required for one period, by this system of maintenance, 25 per cent will be consumed in small repairs, and 75 per cent in one mass for re-rolling, and that the period lasts 2 years.

It is the opinion of M. Graeff that upon roads of large traffic this system of maintenance, as compared with the one of constant repairs, effects a saving of material that may, in some cases, amount to 40 per cent; and that during a period of three and a half years, upon certain observed roads in the Department of the Loire, the saving of labor was 10 per cent.

Maintenance of Gravel Roads.

The maintenance and repairs of road-coverings composed of gravel, or of a mixture of gravel and broken stone, may be conducted upon the same principles, and by the same methods applicable to those of broken stone.

CHAPTER V.

STREETS AND STREET PAVEMENTS.

A STREET, in a city or town where the best ordered modern devices for promoting the comfort, convenience and health of the inhabitants have been introduced, should provide, upon and beneath its surface, (1) for the accommodation of ordinary travel and traffic, (2) for the drainage of the surface and subsoil, (3) for conveying away the fæcal and liquid refuse called sewage, and (4) for conducting water and gas to the inhabitants.

The subject of providing facilities for carrying on the necessary travel and traffic of a street, by suitably draining and paving its surface, is properly embraced in the design and scope of this work. A few brief suggestions with regard to sewerage and sub-drainage will not be out of place, before proceeding to a description of street pavements.

The importance of sewers in their relation to the health of a people cannot well be overstated. Those of ancient times were generally designed to receive and convey away both the fæcal refuse and surface water, and those of some of the best sewered cities of the present day have been planned and constructed with the same objects in view. The early sewers of England carried off the surface drainage only, the fæcal matter being generally collected in cess-pools located beneath or very near the habitations of the people, until the year 1847, when it was made obligatory to pass it

into the sewers. In districts where the sewage is used for enriching the land, the question of its separation from the rain-fall may be an important one. On the other hand the surface drainage of streets that are closely built up, or where the traffic is heavy, is quite as impure, in time of moderate, or during the first stages of heavy rain-fall, as any sewage, and it might be unwise to allow all of it to flow directly into the fresh water courses of the neighborhood, in localities where the purity of those streams could be preserved by passing it into the sewers. In some cases the sewers take only the moderate rain-falls, the rain-fall pipes being so arranged that when their contents attain a certain velocity, the sewer ceases to intercept it in whole or in part. Circumstances of a local character, will control the plan and details of a system of sewerage, to such degree, that no universal rules for the guidance of the engineer can be laid down, although there are some general principles applicable to every locality. Even when the question of the manurial value of the sewage is to be considered, it will not always be judicious "to convey the rain-fall to the rivers and the sewage to the land," which is advocated by some sanitary writers as an unexceptionable rule.

Inasmuch as sewers are or should be water tight, as otherwise the contamination of the surrounding soil, and consequently of the atmosphere, by leakage, would be the certain result, they in no sense, when properly constructed, act as drains, by lowering the subsoil water-level. In well paved streets very little of the rain-fall is absorbed into the soil, but finds its way into the sewer, or other channels provided for it, and were it not for the unpaved areas, including back yards and unimproved lots, the question of draining the soil,

in built-up streets would not, perhaps, possess great importance, especially if the soil be of a sandy or gravelly character.

It has been shown in Great Britain, from carefully prepared statistics, that the death rate from pulmonary diseases was reduced 50 per cent by sewering certain towns in such manner as to lower the subsoil water by drainage, while in other towns sewered with impervious pipes throughout, with no provision for drainage, there was no decrease in the death rate from consumption. Some provision for subterranean drainage should therefore be made without using the sewers for that purpose, although the laying of sewers alone, by cutting through the various impervious strata, invariably results in the drainage of the surrounding earth to a greater or less degree.

It is easy, when constructing the sewers, to arrange an effective system of subsoil drainage, generally at a moderate cost. There are several ways of doing this, among which the following may be mentioned:

First. The method by perforated inverts, gives when the invert blocks are laid, a series of continuous channels in the lower portion of the sewer. The joints between the invert blocks are left open on the sides and bottom, but are closely filled and pointed with mortar between the sewer and the longitudinal channels, to prevent the escape of sewage into the latter.

