the county from any damages arising in any manner from the improvement. Following this petition the County Engineer makes plans and estimates of the cost and the commissioners make the assessment, which takes into consideration frontage, depth of property, character of soil and distance from the city of Cleveland. Usually it amounts to 25 per cent. of the total cost. The assessment and the advertisement for bids are usually published at the same time. The contract cannot be awarded until the assessment has been certified to the County Auditor for collection and ten per cent. of the amount—about 2½ per cent. of the contract price—has been paid into the county treasury. The County Commissioners are allowed to issue bonds to the amount of one per cent. of the tax duplicate, which gives it a fund of $3,000,000 to carry on work. Special legislation was obtained to facilitate the maintenance of roads, and competitive bids are received for materials and labor employed directly in repairs.

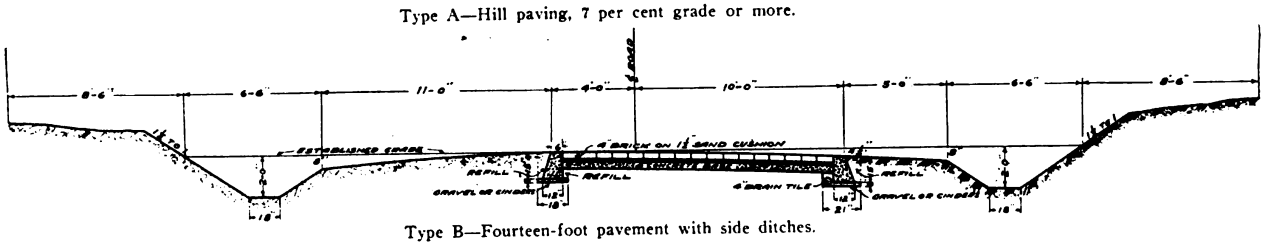
Work carried on under these laws consists generally of a roadway 30 feet wide between ditches. A curb is set four or five feet from one of the ditches. A brick pavement four inches thick on a four-inch concrete base is laid for a width of fourteen feet. This leaves a dirt road of eleven or twelve feet between the inner curb and the second ditch. The dirt roadway is much used by farmers in dry weather, as under those conditions they prefer it to the hard brick road.

Either sandstone or concrete curbing is used. The concrete curbing is six inches wide at the top, twelve at the base and fifteen deep. The sandstone curbing is four or five inches wide and fifteen inches deep.

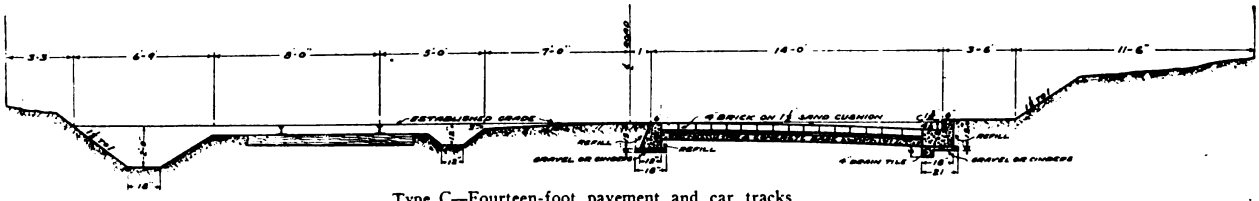
The specifications require that the brick used in the roadway shall be free from marked warping or distortion and uniform in size so as to fit closely together and make a smooth pavement. They must be homogeneous in texture and free from laminations and seams, evenly burned and thoroughly vitrified. Bricks kiln-marked to a heighth or a depth of over 3/16-inch are rejected. Rounded corners, the radius of which



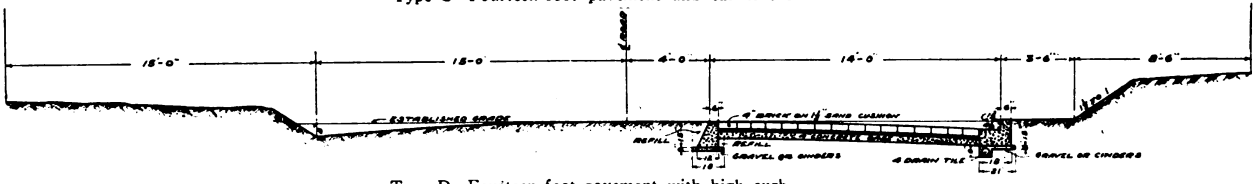
Type A—Hill paving, 7 per cent grade or more.



