and learn that lesson. When you know it, you can reënter your class. That is the punishment I have thought of to correct your "want of attention."

That was the way Madame Loubert put it — "want of attention."

Pupasse looked at her — at madame, a silent but potent spectator. To be sent from home because she did not know the rule of the irregular verbs! To be sent from home, family, friends! — for that was the way Pupasse put it. She had been in that school — it may only be whispered — fifteen years. Madame Loubert knew it; so did madame, although they accounted for only four or five years in each class. That school was her home; Madame Loubert — God help her! — her mother; madame, her divinity; fools' caps and turned-up skirts, her life. The old grandmother — she it was who had done everything for her (a *ci-devant* rag-picker, they say); she it was who was nothing to her.

Madame must have felt something of it besides the loss of the handsome salary for years from the little old withered woman. But conventionality is inexorable; and the St. Denis's great recommendation was its conventionality. Madame Loubert must have felt something of it, — she must have felt something of it, — for why should she say, "Volunteer"? Certainly madame could not have imposed *that* upon *her*. *It must* have been an inspiration of the moment, or a movement, a *tressaillement*, of the heart.

"Listen, Pupasse, my child. Go home, study your lesson well. I shall come every evening myself and hear it; and as soon as you know it, I shall fetch you back myself. You know I always keep my word."

Keep her word! That she did. Could the inanimate past testify, what a fluttering of fools' caps in that parlor — "Daily Bees," and "Weekly Couriers," by the year-full!

What could Pupasse say or do? It settled the question, as Madame Loubert assured madame, when the tall, thin black figure with the bag of books disappeared through the gate.

Madame Loubert was never known to break her word; that is all one knows about her part of the bargain.

One day, not three years ago, ringing a bell to inquire for a servant, a familiar murmuring fell upon the ear, and an old abécédaire's eyes could not resist the temptation to look through the shutters. There sat Pupasse; there was her old grammar; there were both fingers stopping her ears — as all studious girls do, or used to do; and there sounded the old words composing the rule for irregular verbs!

And you all remember how long it is since we wore funnel-shaped hoop-skirts!

Grace King.

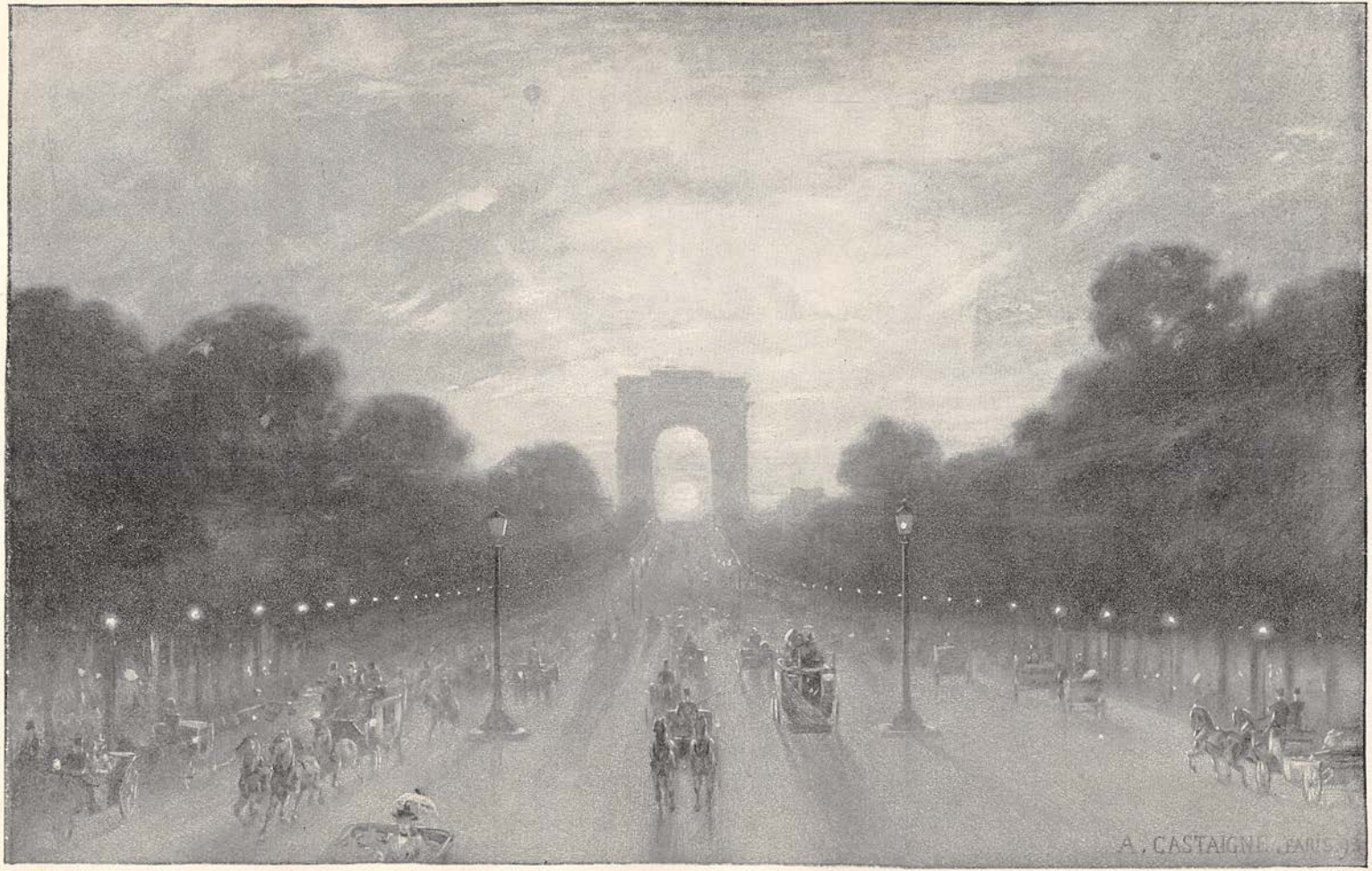
STREET-PAVING IN AMERICA.

THE association of paved roadways with epochs of great advancement, as in the transcendent days of the Greeks and Romans, and their neglect in periods of retrogression, as in medieval times, when isolated castles became monumental evidences of a difference between individual and common welfare, and the renewed demand for them in the better days of the nineteenth century, indicate a relation between them and civilization.

Some understanding of what is involved in the problem of better streets may be drawn from the statistical information found in the census of 1890. It is only in American cities having a population of more than 10,000 that less than one third of the total length of streets has been paved in any manner. If the construction of new pavements on the remaining 24,838 miles of streets in such cities proceeds as rapidly as now seems probable, the expenditures for this work in the next ten years will aggregate upward of a billion dollars. It is doubtful if more than sixty per cent. of the streets of these cities would then be well paved.