Second. Make the foundation of the sewer itself serve the purpose of a blind drain, by forming it of well compacted broken stone of various sizes. Between the broken stone and the earth on either side, a vertical layer of straw, hay, or fine brush may be placed, to prevent the choking of the drain with soil.

Third. Make a blind drain on each side of the sewer, by filling in with broken stone or a mixture of stone and coarse gravel, instead of ordinary soil.

Fourth. An ordinary drain of brick like any of those shown on page 56, or a tile drain, on each side of the sewer foundation will answer as well as any other, and can easily be laid at less cost than a blind drain of stone. Whatever method be adopted, it should be such as will secure a thorough drainage of the soil to the level of the floor of adjoining cellars. The areas in rear of the houses may be drained by either tile, brick, or blind drains, connected by a single pipe with the house drain, and thence with the sewer. As the arrangement of these drains, their relation to the soil pipes, and the location and design of the necessary traps and ventilating shafts, to prevent the escape of sewage gases into the houses, belong to the province of the sanitary engineer, no further reference to them need be made here. The treatment of the street surface will next be considered.

Street Pavements.

It is desirable, for several reasons, that the surfaces of streets through large towns and cities should be paved.

The essential requisites of a good street pavement are, that it shall be smooth and hard in order to promote easy draft; that it shall give a firm and secure foothold for animals, and not become polished and slippery from use; that it shall be as noiseless and as free from mud and dust as possible; and that it shall be easily cleansed, and shall not absorb and retain the surface liquids, but facilitate their prompt discharge into the side gutter catch-basins. It should also be of such material and construction, that it

can be readily taken up in places, and quickly and firmly relaid, so as to give easy access to water and gas pipes. Facility of repairs at all seasons of the year is another important requisite. Economy of maintenance and repair require that the material at the surface shall be durable.

All the road coverings heretofore described are wanting in one or more of the most important of these qualities, while they possess beyond doubt, some of those that are least essential, in even a greater degree than the best street coverings.

Road surfaces of broken stone or gravel, produce less noise, and give a more secure footing for horses than blocks of stone or wood, or a continuous surface of asphalt or other material, but they require such constant supervision to arrest the formation of ruts, and are so infested with either dust or mud, as to render them greatly inferior to a good stone or asphalt pavement for streets subjected to heavy traffic. An exception may perhaps be made in their favor upon suburban streets so extensively devoted to light travel or pleasure driving, as to justify the expense of frequent sprinkling by day and sweeping by night. These kinds of road coverings are also conceded to be excellent for the drives in public parks, and there are cases where the principal thoroughfare leading thereto should be constructed after the same method, and maintained with the same care, as the park drives, especially if the bulk of the travel and traffic over it be of a light character. They should be swept every night, and in dry weather sprinkled repeatedly during the day. Carts conveying the materials for repairs, whether gravel or broken stone, should be kept constantly upon the street, especially during those hours when it is least fre-

quented, so that all ruts and depressions may be promptly filled as soon as they begin to appear.

It must be admitted, however, that there appears to be no trustworthy record of any urban street of this kind, in a thickly settled district, which has been maintained in such manner, that the inconvenience and annoyance inflicted by dust and mud upon the residents or people doing business on either side, did not in reality amount to a most serious public nuisance.

Pavement Foundations.

The object of a pavement being to secure a hard, even and durable surface, and not to any considerable extent, nor necessarily, to support the weight of heavy loads, it is evident that the surface will soon subside unequally, forming ruts and depressions, unless it rests upon a firm and solid foundation. A good foundation is as necessary for the stability of a pavement as for that of any other construction.

Bad foundations invariably produce bad pavements sooner or later, while with a good foundation the quality of the surface upon which the wear takes place, depends upon the material used for paving, and the manner of laying it down.