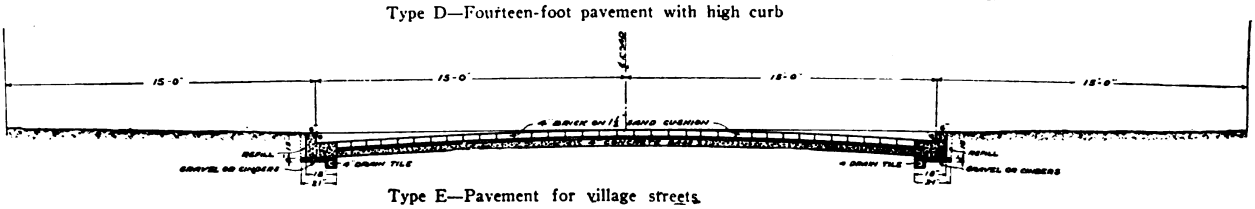
Type B—Fourteen-foot pavement with side ditches.



Type C—Fourteen-foot pavement and car tracks



Type D—Fourteen-foot pavement with high curb



Type E—Pavement for village streets.

TYPICAL CROSS SECTIONS OF CUYAHOGA COUNTY STANDARD PAVEMENTS

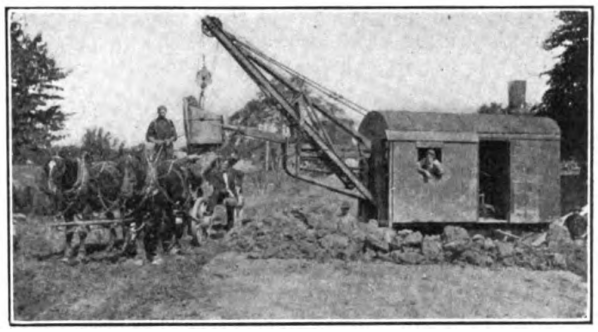
is from one-eighth to one-quarter of an inch, are required. Bricks must have not less than four nor more than six lugs or projections on one or both sides of the bricks, the area of each lug to be not more than one-half of one square inch, so that when laid there shall be a separation of at least ⅛ inch and not more than ¼ inch. Imprints of the name of the maker must be by recessed letters. The ends of the bricks must have a semi-circular groove so located that when the bricks are laid together the grooves will match. The size of the bricks shall not be less than 3¼ by 4 by 8½ nor more than 3½ by 4 by 9 inches. Any bricks that loose over 20 per cent in the rattler standard test, or increase more than 4 per cent after immersion in water for 48 hours, are rejected. On grades of 5 per cent or over a special form of brick suitable for steep grades is used.

Standard practice is followed in all matters of construction just as strictly as in laying city pavements. The subgrade is rolled with a steam roller. The concrete base, 4 inches thick, is composed of one part Portland cement, 2½ parts of sand and 5 parts of broken slag or stone of a 1½-inch size. If mixing is done by hand the cement and sand are mixed dry before the aggregate is added. On the concrete a two-inch cushion of sand is laid and shaped by a template. Bricks are laid at right angles to the curb lines, except at intersections. Longitudinal joints are broken by a lap of half the length of the brick. End joints are made close by the use of a steel bar applied to the ends next the curb. Every fourth course of bricks must be straightened in a manner satisfactory to the engineer. After a sufficient number of bricks are laid the pavement is sprinkled with water and soft or misshapen bricks are

COUNTY ROAD. FOUR-INCH BRICK, CONCRETE BASE, STONE CURB

removed. After rolling, the bricks are again inspected and any necessary replacements made. Grout is then applied in two coats to fill the joints to the top, but to insure that they are absolutely flush another sweeping of cement is required before the second has secured its initial set. A complete system of drainage is constructed in connection with the paving, just as in city streets, including storm water drains, catch basins and iron inlets.

Although the pavements laid in the county are practically city pavements, there are differences in construction methods. The high cost of transportation would make an eight-inch bed of ballast cost nearly as much as concrete, perhaps more in some locations. In all cases the grading is heavier, because in constructing the new roads the grades are improved by cuts and fills of considerable depth. Baldwin Brothers, of Cleveland, the largest single contractor for county work in 1909, and employing the largest plant, used a "New Era" grader with excellent results in grading some of the roads. On other jobs they had a Thew automatic steam shovel, which propelled itself on wide-tread wheels instead of the usual track. The contractors state that on cuts of 3½ feet they were able to develop the whole capacity of this shovel—from four to six hundred cubic yards a day. They found that it paid to use the shovel on cuts as light as 1½ feet. The way in which the shovel swings around at an angle of 90 degrees makes it very handy in loading wagons, as is shown in the illustration. At one time Baldwin Brothers had at work nineteen gasoline or steam engines. Bringing water to the work for concrete mixing and for the



THEW AUTOMOBILE STEAM TRACTION SHOVEL

engines they found a troublesome problem. They used a gasoline engine and a pump at the source of supply and in one instance laid two miles of pipe to carry water to the work. Transportation is another problem more difficult to solve than in the case of work in a city. Avery and other traction engines were used with trains of Troy three-yard wagons made for such purposes. While good results were obtained on jobs where this outfit is suited to the conditions, the results at other times were disappointing. On long hauls over good roads with no very steep grades there is no doubt of the superiority of the traction proposition, but wet weather, bad roads and steep grades seriously interfere with its operation. Moreover, in all cases the method of loading and unloading requires to be carefully studied out in advance. The amount to be loaded and unloaded at one time is large, and the problem is to keep the men occupied between loads. Keeping them in motion by carrying them on the train does not solve the difficulty. While the traction outfit is almost indispensable in work of this kind, situated as it often is far from railroads, it behooves any one who intends to try it to work out his problem very carefully in advance.