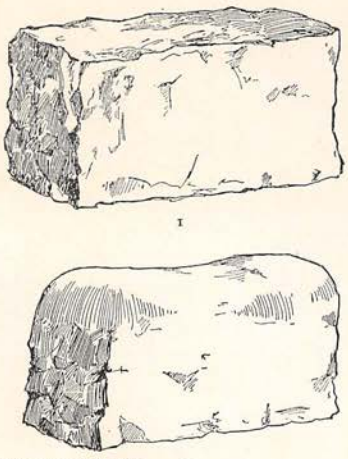
From a well-paved street abutting real estate derives, an increased value, hardly ever less, and often many times more, than the cost apportioned to it. It is, therefore, right that abutting property should, as it does in most American cities, bear the cost of the construction of a pavement, which becomes at once a substantial improvement, having a salable value, on which the property-owner alone can realize. The benefits are shared to some extent by adjacent property which may not abut on the street, but it is doubtful if a fair and practicable apportionment of the cost could be carried beyond the border line, though the justice of this restriction is almost intolerably strained when one paved street is compelled to bear the travel that would pass over others if put in equally good condition.

All calculations of the economies and profits of paved streets fail to encompass the sum of



DRAWN BY A. CASTAIGNE.

CHAMPS ELYSEES, PARIS.



DRAWN BY FREDERICK YOHN. 3

GRANITE BLOCK.

Nos. 1 and 2 show forms of block when laid. No. 3, after several years of wear.

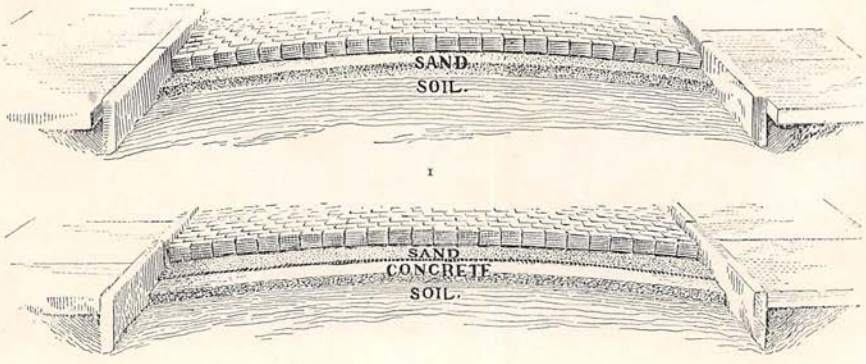
gain from them, because there is much involved that is intangible in character. The benefits of better sanitary conditions, with the consequent productiveness resulting from good health, the saving of expenses for medicines, and the professional services of physicians; the prolonging in some cases of lives that might succumb to the deleterious influences inherent in bad streets — all are incalculable; nor can be estimated the far-reaching effects of the retarded development of a city, due to failure to provide good streets.

The common mistake of regarding the cost of a street pavement as a merely luxurious expense, rather than as a profitable improvement, has, more than anything else, deterred the work of putting the roadways of our American cities and towns in proper condition, and, it should be added, has hindered progress and prosperity immeasurably. It has also had a mischievous influence, when coupled with false ideas of economy, in causing mere cheapness in cost to become with a deplorably large number of people the main desideratum when they find that paving cannot longer be deferred. A record of the failures that it has inevitably led to, since the beginning of experiments in road-making, would tell about all of the history of paving that is worth knowing.

FOUNDATIONS.

THE different pavements are usually designated by the name of the material which is most largely employed in the construction of the surface; and, in consequence, attention is commonly directed particularly to its qualities as sufficient evidence of the merits of the system. This may lead to mistaken conclusions. The foundation is not less important than the surface construction, and should receive the same consideration in paving as in other engineering work. A pavement without a solid foundation is nearly as frail as a house built on a hill of sand. The early failure of much of the road-surfacing in American cities and towns is due largely to lack of requisite foundations. A London engineer who has had much experience has truly said that "the foundation is the pavement." The surface material is merely a covering, which may wear out, and still the foundation will constitute a pavement; if it fails, or solid support is lacking, a road-surface made of the least fragile material will be defective wherever there is an underlying weakness, which may cause more damage than the wear from above. It cannot safely be expected that the pavement will more than temporarily be better than its bed.

The standard foundation is hydraulic-cement concrete, from six to eight inches in thick-

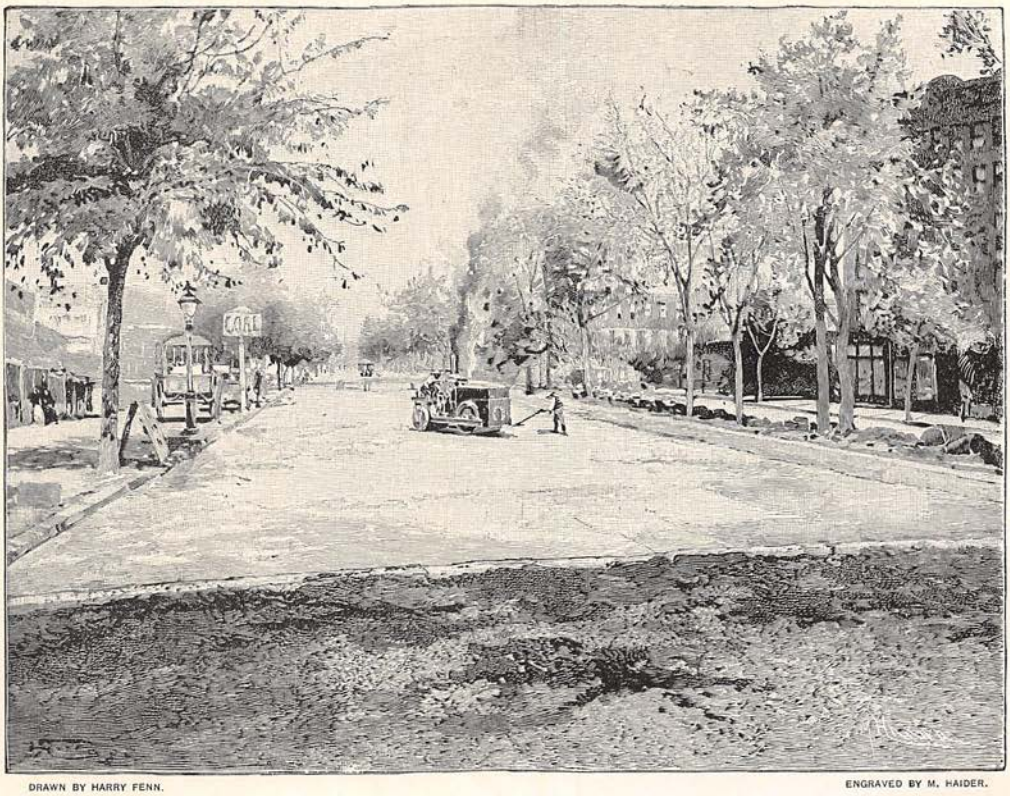


DRAWN BY FREDERICK YOHN.