Among the suitable foundations for a pavement, provided the thickness be adapted to the character of the subsoil and the nature of the traffic, are the following: (1) Hydraulic concrete, six to eight inches in thickness; (2) rubble stones set on edge, but not in contact, with the interstices filled in with concrete; (3) rubble stones set in contact, on edge, like the sub-pavement of a Telford road; (4) cobble stones firmly set in a form of sand or gravel; (5) small rubble stones

of random sizes, in a well-compacted layer; or (6) a layer of broken stone laid in the manner of a Macadamized road.

Sand foundations are in most common use. They are described below, in the paragraphs on cobblestone pavements.

Foundation of Broken Stone.

Broken stone foundations are prepared in all essential respects like a Macadamized road. They should generally be not less than 8 to 10 inches thick, or the usual thickness of a good road covering of broken stone. If the soil be of a yielding, soft nature like most clays, there should be a sub-foundation of sand or gravel, suitably rammed in layers, for the broken stone to rest upon. After the first layer of stone is spread upon the excavated road-bed or upon the sand form, the street may be opened to traffic, or, to hasten the operation of consolidation, rollers may be used upon it. A second and a third layer follow. In spreading the last layer, the required form of transverse section of the road surface is carefully established. The foundation is finished with a layer two to three inches thick of clean gravel, and the pavement is laid thereon, as hereinafter described.

Foundation of Cobble Stones.

The cobble stone pavement set in a sand form, of which a description is given below, although furnishing a very inferior street surface for the reasons therein given, forms a good foundation for a pavement of stone blocks, and has frequently been utilized as such in the reconstruction of old cobble stone roads.

In setting the cobble stones less care would be necessary in their selection with a view to placing those of the same

size together, than if they were themselves to form the road surface and sustain the traffic.

The Cobble Stone Pavement.

The cobble stone pavement is the one in most general use in the United States, especially in new towns and cities, though entirely wanting in most of the essential requisites of a good street surface. It is formed of rounded or egg-shaped hard pebbles, varying in length from 6 to 10 inches, and in width from 3 to 6 inches. They are set side by side, in close contact with each other, with their smallest ends down, in a bed or form of clean damp sand or small gravel, previously compacted in layers upon the natural soil.

This sand foundation should be from 8 to 10 inches in depth, depending on the nature of the sub-soil. Before forming it, the road bed, after it has been excavated to the proper depth, is thoroughly consolidated by ramming or rolling. The sand should be compacted while in a moist state.

The cobble stones, after being set in position, are firmly settled to their beds by a heavy rammer, so as to bring their tops to the required roadway surface. Several rammings are sometimes necessary to secure their even adjustment. It is usual to give the required convexity to the surface—about 1 in 40 to 45 from the centre to the side gutters—by placing the largest stones in the middle, and suitably graduating the sizes toward the sides.

After the pavement is laid a layer of sand or fine gravel, two or three inches thick, is spread upon the surface and allowed to work its way in between the stones.

The defects of this kind of pavement are that its resistance to traction is great, while it is noisy, rough, and difficult to clean. The stones are liable to be pressed down unequally into the sand foundation, resulting in ruts and depressions which necessitate frequent repairs. It is severe upon vehicles and animals, and very unpleasant to travel over.

In laying cobble stone pavements in the city of New York, the usual requirements are that "The paving stones must be heavy and hard, and not less than six inches in depth, nor more than ten inches in any direction. Stones of similar size are to be placed together. They are to be bedded endwise in good clean gravel, twelve inches in depth. They shall all be set perpendicularly, and closely paved on their ends, and not be set on their sides or edges in any cases whatever."

Sand is unsuitable for a foundation, except when in a confined position where it cannot spread or escape laterally, as is usually the case when compacted in the excavated road bed. It should be clean, and if mixed with gravel, screened from all grains exceeding one-fifth of an inch in diameter, and compacted in the foundation while moist, by ramming or rolling it in layers not exceeding four inches in thickness. When all these conditions are imposed it forms a cheap and tolerably good foundation for a pavement.