COLUMBUS PAVEMENTS

Columbus, Ohio is a most progressive city in many branches of public work. There have recently been completed a water filtration and purification plant turning out an adequate supply of clean water and a sewage purification plant which is the second largest in the country. The sewage works including septic tanks and sprinkling filters have served as models for other installations and their operation is being waatched by engineers and others who are or may be engaged in solving similar problems of disposal in other cities. There is now approaching completion the first garbage reduction plant ever built wholly new by any American city, and the second one to be operated by a city. A municipal electric plant lights the city streets and has proved so satisfactory that its capacity has been greatly enlarged. The main street, lighted by arches, is justly famous for its attractive appearance, although it is doubtful if the intensity of the illumination is as great as on the streets of some other cities where high efficiency arcs have been placed at close intervals. The fire department is efficient and will soon be provided with auto apparatus. The largest city park, Olentangy, contains a municipal theatre. Rapid transit facilities are good and the cars large and com-

HAYDEN BLOCK, TAR FILLER. SEVENTEEN YEARS OLD. COLUMBUS

fortable. A well managed asphalt repair plant is one of the comparatively recent municipal enterprises.

In the field of street paving the city showed its enterprise more than twenty years ago by being among the first to construct the two kinds of modern street paving which are practically American inventions—brick and asphalt. Pioneers in new enterprises are apt to acquire experience from which they and their neighbors profit afterwards. So it has been with Columbus. Some of the earlier pavements of both brick and asphalt were inferior in methods of construction to forms that have since developed. Even these, however, were serviceable, though some of them have been resurfaced, and they were the means of developing this superior class of work. Small brick and some of special shape led to the development of the paving block of standard size, and dry asphalt mixtures served to prove the value of richer ones.

About 25 years ago the principal paving material in Columbus was Medina stone block and this is still a favorite material for the heaviest traveled streets. The cost is so great, however, that the interest on the difference in price is great enough to pay for relaying a brick pavement by the time it would wear out on the same street. The accompanying table prepared by Chief Engineer Henry Maetzel gives the record for all kinds of paving laid from 1887 to 1910.

The details for the year 1909 were as follows:

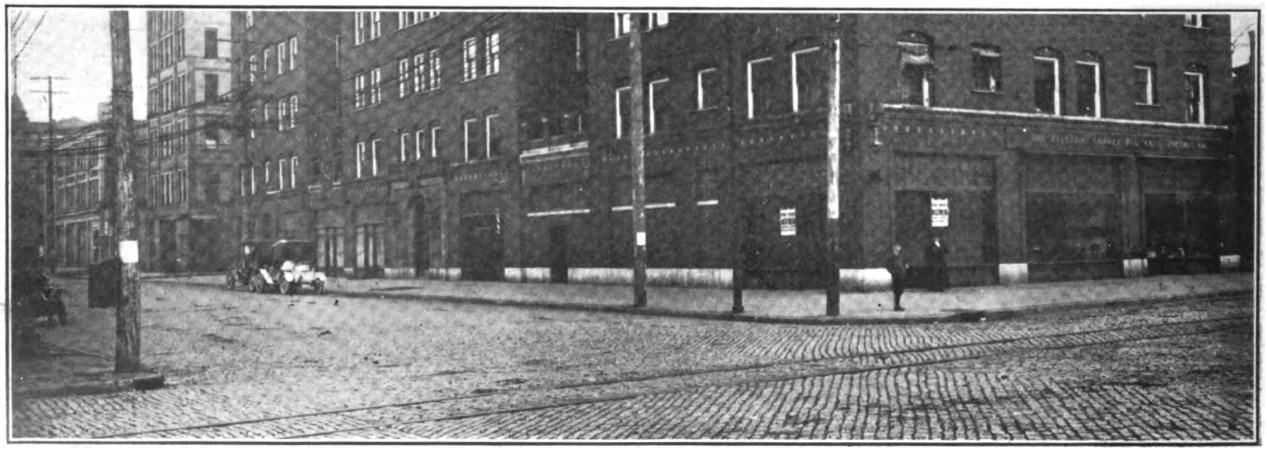
Pavement: All kinds, 19,652 miles, $641,979.34, total cost.
Asphalt: 1-in. binder, 2-in. topping, 26,205 sq. yds.; average price, $1.85.
Asphalt Resurface: 18,983 sq. yds., average price, $1.28.
Brick: Depth of sand cushion 1 in., 245,256 sq. yds. average price, $1.54.
Macadam: 1,557 cu. yds.
Average price per sq. yd. includes 6-in. concrete base, Portland cement, proportions 1-4-8.
Average price for grading, paid for separately, 40c. per cu. yd.
Guarantee on asphalt streets, 10 years.
Guarantee on brick streets, 5 years.
Guarantee on macadam streets, none.
Total thickness of pavements: Asphalt, 9 inches; asphalt resurface, 3 inches; brick, 11 inches; macadam, 14 inches.
Average price of straight curb, 45c. per lin. ft.
Average price of circle curb, 90c. per lin. ft.