1. GRANITE-BLOCK PAVEMENT. 2. IMPROVED GRANITE-BLOCK PAVEMENT.

DRAWN BY A. CASTAIGNE. ENGRAVED BY M. HAIDER.

PAVING FOURTH AVENUE, NEW YORK.



DRAWN BY HARRY FENN. ENGRAVED BY M. HAIDER.

LAYING TRINIDAD ASPHALT ON OLD MACADAM FOUNDATION ON THE WESTERN BOULEVARD, OR BROADWAY EXTENDED.

ness. It is a solid, cohesive mass, with the qualities of a continuous layer of stone, capable of bearing tremendous weights, and affording protection against the damaging effects of frost to the earth beneath. Other forms of foundation, inferior in character, but serviceable, are in use. Cobblestones may be utilized by being set on edge, slightly apart, and filling the interstices with hydraulic cement. A foundation similar to the subpavement of a Telford road may be made of rubblestone set on edge in close contact. Broken stone on gravel, the whole from eight to ten inches in thickness, is one of the cheaper forms, and is well suited to some kinds of paving. A layer of planks, two inches in thickness, on a bed of sand,—or, better, on gravel or broken stone,—is less commendable, though not without some merit. Old pavements, made of the harder materials, may be used when brought to proper grades, rather than have no kind of substantial foundation. This has been done in New York city under a guarantee by contractors of the durability of new paving. Where professional or official responsibility is involved, however, only the approved form of hydraulic-cement concrete can be recommended without risk for streets of more than average requirements; and on steep gradients or marshy soil, as well as for the requisite support of some kinds of surface materials, it is almost indispensable. There is no experiment in using it, and a preference for other forms of foundation will be best justified by consideration of lower cost. Where the constituent materials may be had with little expense of transportation, the price may be as low as fifty cents per square yard; but in cities remote from the sources of supply, it will vary from seventy-five cents to upward of one dollar per square yard. The concrete is composed of a mortar of one part of hydraulic cement and two parts of clean sand, free from clay, mixed with small pieces of broken stone. During the process of mixing water is thrown upon the mass. The concrete is at once spread upon the street (the earth having been first rolled, under a weight usually of ten tons), and is then thoroughly compacted by ramming, until, as careful specifications require, "free mortar appears on the surface." The mixing and spreading of the mortar is necessarily performed with much rapidity by men who have acquired extraordinary dexterity in doing the work. Gravel or cobblestones should be carefully excluded from the mixture, only the angular fragments of broken stone, measuring in their largest dimension not more than one

inch and a half, being suitable for use. Concrete cannot be safely laid during freezing or frosty weather.

The surface materials which share in popular favor, somewhat according to locality, are granite, wood, and asphalt blocks, asphaltic and coal-tar distillate mastics, hard or vitrified brick, and stone suitable for the Macadam and Telford systems of paving, the comparative merits of which, however, are not to be understood as being indicated by the order of mention. With the exception of the Macadam and Telford systems, these different materials, each designating a kind of construction, may be combined, according to methods, under the general distinction of block and sheet pavements, each embracing many varieties, which, within the limits of this article, can be only briefly mentioned.

DRAWN BY OTTO H. BACHER.

HEATING PEBBLES FOR JOINT FILLING, WASHINGTON STREET, BOSTON.

GRANITE OR STONE BLOCKS.

If wearing quality is the main requisite, as it is commonly believed to be for streets where there is much heavy hauling, no material which has yet been extensively tried is superior to granite or trap rocks, which experience has demonstrated can be most serviceably used in the form of small blocks. Failure to discriminate in the quality of stone has in some instances had unfortunate results. Limestones are especially unsuitable. Granite is preferable because it wears less smooth than other hard stones. Under heavy travel granite will give from fifteen to twenty-five years of service with slight repairs, and may be made to last forty or fifty years. It is estimated that in fifteen years, with such usage as it would have on one of the principal business streets of a large city, it would be worn down two inches. If redressed, the blocks would probably wear twenty years longer on a solid foundation.

PAVING.

Various methods of construction have been tried in American cities during the last forty years, experiments having taken a wide range, especially in endeavoring to determine the best dimensions of blocks, as well as the most advantageous way of laying them. The Belgian block — the name being the designation of a method first introduced in the city of Brussels — was for a long time the most approved. It was a radical departure from earlier experiments in the use of stone of large dimensions. The Belgian blocks are small cubes of trap rock or granite of from five to seven inches of surface dimension, with little dressing. They are laid on a foundation of sand and gravel. It has been found that ruts are too easily worn along the longitudinal joints, and longer blocks of granite, laid lengthwise across the street, with the interstices filled with cement, have come into favor. Specifications for granite pavements now usually require that the blocks shall be rectangular in shape, with dimensions of from 3½ inches to 4½ inches in width, from 10 to 13 inches in length, and from 8 to 9 inches in depth, though in some cities these dimensions are slightly reduced. Experience has also demonstrated that while sand and gravel may make a bed which will, at little cost, meet the requirements of granite-block pavements on ordinary business streets, nothing inferior to

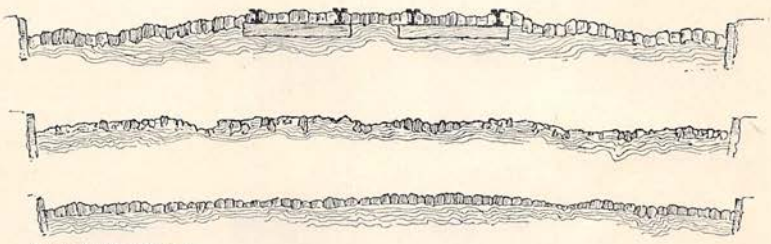
DRAWN BY A. CASTA'GNE.

BROADWAY AND FOURTEENTH STREET.

ENGRAVED BY M. HAIDER.

hydraulic-cement concrete should be used as a foundation on streets where there is much heavy hauling. As a rule, wherever the needs of a street require the use of granite paving, it is equally essential that it should have the best foundation. As a surface material its chief merit is its wearing quality, and there is inconsistency in using it without putting it on a base of adequate solidity, when there can be no better reason than extraordinary need of durability for preferring it.

The common objections to granite-block paving are the nerve-rasping noise caused by contact with it of hoofs and wheels; its slipperiness, resulting from wear and water; the resistance to traction from its uneven surface; and the receptivity of dust and foul substance in the interstices between the blocks, which also are the weakest part of the surface, on account of the difficulties of filling and cementing them sufficiently. And yet these joints are some protection against slipperiness. One of the best granite-block pavements in America was some years ago laid on Westminster street, in the city of Providence, Rhode Island, on a concrete foundation, with the interstices between the blocks compactly filled and cemented, thus making an even surface which could be easily cleaned, and did not permit the accumulation of filth and dirt usually found in the joints of such pavements. It seems improbable, however, that any method of construction can make stone-block paving generally desirable; and in America, as in many of the principal European cities, its use is likely to be restricted to streets where there is much heavy travel. In none of the large cities is it in growing demand equally with other commonly approved kinds of paving.