Sand from the sea shore, or beach sand, from which all earthy matter has been washed, cannot be thoroughly compacted by ramming, on account of the entire absence of cohesion among the grains, which causes it to slide from under and loosen up around the rammer at each blow. Sand of this quality should be consolidated by rolling, or if rollers cannot be had, clayey or earthy matter should be mixed with it in such proportions as experience in each case may suggest.

Old Roads as Foundations.

An old road, whether it be paved, Macadamized or graveled, will generally be found to furnish a good foundation for a new pavement, care being taken to bring its surface to an even state, and to the required form, by removing all large elevations and depressions. If the old covering be cobble stones, the interstices at the surface should be cleaned out and then filled with clean sand or small gravel, well compacted, or, better still, with hydraulic mortar, or with concrete of which the ballast contains no fragments or gravel exceeding half an inch in largest diameter.

Rubble Stone Pavement.

The rubble stone pavement (Fig. 46), resembling the uncoursed portion of some ancient *opus incertum*, is formed with fragments of stone of various shapes and sizes, laid closely and compactly together, so as to form as even a surface as possible, but not in lines or courses. It is superior to the pavement of rounded pebbles, inasmuch as it may be made more even. It will therefore offer less resistance to traction, and be less severe upon vehicles and animals. The fragments of stone are such as can usually be selected, or produced with very little labor from the refuse of a stone quarry. The dimensions may vary from 3 to 6 inches in breadth and 6 to 12 inches in length, while the depth, to prevent their tilting up, should not be less than 5 or 6 inches. They are laid like cobble stones, in a form of sand or gravel, each stone being carefully adjusted to its place, so that when it

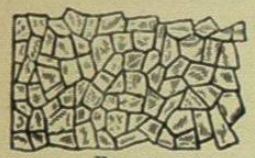

Fig. 46.

has been properly rammed its top face will coincide with the required surface of the pavement. Continuous joints in the direction of the draught should be avoided, in order to guard against the tendency to wear into ruts. To this end the long stones should not be set with their largest dimensions parallel to the sidewalks.

A rubble stone pavement laid in the manner above indicated, forms a good foundation for a pavement of stone blocks, and they may be laid upon a layer of sand or gravel about one inch thick, or in a bed of cement mortar, preferably the latter, although attended with some extra expense.

Concrete Foundations.

Foundations of concrete, for street pavements, may be laid by the same method, and the concrete should be made after the same formula already laid down for roads, except that they should generally be somewhat thicker, to enable them to withstand the heavy traffic which passes over them in most cities and large towns. Upon firm and nearly incompressible soils, a thickness of 6 to 7 inches properly rammed in one or two layers, will ordinarily suffice, but in soils of a spongy, elastic nature, or largely composed of clay, a thickness of 8 to 9, or even 10 inches, will not be excessive. Though the most costly, it is the best street foundation, all things considered, that has yet been devised. In a few weeks after laying it becomes a strong, solid monolith, and even if it should crack in many places, in consequence of the great and varying loads upon it, or from unequal powers of resistance, and therefore unequal subsidence of the underlying soil, its superiority to any other kind of bottoming can scarcely be doubted. Perhaps not the least of its many

advantages is the protection it affords against frost in high latitudes, subjected to long continued cold weather, such as prevailed in the northern portions of the United States, and in the Canadas during the winter of 1874–5. It was then observed that in Broadway, New York city, where the stone-block pavement rests upon a concrete foundation, the water and gas pipes were almost entirely exempt from injury by frost, while in the side streets, and notably in Fifth Avenue, which is covered with the Belgian blocks set in a sand foundation, the pavement had to be taken up to such an extent, and in such numerous places, as to cause serious annoyance to the traffic, to say nothing of the expense incurred in repairs, and the permanent injury to the street. It is impossible to take up a pavement in places, and relay it in the same condition in which it was found.

Rubble Stone Foundations.

Rubble stone foundations for street pavements are constructed in essentially the same manner as for roads. Their thickness, however, should rarely be less than 8 to 10 inches, and they should not be resorted to, if the road bed is composed of easily compressible, or spongy soil, in which the stones comprising the lower layer would fail to find a firm and stable bed.