(In connection with this subject it may be mentioned that the records of the engineer's office are kept in excellent shape although there have been no published reports for a good many years. The last report published was so detailed that

COLUMBUS, OHIO
Length of Streets in Miles Improved Each Year from 1887 to 1909

	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900
El-O-So Asphalt														
Trinidad Asphalt	1.392	2.093	3.202	2.940	1.279	1.705	.563	1.413		.178	.175		.114	
Kentuck Rock Asphalt				.819										
Lime Rock Asphalt									.416					
American Asphalt														
Bermudez Asphalt														
Trinidad Asphalt Resurface														
California Asphalt														
California-Cuban Asphalt														
Asphalt Block														
Asphaltic Concrete														
Medina Stone	.577	2.084	1.957			.083		1.553	.034	.181				.082
Mt. Airy Granite														
Georgia Granite	.213	.666		.185										
Greenfield Stone		.163	.104											
Hayden Block		1.220	1.164	2.657	5.380	4.357								
Miscellaneous Brick and Block	.856	5.011	12.757	4.410	13.463	8.975	.861	.939	2.956	5.451	1.564	1.668	.837	.220
Boulders	.736	1.267	1.067		1.326									
Macadam, Tarviated, etc						.225		2.108	1.879	.904	.169	.126	.209	
Totals	3.774	12.504	20.251	11.011	21.448	15.345	1.424	6.013	5.285	6.614	1.908	1.791	1.160	.302

	1901	1902	1903	1904	1905	1906	1907	1908	1909	Total Miles	Total Sq. Yd.	Total Cost
El-O-So Asphalt					.211	.632	.799	.071		1.713	33,678	$96,390.05
Trinidad Asphalt	.267	.295	.284	.148			2.495	.429	1.823	20.795	399,041	1,083,957.90
Kentuck Rock Asphalt										.819	14,943	39,563.33
Lime Rock Asphalt										.416	7,932	21,027.42
American Asphalt	.234									.234	7,331	11,811.90
Bermudez Asphalt						.173				.173	3,208	6,893.78
Trinidad Asphalt Resurface								.561	.510	1.071	75,825	152,265.30
California Asphalt									.237	.237	3,192	9,363.10
California-Cuban Asphalt									.394	.394	7,672	6,029.02
Asphalt Block				.105						.105	1,853	7,588.20
Asphaltic Concrete							.232	.438		.670	8,055	20,771.04
Medina Stone		.077	.045			.475				7.148	128,604	496,216.50
Mt. Airy Granite						.104	.095			.199	24,240	98,896.36
Georgia Granite							.077			1.141	40,390	173,818.88
Greenfield Stone										.267	5,282	19,087.66
Hayden Block										14.778	298,878	747,297.86
Miscellaneous Brick and Block	.689	1.243	1.091	1.760	4.249	9.256	6.622	23.289	15.869	123.936	2,268,169	5,067,495.60
Boulders										4.306	50,450	45,037.34
Macadam, Tarviated, etc		.173	.572	.770	1.009		.175	1.960	.819	11.098		232,107.30
Totals	1.190	1.788	1.992	2.783	5.469	10.640	11.350	26.748	19.652	189.500	3,378,743	$8,335,618.54



FOREGROUND, MEDINA SANDSTONE LAID IN 1888. BACKGROUND, FIRE CLAY BRICK LAID IN 1888, COLUMBUS

the cost of the edition was $10,000. For reasons of economy the reports have since been omitted.) The table shows that in the early years a fair amount of stone pavement was laid, but that it has practically gone out of use in new constructions. Besides Medina, some Georgia granite has been used but the high freight rates and the abundant supply of an excellent and cheaper material have restricted its use. Asphalt figures in the total of 189 miles of paved streets to the exten of 13 per cent. During the first year of the record more asphalt was laid than any other paving material, and Columbus seems to have even yet a certain fondness for this paving material, at least for the best residence streets. The trials of many kinds of asphalt would seem to indicate a desire to find a variety which would compare in price and durability with brick, but the figures do not indicate any decided success. A colored map of the city in the engineer's office, however, does show a considerable area of asphalt in the east end, the best residence section in the vicinity of Broad street, the show street of the city, which is a wide, parked highway paved with asphalt, shown in one of the illustrations. In all probability it is as handsome a street in general appearance as any in the country.