DRAWN BY FREDERICK YOHN.

SURFACE LINES OF SOME WOOD-BLOCK PAVEMENT IN CHICAGO.

WOOD BLOCKS.

Wood has been tried as a paving-material in many ways, varying from simply laying thick planks on the level earth of roadways, as may still be seen in some towns where the soil is sandy, to the more ingenious methods of block construction. It was long believed that there were qualities in wood of some kind which, by some process of treatment, as well as by some manner of use, could be made serviceable in a superior degree in paving; and how tenaciously this idea was adhered to is indicated by the many experiments made for a brief time with some success. The qualities of the material seem to have undergone all conceivable tests within the range of science, and the methods embrace about all the variations of practicable construction, including, to some extent, combinations with other materials, with results which have demonstrated that the simpler forms are the better.

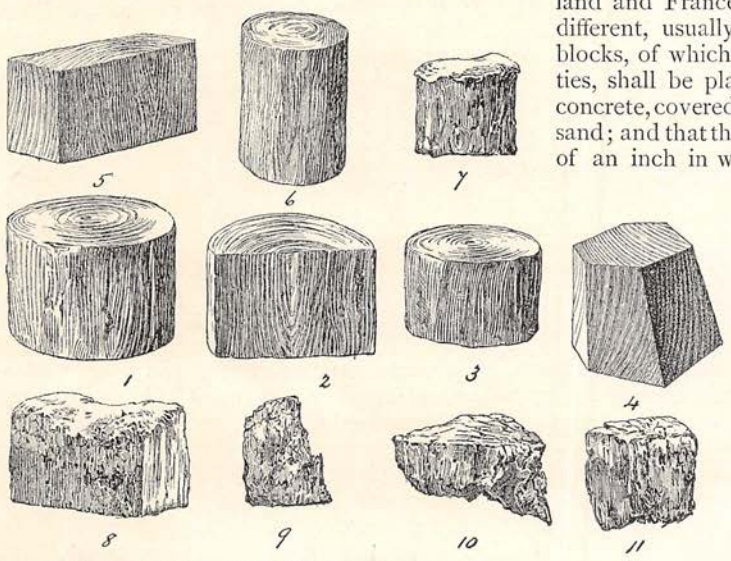
The kinds of wood most largely used in America are pine, cedar, cypress, and oak, a choice between which is determined in different localities by convenience of supply rather than by superior quality. If from two to five years' longer service is preferable to lower cost, the wood having the greatest density and toughness should be used.

Attempts to protect blocks from decay, and to prolong their durability, by subjecting them to processes known as mineralizing or creosoting, or by boiling them in oil, or covering them with compositions of tar and other substances, have not been conspicuously successful; on the contrary, there are doubts as to their utility, as blocks which have undergone such treatment, when examined after having been long in use, have shown no other effect than mere discoloration and a closing of the fibers of the wood, which seemed to have hastened internal decay. The cylindrical and rectangular forms of blocks are most approved: the former from 8 to 10 inches in diameter and 7 inches deep; the latter 4 inches wide, 5 inches deep, and 8 inches long.

The most important considerations in methods of laying the blocks are the foundation and the joints. Early failures of wood pavements laid on sand and gravel were attributed, doubtless correctly to a great extent, to the character of the foundation; and experiments which aimed to remedy this defect brought into use in various ways planks from 1½ to 2 inches in thickness for a subpavement. Much stress was put upon the desirability of having an elastic as well as a uniformly solid foundation, and sand was spread over the layer of planks to a depth of two inches or more, making what was called a cushion. The same material was by some also placed under the planks, and others used a sub-

course of gravel or broken stone. As a means of giving greater firmness to the pavement, and preventing the displacement of blocks, wooden wedges, held by a groove in the foundation planks, were, in one system which was in favor for a time, placed between the parallel rows of blocks, reaching to within about three inches of the surface, the remainder of the open space being filled with gravel and tar. Finally, hydraulic-cement concrete, with a top layer of sand as a cushion, came into use, but it has had reluctant acceptance on account of its increased cost, and, therefore, the plank foundations are still preferred for wood-block paving, most extensively, however, in cities of the South and West. Attempts to protect wood by chemical treatment from the damaging effects of water have been supplemented by a method of laying roofing felt under the blocks, and inserting it in the interstices between them for the purpose of absorbing moisture. The theory that led to the adoption of this system, which has distinct recognition, was that expansion and contraction, under variable atmospheric conditions, were the principal causes of the early failure of wood-block pavements. Water has always been recognized as their unconquered enemy. Experience has demonstrated, however, that no better protection can be afforded than by methods which facilitate drainage.

It is often asserted by persons who argue against wood-block pavements that the destructive tendencies of their absorption of liquids are also objectionable because they develop processes of fermentation and decay, which produce unsanitary conditions. As a theory this is too plausible to be disputed, but an attempt to verify it by a comparison of the mortality statistics of cities largely paved with wood blocks, and those having other pavements, is disappointing. The destructible character of wood, however, renders it one of the least durable materials, and experience indicates that satisfactory service cannot be expected from it for a longer period than ten years; but, notwithstanding its deficiency in wearing qualities, it continues to share in public favor in some of the principal European cities, chiefly because its surface is easily tractive, and at the same time is neither so hard nor so slippery as some other pavements, while it is also less noisy. The standard specifications, in England and France, while in some respects different, usually require that the pine blocks, of which there are several varieties, shall be placed on a foundation of concrete, covered with about two inches of sand; and that the joints, about five eighths of an inch in width, shall be filled with grout, with a top coat of hydraulic cement. The specifications vary as to the materials that shall be used in filling the interstices, but all aim to make them firm and impermeable, for the protection of both the blocks and foundation against water, as well as for the purpose of giving to the pavement a smooth surface, and preventing accumulation of dirt in the open spaces. It has been found that wood-block pavements in London, where they are as well constructed as anywhere, need repairs after they have been in use two or three years, and in seven to ten years are no longer fit for travel.

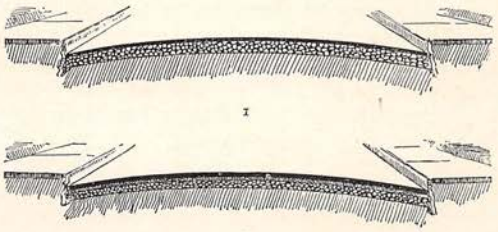


DRAWN BY AUGUST WILL, FROM PENCIL SKETCHES BY FREDERICK YOHN.

1, 2, 3, 4, 5, AND 6, FORMS OF WOODEN BLOCKS. 7, A CEDAR BLOCK AFTER FIVE YEARS' USE. 8, 9, 10, 11, PINE BLOCKS AFTER SEVENTEEN YEARS OF SERVICE.