After the stones have been laid down to the required thickness, the surface should be made as even as possible, by breaking the stones of the top layer into small fragments, so as to fill on the surface interstices. For this work the long handled hammer described on page 73, will be found to answer very well. There should then be spread on the surface a layer, 2 or 3 inches in thickness, of binding material,

such as the detritus of the stone yards, or a mixture of clay, sand and gravel, or ordinary hard pan, or unscreened gravel.

The road may then be thrown open to traffic, or compacted by rollers, the ruts and depressions being constantly raked in. When the surface has become hard, smooth and even, a layer of about 2 inches in thickness of clear gravel is evenly spread thereon to receive the paving blocks. The top surface should be adjusted parallel to that of the finished street.

This foundation, therefore, is nothing more than a substantial road covering, consisting of a rather deep bottoming of rubble stone, surmounted with a thin surface finish of Macadam stone and binding material.

Foundations of Rubble Stone and Concrete.

Pavement foundations of rubble stone, filled in with cement-concrete, formed after the general directions given on page 105, doubtless rank next to those of cement-concrete alone, in firmness and durability. Their thickness may vary from 6 to 8 inches, if the road bed be mostly clay of a yielding character, or if it be elastic or spongy.

In order to economize in the cost of the concrete filling, care should be taken when laying down the rubble stones, to adjust their upper edges somewhat evenly, so as generally to bring them into a surface parallel to that of the finished street.

Sidewalks and Side Gutters.

For the convenience of foot-passengers, streets must be provided with sidewalks, on either side. Their width, which will depend upon the space that can be spared from the carriage way, the kind of traffic carried on in the locality,

and the number of people requiring daily accommodation, should seldom be less than six feet, or more than fifteen. They are usually paved with flagging stones, brick, asphalt, wood, or cement-concrete, or some other variety of artificial stone, as described in Chapter VI. and should slope toward the street not less than 1 inch in nine or ten feet, in order that the surface water may be conveyed promptly into the side gutters.

The carriage way is separated from the sidewalk by a line of flagging-stones, sunk into the ground on their edges. These are called curb-stones, and form the outer side of the sidegutters and sustain the sidewalk, with the pavement of which their upper edges are set flush, so that the water can flow over them into the gutters. Their lower edge should extend at least 6, and preferably 8 or 10 inches below the surface of the street pavement, to which they act as a kind of abutment.

It is usual to pave with special care for a width of 14 to 16 inches, the lowest portions of the street on either side, called the side gutters, where the pavement meets the curb-stones. The slabs used for this purpose, called gutter-stones, or simply gutters, are laid flatwise, so that their upper faces form a part of the street surface. In the city of New York the curb-stones for the best paved streets are required to be not less than 3 feet long, 20 inches wide, and 5 inches thick; and the gutter-stones not less than 3 feet long, 14 inches wide and 6 inches thick. In streets crowded with traffic there is this objection to gutter-stones of uniform width, that the continuous longitudinal joint between the gutter and the rest of the pavement, wears into long, deep ruts, or grooves, which cause severe strains

upon the running gear of vehicles, when the wheels, having once entered the rut, attempt to leave it. A remedy for this evil would seem to be to break the continuous joint, by making the gutter-stones of different widths—say 12 inches and 15 inches alternately, as shown in Fig. 47. Pavements for sidewalks are more fully described in Chapter VI.

Pavement of Stone Blocks.

Although the form and dimensions of paving blocks have been the subject of much discussion, all authorities agree that the material should possess in a superior degree the qualities of toughness and hardness, so that it shall not crush, nor wear away too rapidly, under the effects of the traffic conducted upon it. It is also very desirable that the stones shall not polish and become slippery. While there may be considerable variation in the widths and lengths of blocks for the same pavement, they should be of uniform depth, or very nearly so, if the foundation be other than a form of sand or gravel. Were it otherwise the blocks of least depth would require to be underpinned at considerable extra cost, either with good mortar, or stone chips laid in mortar, in order to bring their tops to the required height. If a thick joint of sand alone be placed between them and the foundation, they will subside more than the blocks of proper depth which surround them, under which the layer of sand is very thin. The condition therefore that the blocks shall settle equally, requires them to be of uniform depth.