But brick paving holds the unquestioned supremacy in Columbus; a position it has gained through its quality, durability and economy. From an insignificant beginning in 1887 of 6 per cent. of the total it has climbed up to the first place and in 1909 constituted 80 per cent. of all the paving laid during the year and 72 per cent. of all the existing paving laid during the 23 years which the record covers.

The paving situation in any city cannot be fairly considered apart from the question of supplies of raw material. Columbus is an inland city, without water competition in freight rates. The soil in that part of Ohio is heavy, with occasional beds of clay and shale, and some sand not usually free from clay, and there are strata of oölitic limestone. The city obtains its best sand from Lake Erie, shipments being made from Cleveland, Toledo and Sandusky, the latter city having the bulk of the trade. Bank sand can be obtained from other localities by rail, the best of it from the vicinity of Marion. Within the last few years a dredging company has operated a suction dredge on the Scioto river, which flows through the city, and supplied sand and gravel. Their company has an excellent plant for unloading material from barges and transferring it to wagons, and it plays an important part in the local market. Limestone, of a quality suitable for concrete, occurs at a number of points a few miles out of town. The hardest stone, however, comes from the vicinity of Marion. Columbus is favorably located with reference to the manufacture of cement. The mills at Cumberland, Md., supply a considerable quantity, and other mills in Pennsylvania and Ohio are not too far away to be shut out of the market. Clay and shale suitable for the manufacture of paving brick occur at a number of places and the competition of various varieties have been sharp. Athens, Nelson, Portsmouth and Canton supply a large quantity. Asphalt from the West Indies can reach the market via Atlantic coast points with a freight rate of about $4 a ton. The rate on California varies from $10 to $12 a ton.

ASPHALT PAVEMENT ON BROAD STREET, COLUMBUS

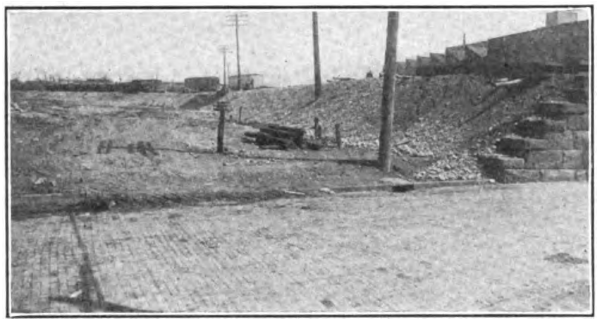
Tar for filling joints may be obtained from the Barrett Mfg. Company's plant in the city where a distillery, formerly owned by the Forest City Chemical Company, has been operated for many years. The company maintains special tank wagons and ships tar directly to the street for contractors who desire it. The tank is gauged before and after pouring, to determine the amount used, and the operation is simple and economical.

Construction methods as well as a good supply of excellent material have contributed to the pre-eminence of brick as the Columbus paving material. The engineer's specifications for all kinds of paving used in the city occupy 19 legal-sized pages of a printed form of fine type. They are complete and free

MAIN STREET, COLUMBUS, NATIONAL ROAD FROM CUMBERLAND, MD., TO RICHMOND, IND., PAVED IN 1890

from ambiguities. The Columbus method of laying brick pavement consists in laying a six-inch bed of Portland cement concrete and covering it with a one-inch cushion of sand. Upon this are laid 4-inch bricks and the joints are filled with tar. Pavements are guaranteed for five years.

In connection with the provision regarding paving, property owners are specifically given the right to remove and use any old material occurring in the street previous to paving. Rolling of the sub-grade is done by a roller weighing not less than 350 pounds per lineal inch of roller and the surface is rolled not less than three times. Several kinds of curbing are used; granite is used on some of the downtown streets, Medina on more, but Berea stone is the principal material. Com-