In America wood-block pavements have not grown in favor. There is at present comparatively less demand for them everywhere than was the case a few years ago, except in parts of the country where suitable wood is obtainable more easily or at less cost than other paving-materials. In some of the cities of the Northwest and South they are extensively in use, and there is a continued demand for them, without requirement of concrete foundations or impermeable joints. In San Antonio, Texas, a native wood which grows in the form of a thick bush, known as mesquit, is used as a paving-material. It apparently has extraordinary du-

rability, and the expectation is that it will be serviceable for forty years or more. The blocks are of hexagonal shape, with the top slightly smaller than the bottom, and are laid on a foundation of concrete covered with sand.

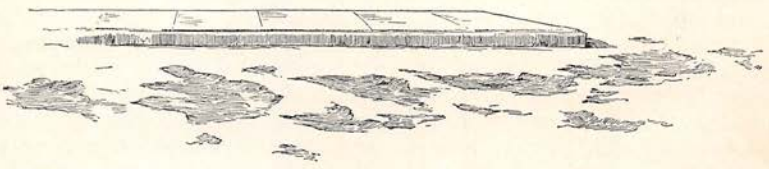


ASPHALT AND VULCANITE STREET PAVEMENTS.
1. Shows foundation of concrete with wearing surface above. 2. Shows a bottom course of broken stone with a top course of smaller pieces of stone.

SHEET PAVEMENTS.

DURING the last fifteen years, interest in what is commonly known as the sheet pavement, made of materials combined in the form of a mastic, has been rapidly growing in America. It is the most completely distinct modern product of experimental paving; its chief advantage over the block system being a surface of unbroken smoothness, which offers little resistance to traction. The different compositions numbering fifteen or more, used in this system of paving have been indiscriminately identified by the public with asphalt, which, though introduced in small proportions, is an essential part of the standard formula. All sheet pavements, however, cannot be properly called asphalt pavements; for asphalt is not used at all in some of the compositions, and those which are technically designated by the name in America, in discriminating between the different kinds of mastic, are only successful imitations of the original and genuine asphalt pavements, as laid in Europe, where asphalt first attracted attention as a material suitable for paving in 1849. It had long been in demand for commercial uses, and, while being transported from mines in France and Switzerland, particles falling from the wagons were crushed under the wheels, their compression being aided by the heat of the sun, thus forming a very good road surface, which suggested the idea of trying it in street-paving. The first experiment, which was on a macadam road, was encouraging, and in 1854 a portion of a street in Paris was paved with asphalt on a concrete foundation. It met expectations, and four years later other streets were similarly paved. It grew rapidly in favor, and in 1869 asphalt pavements were introduced in London; but not until 1880 were they given a trial in Berlin. They are now extensively in use in these as well as in other European cities. In distinction from the American pavements of the same name, the material of which they are made is now commonly called "natural asphalt rock." It comes largely from mines in France, Switzerland, and Italy, and is in the form of a bituminous stone, composed of amorphous carbonate of lime thoroughly impregnated with mineral tar. It is of a dark-brown color, is not easily broken, but can be cut, and is malleable. Analysis shows that about twelve per cent. of the substance is bitumen, and the remainder amorphous carbonate of lime. After it is taken from the mines in the shape of large rocks, it is crushed into small pieces, and is then reduced to a powder by a process of grinding. It is afterward heated in revolving cylinders at a temperature of 280 degrees Fahrenheit, is carried in carts or tanks, still heated, to the street to be paved, and spread on a concrete foundation, in a uniform layer of five inches, which, by the pounding of hot iron rammers, wielded by men, is compressed to a thickness of two and a half inches, after which hydraulic cement is swept over it, and it is again pounded with rammers. Not later than the second day after the work is completed the pavement is ready for use. It costs more than the standard American sheet pavement. On the question as to whether it is better, all things considered, there is an irreconcilable difference of opinion, proceeding from opposite points of view. The issue, however, is unimportant, as the system of sheet paving in America will, for the practical reasons which brought it into existence, probably continue to be essentially unlike that of Europe.

Attempts to produce a mastic which would be an acceptable substitute for the European asphalt rock have encumbered the streets of American cities with various kinds of worthless compositions. Coal-tar, pitch, and rosin, used as cementing substances, have been combined with sand, gravel, ashes, lime, sawdust, and other materials, in what have been repre-



ASPHALT PAVEMENT AFTER FOUR YEARS OF SERVICE WITHOUT REPAIRS.

sented in some instances to be asphaltic mixtures; but most of them have soon failed under the wear of travel and exposure to the weather, the evaporation of the volatile oils being quickly followed by disintegration of the remainder of the composition.

Mr. E. J. de Smedt, a Belgian chemist, who had studied asphalt pavements in Paris before coming to the United States in 1861, conceived the idea in 1869 of making a mixture of silicious sand and pulverized carbonate of lime, cemented together by Trinidad asphalt, the latter being first refined and tempered with heavy petroleum oils or the residuum of the distillation of them. In 1870 the first Trinidad-asphalt pavement was laid for public use in front of the city hall in Newark, New Jersey. In 1873, Fifth Avenue, between Twenty-fourth and Twenty-fifth streets, opposite the Worth monument, in the city of New York, was paved with this composition, and other samples of it were subjected to trial about the same time; but there was little demand for it until after Pennsylvania Avenue in Washington had been partly paved with it under the direction of a special commission appointed by Congress in 1876. Hundred of miles of it are now in use on the streets of American cities.

DRAWN BY A. CASTAIGNE.

RESULT OF BAD PAVEMENT, PARK AVENUE, NEW YORK.

Asphalt is not, as may be supposed, used in large proportions in the composition. Merely enough of it is introduced to cement the other materials. The mixture of the refined Trinidad asphalt and the residuum of the distillation of petroleum oil is known as "asphaltic cement," which constitutes from ten to fifteen per cent. of the paving composition, the rest of which is fine sand and from three to five per cent. of pulverized carbonate of lime. Slight changes in the formula are made to suit differences of climate. The asphaltic cement is separately heated to a temperature of about 300 degrees Fahrenheit. The sand and carbonate of lime are heated in rotary drums to about the same temperature, and are combined with the asphaltic cement in a mechanical mixer. After the sand has been thoroughly impregnated with the cement, the heated mixture is carried in carts to the streets to be paved, where it is spread by means of hot iron rakes, being tamped by hand-implements, and afterward compressed, first by hand-rollers, and then, after hydraulic cement has been swept over it, by heavier steam-rollers, until it is reduced to a thickness of from one and a half to two and a half inches, as the specifications may require.

The asphalt most largely in use for paving purposes in America comes from the island of Trinidad, where it is found in what is known as Pitch Lake, situated about one mile from the sea, at an elevation of 138 feet; and deposits

DRAWN BY A. CASTAIGNE. ENGRAVED BY H. DAVIDSON.