Hence, for pavements laid in mortar, the blocks should b of nearly uniform vertical thickness. As each stone is liable to have upon it the entire weight of the load carried by one wheel, it should be sufficiently large to resist crushing, and

be so firmly supported underneath as to resist depression. In the direction of the draught, it should be no broader than the length of a horse's shoe, say not exceeding 4, or at most 4½ inches, in order that the joints between the blocks may give a firm foothold at each step without slipping. Their depth in a vertical direction should be a little more than double their horizontal breadth, in order that they shall not tilt up on one side when a weight comes upon the other. For the same reason, and to increase the area of bearing surface on the foundation, their length across the street, should be at least equal to their depth, and may advantageously exceed it to some extent.

The most desirable dimensions for paving blocks are

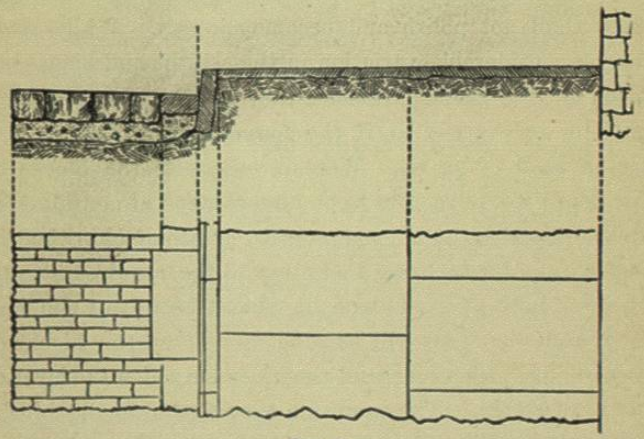

Fig. 47.

therefore as follows: 3½ to 4½ inches broad measured along the street; 9 to 12 or even 15 inches long measured across the street, 8 to 10 inches in vertical depth.

The stones are placed closely in contact, on their edge in

continuous courses, with their largest dimensions either directly across the street as in Fig. 47, or at an angle of 45° to 60° with its axis. It is claimed that the latter method is preferable, as the blocks are then less likely to wear into a convex form. When the joints run crosswise, the edges of the cross-joints receive a more severe impact from the wheels than when the latter cross the courses diagonally.

The stones of the same course must be of the same breadth, the broadest edge of each stone being placed down, when there is any difference in this respect. The joints are then close below and open on top, and should be compactly filled in with sand or fine gravel. Granite chips are sometimes wedged in between the blocks. Paving blocks generally give joints sufficiently open to secure a good foothold for horses, without rendering special care necessary to attain that end. When placed as in Fig. 47, the continuous joints run across the street and not lengthwise of it.

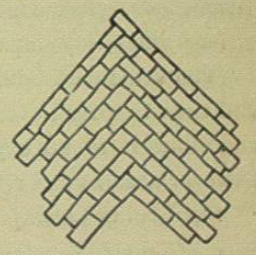

Fig. 48.

Upon steep streets the blocks are sometimes arranged in two sets of diagonal courses meeting in the middle of the roadway in an angle pointing up the ascent, as shown in Fig. 48. The joints, by sloping downwards to the right and left, aid the flow of surface water and other liquids into the side gutters.

If the foundation be concrete, or rubble stone filled in with concrete, or an old broken stone, cobble stone, or rubble stone covering, in good condition, it would be advantageous, and produce in many respects a better pavement, to

set each stone firmly in a bed of stiff, though not very rich, cement mortar, care being taken not to disturb it again, or allow any travel upon it, until the mortar has had some days to set and harden. Some constructors recommend the use of cement mortar in the joints between the blocks. The mortar for this purpose should be mixed with a small quantity of water—not enough to make it plastic—and should then be tamped into the joints, or calked in after the method pursued in pointing first-class stone masonry.