TAR-FILLED BRICK, LAID IN 1909. STANDARD CATCH BASIN. COLUMBUS

bined concrete curb and gutters are also used to a considerable extent on resident streets. Catch-basins are built by the paving contractors on new streets, and a very good form with cast iron inlet and trap is constructed for the low figure of $35. Concrete is mixed in the proportion of one part of Portland cement, 4 parts of sand or stone screenings and 8 parts of broken stone or gravel. As regards cement, the tests adopted by the American Society for Testing Materials are used as regards specific gravity, fineness, time of setting, strength, constancy of volume and composition. The broken stone includes sizes from 2½ to ½ inch. If the concrete is mixed by hand the sand and cement are first mixed dry. Some variation in the size of paving brick is allowed. The length may be from 8 to 9 inches, width 2¾ to 3¾ inches, depth 4 to 4½ inches. Edges are rounded ⅜ inch, the brick are molded with lugs or wide-spaced raised letters, 3/6 inch high, on one face. Bricks are subject to the rattler test of the National Paving Brick Manufacturers' Association, the rattler being 20 inches long and 28 inches in diameter, and revolving at a speed of 30 revolutions per minute for 60 minutes. Ten bricks makes a charge, and 300 pounds of cast iron foundry shot are put in the rattler. The shot are of two sizes, 1½ inch cubes and oblong pieces of 2½ inches square section and 4½ inches long. The loss must not exceed 18 per cent of the original weight. No test for absorption is specified. All bricks are laid at right angles with the curb, stretchers being used only at streets or alleys with center gutters. After ramming, the bricks are rolled with a roller weighing between 150 and 200 pounds per lineal inch. The coal tar paving pitch used in pouring the joints must have a melting point of not less than 130 degrees F. nor more than 140 degrees. It is poured at a temperature of 250 degrees. A top dressing of sand is spread over the pavement while the tar is still hot.

None of the Columbus contractors employs very extensive equipment in the construction of pavement except A. G. Pugh & Company, who have maintained an asphalt plant for many years. Luchtenberg & Company have used in grading, an Austin excavator and also a Thew steam shovel. The Austin excavator has given good results wherever large bolders or gravel were not found. The Thew shovel was used in excavating the earth for a street that was lowered in connection with the elimination of a grade crossing. The contractor speaks very favorably of the working of the shovel. It is specially commended for the accurate grading which it does and the even surface of the finished work, which requires very little trimming up afterwards. Bottom dump wagons are generally used. Long, low wagons have always been the type used in this section of the country, hence the Studebaker is a favorite, although Troy, Austin and other wagons are also used. Concrete mixers are generally employed in the foundation work, the Foote continuous mixer apparently being the favorite. Brick tongs are of course used in unloading cars, but conveyors are seldom seen in Columbus. This seems strange, as their cost is small and their economy beyond question.

One new paving material was used last year—Tarvia two-coat work—in which the hard limestone already mentioned as obtainable from Marion was used as road metal. From the excellent results obtained it seems likely that this may become a popular material in the outlying districts.

The municipal asphalt plant is one of the interesting Columbus enterprises, because the plant is an unusually good one, well adapted to the purpose and because it has been managed in an exceptionally able manner. Political considerations have not been allowed to hamper the management in the selection of employees. For a superintendent the city choose an experienced asphalt man, W. W. Horn, and the results justify the wisdom of their choice. The plant was built by Hetherington & Burner. It is substantially constructed of steel and concrete, is absolutely fireproof and is as nearly automatic in its operation as such a combination of machinery as can be. Four men can operate it and turn out all the material ordinarily needed for a single repair gang. While one street of 7,000 yards was being wholly resurfaced only nine men were required at the plant. The plant consists of a boiler engine, two seven-ton asphalt plants, on sand drier, one mixer, air pump, and the suitable elevators and accessories. The plant was described in our issue of March 3, 1909. In 1909 4,054 patches amounting to 10,247 yards were laid on 41 streets, the amount and cost of materials used being as follows: 1,619,100 pounds of sand, $647.64; 189,782 pounds asphalt, $2,277.50; dust, 224,875 pounds, $314.73; flux, 30,583 pounds, $257.83; cement, 2,695 pounds, $7.15; coal, 155,606 pounds, $120.52; labor, $3,554.59; miscellaneous, $643.62; total, $7,863.58.

The prices paid for material and labor were as follows: Asphalt, $24 per ton; limestone dust, $2.80; flux, $16.87; sand $.80; coal, $1.55; labor, $.22 2/9 per hour; foreman, $.40; engineer, $.30; rakers, $.27½; teams, $.40. The figures for the resurfacing job, on Eleventh avenue, comprising, 7,075 square yards, were as follows:

COST OF RESURFACING ELEVENTH AVE. WITH ASPHALT

Removing old asphalt and cleaning	$270.22	
7½ cu. yds. concrete stone	6.00	
6 cu. yds. asphalt sand, @ 80c	4.80	
8 barrels Alpha cement	9.50	
Labor on concrete and hauling materials	22.06	
Labor resetting curb	4.97	
Relaying 12 sq. yds. brick	8.00	
Total		$325.55
BINDER		
282 cu. yds stone, @ $1	$282.00	
38,882 lbs. asphalt, @ $24	418.58	
6,209 lbs. asphalt, @ $16.87	52.29	
15 tons coal, @ $1.55	23.25	
Labor, plant and street	354.01	
Hauling	129.00	
Superintendence	40.00	
Total		$1,299.13
SURFACE		
609 tons lake sand, @ 80c	$487.20	
132,889 lbs. asphalt, @ $24 per ton	1,594.60	
61 tons dust, @ $2.80	170.80	
24 tons coal, @ $1.55	37.20	
6 bbls. Louisville cement	4.50	
Labor, plant and street	661.74	
Hauling	217.80	
Superintendence	60.00	
Coal oil, waste, etc	3.22	
Total		$3,237.56