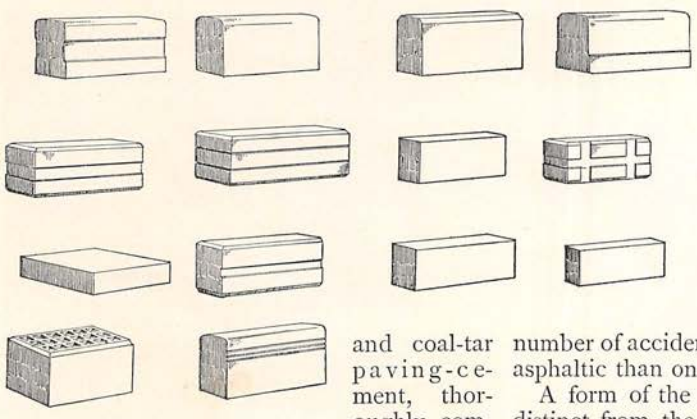
PARK AVENUE, NEW YORK, WITH ASPHALT PAVEMENT.

of it, which have become known as "overflow pitch," or "land pitch," are found on the land about the village of La Brea. The lake covers 115 acres. Shallow streams of water, a few feet wide, flow through the pitch, elevations and depressions of which cause the surface to be uneven. The asphalt is excavated with picks, usually to a depth of about three feet. Loaded carts may easily be driven over the surface of the lake, but the viscous quality of the asphalt is indicated by the filling up in a few hours of the pits made in the excavation of the material. Of the asphalt exported to the United States from Trinidad in 1891, 45,170 tons were taken from Pitch Lake, and 10,450 tons from land in and near La Brea. The lake asphalt is preferred, because it is believed to have better cementing qualities; and its use is now required by the paving specifications in many cities, experience with some of the pavements in which "land pitch" was used as the cementing material having been unsatisfactory.

Asphalt has been found in Cuba, in Mexico, and in many places in the United States; but none of it has been successfully used in cementing the composition of sand and pulverized carbonate of lime. A native asphalt is used for paving purposes with some success in California; and deposits of sand impregnated with bitumen have been found in Kentucky, but such experiments as have been made with it have not yet satisfactorily demonstrated that it has sufficiently durable qualities as a paving-material.

A kind of sheet pavement, commonly supposed to be asphaltic, and like it in appearance, is sometimes called vulcanite, but it is becoming more distinctly known as coal-tar distillate, because this is the principal cementing material, combined with about four per cent. of Trinidad asphalt, the remainder of the composition being sand and pulverized stone, with small quantities of hydraulic cement, slaked lime, and flowers of sulphur. The method of spreading and compressing the material is the same as with the asphaltic pavement; but the foundation usually consists of from four to six inches of broken stone, coated

with coal-tar paving-cement, in the proportion of about one gallon to the square yard of base, on which there is spread what is commonly called a binder-course, two inches in thickness, composed of smaller broken stone



DRAWN BY FREDERICK YOHN.

SOME FORMS OF PAVING-BRICK.

and coal-tar paving-cement, thoroughly compacted with heavy rollers. On this is laid the surface composition. A common objection to it is that it becomes so soft on warm days that wheels and hoofs leave impressions upon it, and in extremely cold weather it becomes very hard, with a tendency toward fragility, and frequently cracks.

The base and intermediate course of this form of paving are sometimes used for an asphaltic surface composition, or a concrete foundation four inches in thickness may be substituted for the base of broken stone, either of which should be cheaper than the so-called standard Trinidad-asphalt pavement, and quite as well suited to streets on which the travel is comparatively light.

The American sheet pavements, in comparison with those of Europe, are not deficient in tractive or sanitary qualities. Their worst faults are shown in tendencies of the mastic composition to disintegrate in places where the surface soon wears away, or in eruptive disturbances, which may result from improper use of materials, as well as mistakes or carelessness in work. To these causes oftener than to the effects of wear the failure of sheet pavements in American cities can be traced; and as the difficulties of doing all of the work with the requisite exactness and uniformity seem to be to some extent unavoidable, the only safe assurance of durability is an adequately protected guarantee, at the time of construction, that they will be kept in good condition for a fixed period of time.

Some of the common objections to the asphaltic pavements are the clicking noise of hoofs striking upon them, the easy raising of dust from them by passing winds, and their slipperiness when wet. In considering these objections, the thought will doubtless come to the reader that sprinkling will allay the dust, but will at the same time increase the danger of accidents from the slipping of horses. The slipperiness about which so much complaint has been made, however, is a characteristic of the asphaltic pavements of Europe more than those of America, due to a smoother surface and to the limestone in the former, which do not afford as good a foothold as the sand composition of the latter, though official statistics from American cities indicate that a slightly larger number of accidents result from slipperiness on asphaltic than on other pavements.

A form of the American asphaltic paving, distinct from the sheet system, is represented in the use of the material as a cement, combined with crushed limestone, compressed under great weight into large blocks, which are laid in a foundation of gravel and sand. This kind of paving is not, however, in extensive use.

PAVING-BRICK AND THEIR USE.

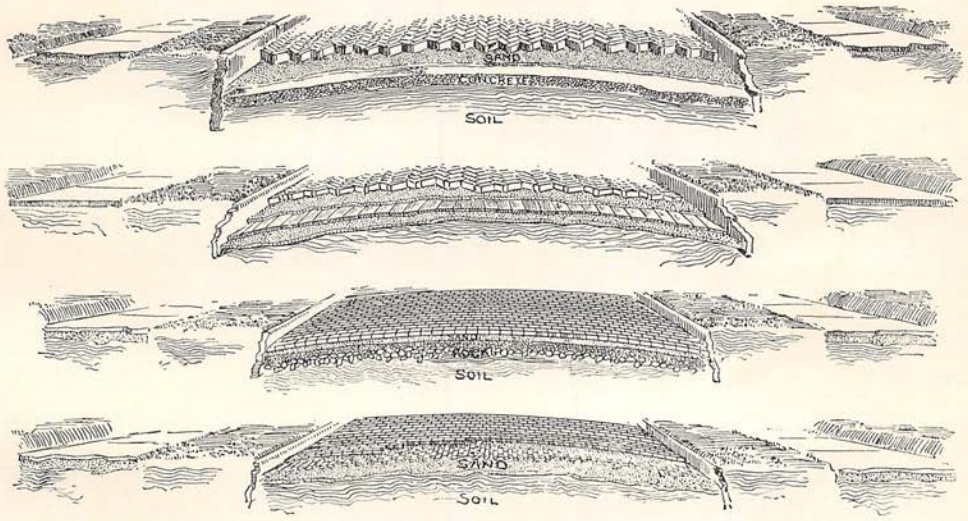
WITHIN the last five or six years, in the smaller cities of the Western and Middle States, there has been a demand for brick as a paving-material, which has grown more rapidly than the facilities for supplying it. The experiments with it, conducted professedly without knowledge that it long before had been used for such purposes in Holland, are traced back to the year 1870, when it was first tried in the United States as a street-paving material in Charleston, West Virginia, at about the same time that the first sample of Trinidad-asphalt pavement was placed at the service of the public in Newark, New Jersey. While the growth of the two systems in public favor has been contemporaneous, in only a few of the larger cities have they been brought into rivalry in any degree, largely because the promoters of each have not found their most tempting opportunities in the same fields. The experiment at Charleston grew out of an idea conceived by Dr. John P. Hale, of that town, that bricks which had been compressed and burned to unusual hardness for use in the construction of a house which was being built for him, would be a good substitute for broken stone as a street-paving material. When Dr. Hale explained his idea to the common council of Charleston, it was pronounced absurd by many of his fellow-citizens; but, as he proposed to bear the

expense of the experiment, he was given permission to lay, according to his own plans, a sample of brick pavement on the busiest street in the city. The people of Charleston, contrary to their expectations, found that the new paving-material, instead of being crushed into pieces in a month, had durable qualities. Since 1873 the demand for it there has been exclusive, and it is now in use on several miles of streets.