The joints may be filled with bituminous mastic, or bituminous limestone, into which chips of granite or pieces of hard slate are compactly driven while it is warm and soft.

The usual method however, is to set the blocks in contact, and then to spread over the pavement a layer of clean sand, and allow it to work gradually into the joints. The sand however absorbs and retains the filthy surface liquids.

Sand being incompressible when in a confined state, constitutes a good filling, with the objection above named, especially when the blocks are set in mortar, as it then has no avenue of escape, and readily adjusts itself, and assumes a new condition of stable equilibrium, for every change or disturbance caused by the vibrations of the roadway.

When the foundation is a form of sand or gravel, or very uneven broken stone, or rubble stone, requiring a thick layer of sand to bring the surface to the required form, the paving blocks are not bedded in mortar, but are generally set in place upon a layer of clean sand or gravel spread upon the foundation to receive them. As the work progresses each block is slightly rammed, and when an area several yards square, reaching entirely across from one curb to the other has been completed, a heavy wooden rammer weighing 50 to 60

pounds manned by two men, is passed over them, a number of blows being given to each block. The blocks which break must be replaced by others, and those whose tops are forced below the required street surface, are taken up, additional sand filled under them, and then reset. A layer of clean sand about two inches deep is then spread over the pavement, and allowed to work its way gradually in between the blocks.

When the foundation is only a sand or gravel form, the paving stones should be somewhat larger in horizontal area than if intended for a concrete or broken stone foundation, for the reason that small blocks, and more especially thin blocks set on edge, have a tendency to settle into sand unequally.

Upon streets having a longitudinal inclination exceptionally great, special precautions may very properly be taken to secure a more perfect foothold for the horses' feet, than would be afforded by rectangular or cubical blocks placed horizontally with close joints.

If the blocks can be procured of marked wedge shape without extra cost, it will generally suffice to set them with their broadest edge down, as in Fig. 49, so as to form a

Fig. 49.

series of open joints across the street. These may be filled in, to within about one inch of the top, with granite chips firmly driven with a hammer, and topped off with a two-inch layer of clean sand. Some stone can be split readily into these forms.

With blocks that are essentially rectangular, the same end may be gained by setting the transverse courses about

three-fourths of an inch apart, and interposing a course of slate between them as in Fig. 50, with the upper edges about

Fig. 50.

one inch below the street surface, finishing the work with a layer of sand as before, or, by a simple method, the stones may be set slightly canted on their beds so as to lean toward the descent as in Fig. 51, thus forming a series of triangular

Fig. 51.

ridges, or corrugations across the street. The joints are filled in with clean sand in the usual way.

The Guidet Pavement.

Broadway, in New York city, below Fourteenth St., is covered with what is known as the Guidet pavement, composed of granite blocks as shown in Fig. 47, set on a foundation of cement concrete 6 inches thick. The same kind of pavement similarly laid, surrounds the New York post office, at the corner of Broadway and Park Row.

Upon newly made earth, or in wet, springy or swampy soils, the foundation should always be a layer of good concrete, at least 6 inches thick, laid upon a bed formed parallel to the finished street surface. The stones are then set in a layer of clean sand spread over the concrete to a depth of half an inch to an inch. The left hand portion of Fig.