A Legislative bill has recently passed the house which is in effect a recognition of the success of the enterprise, and shows a desire in some quarters at least to further extend its usefulness. The bill is general in its provisions and would give to all Ohio cities the right to construct asphalt pavement by the day labor system under certain conditions de-

BRICK, TAR FILLED, LAID IN 1888. COLUMBUS

signed to secure reasonable prices and guard against the possible monopilization of the branch of a paving industry that might become demoralized by politics and consequently increase rather than decrease costs to property owners.

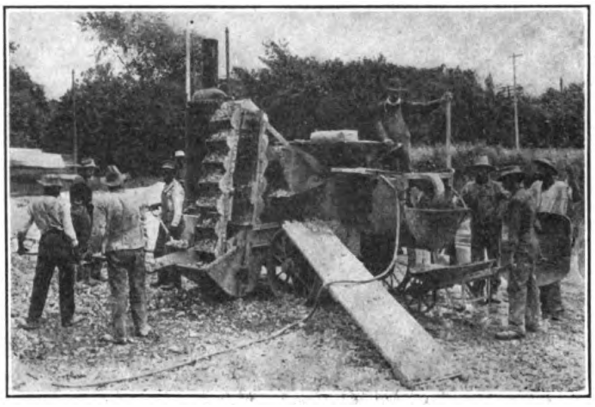
Columbus is essentially a brick-paved city, however, and will probably remain so. Their pavements differ from those in Cleveland chiefly in the use of bituminous filler. They have some cement-filled pavements, but object to them because of the noise; although the edges of the brick tend to chip and round more with the bituminous than with the cement filler.

PAVEMENTS ON OHIO STATE HIGHWAYS

THE State Highway Department of Ohio, which was organized in 1904, found a constantly increasing field of usefulness until, in 1909, by the aid of legislation increasing its authority and providing means of apportioning the expense, it was able to grant applications for the improvement of 53 roads in 36 counties. Contracts were entered into which amounted in the aggregate to $534,945, of which the State contributed $194,866, exclusive of engineering and inspection.

At first gravel and macadam were the only classes of construction. Macadam, however, has fallen into disrepute in the State owing to its failure, as ordinarily laid, to meet present traffic conditions. It is stil an open question whether some comparatively new system of road construction will supply the need or whether the paving materials that have stood the test of time in city streets will prevail. The record of the last two years' work of the Highway Commission will show what the tendency has been in Ohio.

In 1908 the contracts let amounted to 25.69 miles of ordinary macadam and 7.17 miles of brick pavement. In 1909 the figures were 36.09 miles ordinary macadam, 5.57 miles of tar or asphalt treated macadam, and 20.45 miles of brick pavement. Incidentally it may be mentioned that the only increase in cost in the work done last year was met entirely by an automobile tax which amounted to $46,000. That the improvement of country roads with permanent pavements has met with general approval is evidenced by the fact that local county authorities have extended the improvements begun by the State entirely at their own expense. For instance, Portage county assumed $64,913 for the construction of over six miles of brick paved road, though the amount available from the State was but $10,586. Fifteen counties that did not construct State aid roads in 1908 built them in 1909, an increase of 15 per cent.



CONCRETE MIXER ON FOUNDATION WORK. COLUMBUS

According to the kinds of road-making materials available, Ohio naturally is divided into three sections. The central and southern parts of the west half of the State contain large quantities of good gravel and also a number of limestone quarries; the central and northwestern parts contain many large limestone quarries equipped with great crushing plants; the eastern part of the State from lake Erie to the Ohio river contain coal, gas, fire clay and shale, which make possible the

BRICK CONVEYOR ON OHIO STATE WORK

manufacture of the best paving brick at a minimum cost. Commissioner Wonders advises that the roads in each division should be constructed of the materials most easily available, and it is the road builders problem to manipulate the materials so as to obtain the best results.

For the purpose of aiding in the solution of these problems the State appropriated $10,000 for making a test of materials, particularly of dust preventatives and road preserving materials. A section 400 feet in length, 16 feet wide, was assigned for the use of each of the seventeen materials used, the whole forming a continuous road. Nelson avenue, east of the city of Columbus, extending north from Broad street to St. Mary's Academy, was selected for the experiments. Manufacturers of road preparations were invited by letters to participate in the work. The Highway Department paid for all labor and materials used in the work and each firm supplied an expert to superintentend the work in order that it should be done in accordance with the manufacturer's ideas. In addition to the sections constructed in this manner, a few sections were built using Portland cement as a binder, after methods worked out by the department. The following were the materials used:

Glutrin, a by-product in the manufacture of wood-pulp, manufactured by the Robeson Process Company of Au Sable Forks, New York. It is applied to the surface of a finished water-bound macadam road by a sprinkling wagon.