Other cities and towns were, however, slow to adopt Charleston's new kind of paving, and, though there was nothing lacking in the home laudation of it, the experiment had little more than local fame for several years; in fact, there is no evidence that it was known as an example in Bloomington, Illinois, when in 1874 permission was granted to N. B. Heafer to lay a brick pavement on Center street, opposite the court-house, in that town. This, too, was proposed as an experiment, and it is still in evidence, eighteen years of use having worn away about an inch of its surface without otherwise impairing it.

The Charleston and Bloomington pavements were in some respects not alike — in none, really, other than that baked clay was the material chiefly used in their construction, and the qualities of this were different. The brick were the kind manufactured in the respective localities for building purposes: those used in Charleston, a dark red in color, were compressed and burned somewhat harder than usual; the Bloomington brick were of a yellowish color, with less density, and were apparently more friable. The foundation of the Charleston pavement was composed of a layer of planks, covered with sand, on which the bricks were laid on edges in zigzag courses, the interstices being filled with sand. The Bloomington pavement was put on a base of coal cinders, four inches in thickness, covered with a layer of sand, on which a course of brick was laid; this being also overspread with sand, whereon was placed the surface layer of brick on edge. The success credited to these systems as experiments must be regarded as rather marvelous; but if it encourages imitation, the results may be unfortunate. Later experiments have led to improvements both in quality of materials and method of construction.

The manufacture of what are known as paving-brick has within a few years become a distinct industry, which has already grown into large proportions, requiring millions of dollars of capital in its operation. Chemical discoveries, aided by improvements in machinery, have made it possible to produce, from some kinds of clay, brick which rival granite in hardness; yet the industry is probably in the infancy of all its possibilities. The advancement has been rapid, however, during the time that attention has been directed to it: the brick made ten years ago withstood a pressure of from 500 to 4200 pounds per square inch; some are made now which withstand a pressure of 22,000 pounds per square inch. Clay unlike that ordinarily used for building-brick is required; it should be vitrifiable, with qualities capable of certain chemical affinities. The better paving-bricks are made from shale clays, which in some places are mined at a depth of about three hundred feet in the earth, and in other places are found on the surface. In the crude state these clays are much like stone. In the process of converting them into brick they



DRAWN BY FREDERICK YOHN.

SYSTEMS OF BRICK PAVING.

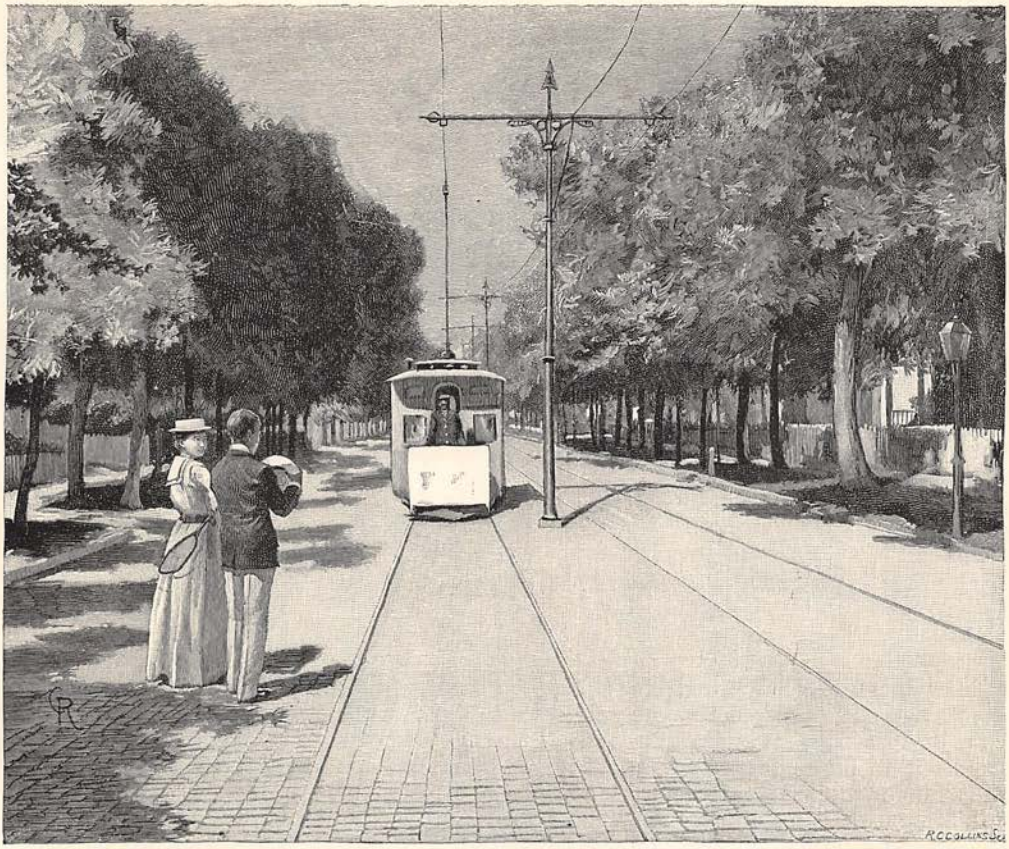
DRAWN BY GUY ROSE. ENGRAVED BY A. BLOSSE.

LAYING A BRICK PAVEMENT.

are pulverized by machinery into a fine powder, which, when mixed with water, becomes a plastic mass, capable of being molded into any of the various forms made for paving purposes. Some blocks are much larger than the ordinary brick, and are intended to afford peculiar advantages, either in the character of the surface or in durability; but experience has led to a preference for brick of about the same shape and size as those used for building purposes, mainly for the reason that they undergo the heating process to which they are subjected with more thorough uniformity than the larger blocks. This process usually continues for about ten days at from 2000 to 3000 degrees Fahrenheit. If the clay does not possess the requisite qualities, it will fuse under heat that will produce vitrifaction, and the bricks will be useless.