47 shows this pavement. The usual specifications for the Guidet paving blocks require that they shall be of granite, equal in hardness to the Quincy granite, of durable and uniform quality, each measuring not less than 3½, nor more than 4½ inches in width, on the upper surface or face, and not less than 10 nor more than 15 inches in length, and not less than 8 nor more than 9 inches in depth. Blocks of 3½ inches in width on the face, to be not less than 3 inches in width at the base; all other blocks to measure on the base not more than 1 inch less in width or in length than on the face. The blocks are set upright in close contact on their edges, in courses, with the longest dimensions and the continuous joints running across the street, breaking joints lengthwise of the street. The ends of the blocks are dressed off so as to give close joints in the direction of the draught, while the broad vertical sides of the blocks are left rugged or uneven, or with the split rock-face, so that the continuous joints running across the street are somewhat open. This pavement, besides being firm, strong and durable, offers a good foothold for horses, in its open cross-joints, and an easy draught for loaded vehicles in the narrowness of the blocks. It gives very general satisfaction in New York, and seems well adapted to a street subjected to very heavy traffic. It would be an improvement, with a concrete foundation, to set the blocks in cement mortar, as a security against unequal settlement. It requires from 24 to 25 of these blocks to lay one square yard. Their cost, exclusive of land haulage from the dock to the street where they are to be used, varies with the price of labor, from 12 to 15 cents each, after allowing for loss and breakage. The cost of a sand foundation in large cities generally comprises excavating and rolling the

road bed, hauling away the excavated material, and purchasing, transporting, filling in, and rolling the sand, and will therefore, vary with the price of labor and sand, and the length of haulage. In the city of New York a sand form 9 to 12 inches thick, will cost, when ready for the pavement, from 40 to 60 cents per square yard.

A good cement concrete foundation 6 inches thick, exclusive of excavating and compacting the road bed and removing the materials, will cost from $1.40 to $1.50 per square yard.

At the present time, (autumn of 1875) contracts could be let in New York city, for the Guidet pavement on a sand foundation 6 to 8 inches thick, for from $4.75 to $5.25 per square yard. This includes a very liberal profit to the contractor.

In some localities, cubes of eight inches are preferred for paving. Their cost, delivered upon the streets in our eastern city, will generally not exceed $2.75 to $3.00 per square yard of surface. When laid upon a form of sand or gravel, 9 to 12 inches deep, it will cost at least 50 cents more per square yard to make the foundation and lay the stone, bringing the total cost of the finished pavement to $3.25 to $3.50 per square yard.

The Russ Pavement.

Several years ago, a portion of Broadway, New York, was covered with the Russ pavement at a cost of $5.50 per square yard. The natural soil at the level of this road bed was sand slightly mixed with clay. This was excavated to a depth of 17 inches, and then a layer of granite chips, from 4 to 8 inches in largest dimensions, and about half that thickness, was laid upon the bed and rammed down nearly flush with the graded surface. Upon this was placed a foundation

of concrete, six to seven inches thick, formed in detached rectangular sections, and composed of 1 volume of Rosendale cement, 2½ volumes of clean coarse sand, 2½ of broken stone like the Macadam road metal, and 2 of coarse gravel. The paving stones were rectangular blocks of sienitic granite, 10 inches deep, 10 to 18 long, and 5 to 12 wide, set in courses at an angle of 45° with the axis of the street, and so arranged that the pavement could be taken up in rectangular sections of 4ft. by 3½ft. in order to reach the gas and water pipes, without disturbing the adjacent portions.

This pavement did not give entire satisfaction, the surface of the blocks being too broad to give a good foothold for the horses. They also became smooth, polished, and slippery. It was therefore replaced by the Guidet pavement already described.*

* The following is condensed from the specifications in the patent granted to Mr. Russ, in 1846.

First. The sub-soil is graded.

Second. Granite chips, etc., 4 to 8 inches in diameter, and about half as thick, are laid on the road bed with the flattest sides upward, and rammed flush with the grading.

Third. A concrete foundation 8 to 10 inches thick is then laid in frames of sound wood, cast iron, iron stone pottery, burnt earth or any other fit material, thicker at bottom than at top. Before the concrete is put in, bars of iron are placed into the panels, crosswise, with holes in them, through which they are united by an eyebolt, with a ring in the head of each bolt. Large panels receive 2 or more sets of such bars, bolts and rings. The concrete is then filled in and consolidated, after which it may be lifted out of any panel to obtain access to sewers, gas or water pipes, etc.

Fourth. The pavement consists of granite or sienite blocks averaging 10 to 12 inches long, 4 to 5 inches wide on the top surface, and about 10 inches deep, carefully laid, the ranges of stones forming