Standard Macadam Asphalt Binder, "a heavy product, almost solid asphaltum," manufactured by the Standard Oil Company. It is poured upon the top layer of the stone.

STATE WORK, SHOWING HEAVY CURB

Standard Asphalt Road Oil, "a manufactured product containing from 30 to 50 per cent. of petroleum asphalt;" manufactured by the Standard Oil Company. It is a surface treatment.

Pioneer Asphalt Cement, an asphaltic product mined in Utah by the American Asphaltum & Rubber Company of Chicago. It is applied to the top course.

Tarvia X, a coal tar preparation manufactured by the Barrett Mfg. Co. of New York. It is applied at a temperature of 250° to 300° F. to the top course as a filler by the use of compressed air.

Tarvia B, a coal tar preparation of "less tenacity and lower viscosity than 'Tarvia X'," also manufactured by the Barrett Mfg. Co. It is applied cold as a surface treatment.

Liquid Asphalt, "a manufactured product carrying in solution 60 to 65 per cent. of asphalt fluxed with other constituents of a non-volatile nature." It is manufactured by the Indian Refining Company of Cincinnati and is a filler.

Taroid, "a coal tar pitch prepared in liquidized form as a binder," manufactured by the F. J. Lewis Mfg. Co., of Chicago.

Fairfield Refined Asphalt Cement, a product consisting of 88% bitumen and 12% mineral matter, manufactured by the Impervious Product Company of Baltimore. It is used as a filler.

Asphaltolene, a product "equivalent to pure asphalt dissolved in petrolene," manufactured by the Good Road Improvement Company of Cincinnati. It is a filler.

Wadsworth Macadam, a new roadway on which Ground Kentucky Asphalt (containing not less than 8% Bitumen) is used as a top dressing. It is manufactured by the Wadsworth Stone & Paving Co., of Pittsburg.

EXPERIMENTAL ROAD. TARVIA TWO-COAT TREATMENT

Carbo-Via, a coal tar product manufactured by The Continental Bitumen Company of Toledo. It is used as a filler.

Road Coating, a tar preparation used as a bituminous binder. It is manufactured by the United Gas Improvement Company of Philadelphia.

Petrolithic Pavement, a process of treating a road with California asphaltic oil by means of the Petrolithic Rolling Tamper. It is constructed by The Petrolithic Pavement Company of Los Angeles, California.

Concrete Macadam, a process in which a grout of cement is rolled into the voids of an unfilled macadam road. Constructed according to plans and specifications prepared by the State Highway Department.

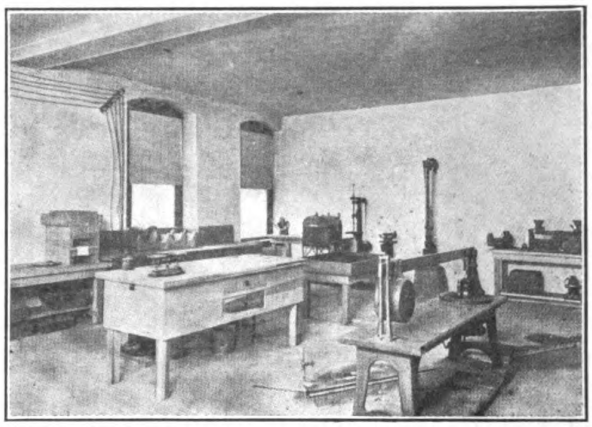
Gravel Concrete, a concrete roadway of gravel and cement. It will be built in accordance with ideas worked out by the State Highway Department.

Water-Bound Macadam, of which a section was built in accordance with the specifications of the State Highway Department.

Another line of experimental work conducted by the State will be carried on in a laboratory in the Ohio State University at Columbus. A room in the basement of Brown Hall has been equipped with about $5,000 worth of machinery, and here tests of paving brick and road stones will be conducted. The tests of road metal are for the purpose of determining the following properties:

Resistance to abrasion. The apparatus used for this experiment is the Deval machine, consisting of a series of four iron cylinders, in which a definite quantity of broken stone is placed. The cylinders are then fixed eccentrically on an iron shaft and the shaft rotated at a rate of 2,000 revolutions per hour. After 10,000 revolutions the stone and dust are removed. The ratio of material passing through a 16 mesh screen to the original weight represents the abrasion by which the different stone are compared.

Cementation test. This test requires more care and has to be conducted according to carefully prescribed conditions. Essentially it consists in making cylindrical briquettes from the powdered stone under examination, and subjecting them to the blows of an automatic hammer. The hammer falls one centimeter at each blow and the number of blows delivered before breaking gives the figure desired.



STATE HIGHWAY DEPARTMENT LABORATORY