Paving-brick should have a degree of density and compactness which will preclude as much as possible the absorption of moisture, together with the strength derived from combined toughness and hardness, which will enable them to bear great pressure without fracture, and at the same time to resist abrasion; in short, they should have, as nearly as possible, the qualities characteristic of granite, with which, indeed, very favorable comparisons may be made, as shown by tests of samples of brick now produced at many points in the Middle States, where the industry seems to be most favored by natural conditions. These tests, applied by various mechanical processes, are employed by many municipal engineers in endeavoring to determine the qualities of brick offered for paving purposes, and while they should not be regarded as conclusive, they certainly have some indicative value. Tests of samples of brick may, however, indicate a degree of durability which could not be realized from their use in a pavement; besides, samples nearly always have better than average qualities; and it is pertinent to add, also, that one of the great difficulties with brick paving is to secure uniformly good quality in the material, owing to the impossibility of producing it in the processes of manufacturing.

The durability of brick, which is unquestionably its best quality, has not yet been demonstrated sufficiently to warrant any manner of suggestion that it may be advantageously substituted for granite where the requirements of service are extraordinary. Experience has



DRAWN BY GUY ROSE. ENGRAVED BY R. C. COLLINS.

COLLEGE AVENUE, INDIANAPOLIS, PAVED WITH BRICK.

been comparatively favorable to it, however, in the smaller cities, on streets bearing moderately heavy traffic, but not without some exceptions, where, owing to defective materials, it proved disappointing. It has been tried in only a few of the larger cities, and in those to a limited extent; but within the last six years a popular demand for it, attracted by its comparative cheapness and durability, has brought it into use in more than two hundred of the towns and smaller cities most accessible to the points where paving-brick manufactories have been located. In some towns the pavements are without foundations other than a spread of gravel, sand, or coal cinders, and the most common forms of base are a layer of broken stone six to eight inches in thickness, of planks, or a subcourse of brick, each covered with sand; concrete is rarely used.

In towns where even a cheaper form of pavement at first cost is desired, the Macadam and Telford systems [1] may be serviceable, but they are better suited to driveways and country roads than to inhabited streets, because they are almost constantly either dusty or muddy, owing to the detritus of their surfaces; and under heavy wear they need frequent repairs, rendering them, in the course of several years, if kept in good condition, more expensive than other kinds of paving. In London the cost of their maintenance, on streets where there was not more than average traffic, was found to be from 40 to 50 cents per square yard yearly.

And now, having somewhat cursorily considered the most commonly used materials, we come to the inevitable, with many the determining, question—the cost. Information on this point can at best be given only approximately; for street pavements, as with any commodity, may not, when alike, cost the same in different cities, or (as is frequently shown where competitive proposals are received from contractors) the same in the same city. Wages, transportation of materials, competition, local conditions, all variably affect prices. An approximation for different points in the United States is given in the table on the following page, the information for which has been furnished by officials in the street departments of the cities named.

The inequalities of cost shown in this table are in some measure due to differences in the

[1] See "Our Common Roads," in THE CENTURY MAGAZINE for April, 1892

qualities of the pavements. The minimum and maximum prices of granite paving in New York, Boston, and Columbus are based respectively on sand and concrete foundations. Minneapolis and Omaha have an advantage in being located within convenient shipping distance of the quarries from which they get their supply of granite blocks, and something is saved, temporarily at least, by laying them on sand. The cost of asphaltic paving in New York is increased somewhat by the requirement that the contractors shall guarantee that the pavements shall be kept in good condition for periods of from five to fifteen years. In Brooklyn it is much lower, because old cobblestone pavements are used as foundations for the asphaltic wearing surface. In Washington the cost of asphaltic pavements is limited to $2.25 per square yard, but this is exclusive of grading, curbing, and "all extra work." The wood-block paving in Chicago, Minneapolis, Milwaukee, Detroit, and New Orleans is placed on plank foundations; in the other cities cited it is on concrete. The differences in the cost of brick paving are due chiefly to distances of transportation of the brick. In Omaha, where the cost is $1.75 and $1.99, the pavement includes a concrete foundation, and a guarantee of good condition for five and ten years respectively is required from the contractors. A guarantee cannot always be secured, in some instances because of inability rather than unwillingness to give it; but it is the best measure of the value of any pavement.

Cities.	Granite.	Asphalt.	Wood.	Brick.	Macadam.
New York	$2.50 to $3.75	$3.45 to $4.45	....	....	$1.47
Chicago	3.04	2.94	$1.00	$2.00	.90
Boston	3.75 to 4.75	3.50	....	2.75	1.25 to 1.50
Brooklyn	2.65	2.00	....	....	....
San Francisco	2.00	2.40	....	....	.40
Minneapolis	1.67	2.75	1.00	....	....
New Orleans	5.00	3.25	3.00	....	....
Washington	2.88	2.25	....	....	.75 to .96
Cincinnati	4.25	2.85	3.50	2.25	....
Milwaukee	2.45 to 2.55	....	1.10	....	1.95
Detroit	4.25	3.20	1.75	2.75	....
Buffalo	3.00	3.00	....	2.55	....
Omaha	2.00	2.98	1.60	1.75 to 1.99	....
Denver	3.40	3.13	....	....	....
Nashville	2.40	....	....	1.30	.50
Kansas City	3.40	2.80	1.50	2.00	....
Columbus, O.	2.80 to 3.50	....	....	1.58 to 2.16	....

Construction does not represent the total cost. A pavement may be very cheap at first and very expensive in the end, made so by necessary repairs and attention. Cost can be accurately determined only by ascertaining the total expenditure during the period that the pavement is serviceable; and when this is divided into a yearly average, a fair and correct comparison can be made. In pursuing this method of calculation, it has been found in London that the yearly cost per square yard of the different kinds of paving most largely in use there, including construction and maintenance, is: of wood, from 40 to 61 cents; asphalt, 33 to 59 cents; and granite, 25 to 69 cents.

Cost, materials, methods of construction,—all important, but merely details of different systems,—should be considered with reference to essential qualities, which, we find in the end, embrace all factors of the paving problem. The sum of these qualities is the standard which is yet unattained to the highest degree, and which stands pointing, for him who can invent the perfect pavement, the way to fame and wealth.

To pave is regarded as a duty to the public. When paving is done, correlative duties are imposed on the public; the pavement which is placed by its command, or voluntarily provided for its benefit, it should protect. Municipal power may be rightfully and helpfully exercised in requiring that the wheels of vehicles shall have tires ample in width to bear the loads upon them with the least wear of the surface of a street. Protection should be given also against abuses of corporation franchises permitting the tearing open of street pavements for the purpose of laying or reaching gas-, water- and steam-pipes, electric wires, and other underground systems. In many of the streets of our larger cities these now constitute a network which should be combined in subways. Openings in pavements for excavations below the foundation are damaging beyond complete repair, and, if numerous, will be ruinous. In some of our best-governed cities it is wisely and rightly required that all desired connections between adjacent property and underground street systems shall be made before the construction of new pavements begins; and, after the work is completed, openings are not permitted to be made, except in cases of extreme necessity, and then only by special authorization.

William Fortune.