prevented. Hence the water in the ditches remains at the level of low tide, and the surface of the road should be established at such height above that level that it will always be firm and solid. Whatever level may be adopted for the roadway across the marsh, it must on approaching the stream rise to the top of the dike to prevent overflow from the stream at that point. This point is illustrated in Fig. 17, which is a longitudinal section through the sluice-pipe. The road is built a little higher than the natural surface, and ascends to the crest of the dike, near the stream. The bridge across the stream in continuation of the road is not shown.

This method of drainage has been very successfully applied in reclaiming the "Jersey Flats" between the cities of Newark and Jersey City, New Jersey, a large tract of marsh land with its natural surface not higher than the level of ordinary high tide, and in large part some inches below that level. These Flats were formerly subject to twice daily overflow, from the Passaic and Hackensack rivers, in which the mean rise and fall of the tide is about 4 feet. The tract was surrounded by a dike or levee formed along the margin of the stream, of the material excavated from a wide open ditch parallel to it on the inside. Numerous broad cross ditches, dividing the marsh into parallelograms, lead into this main ditch. The sluices are located at suitable intervals so as to drain from the main ditch into both the Hackensack and the Passaic rivers. The pipes are usually placed in pairs, and are of various sizes, in only a few instances exceeding two feet in interior diameter. It has been found that a difference of one inch in the inside and outside water level, will open or close the sluice-gates.

By this means a noxious swamp has been converted into arable and thrifty land. It is sufficiently firm to support a roadway upon its surface, without any special precautions in preparing the road bed.

When the embankment requires more earth than the excavation can supply, the deficiency is made up from *side-cuttings*, made in some convenient locality near by. On the other hand when the embankments do not consume all the earth furnished by the excavations, the excess is deposited in *spoil-banks*, usually located on a somewhat lower level than the road surface, care being taken to provide for the drainage in such a manner as to prevent the formation of pools of water that might affect the stability of the side slopes of the excavations.

FIG. 18.

Side Drains.

It is essential to the proper condition of a road, that the surface water of the soil adjacent thereto shall be cut off by suitable open side drains, so that it can not filter under the roadway, and render the subsoil soft, spongy, and incapable of sustaining the weight upon it. Otherwise the road covering would sink into the soft earth beneath, and require to be frequently renewed. In flat and level countries, the side drains (Fig. 18), should be at least two and a half to three feet lower than the bottom of the road covering, and, to prevent accidents to vehicles, they should be placed on the field side of the fences or hedges, when passing through sections of country where such barriers are necessary, as they usually are in agricultural districts. It would be better for the roadway, to place the side ditches between the road and the fences, thus widening the space between the latter, and in-

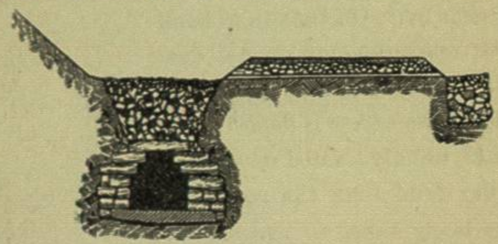


FIG. 19.

creasing the degree of exposure of the road surface to the action of the wind and sun ; and this method should be followed whenever admissible. A line of hedge or shade trees on each side of the road, exerts a very damaging effect upon its condition, and adds greatly to the cost of its proper maintenance. High walls and hedges are more objectionable than open post-and-rail or rail fences.

Upon those portions of the road in excavations, unless it be through rock, open side ditches are inadmissible, as they would soon be filled up by the earth washed down from the side slopes. Covered side drains are necessary. They may be constructed as shown in Fig. 19, with a flooring of concrete, flagging stones, or brick, with side walls of the same material, and covered with flagging stones or with bricks, or

stones corbeled out to meet above the centre of the drain. The roof should be laid with open joints, and then covered with a layer of straw, hay, or fine brushwood, upon which a filling of fragments of stone, bricks, or coarse gravel and pebbles is laid, so as to allow the water to filter freely through, without carrying sediment with it.

Cross Drains.

Besides the covered side drains in cuttings, cross drains are usually deemed necessary to keep the road bed dry. Their depth should be 20 to 24 inches below the road covering. They should have an inclination on the bottom, from the axis of the road to the side drains, of not less than 1 in 100 nor greater than 1 in 30. When the road is level they may run straight across. When otherwise, their plan assumes the form of a broad letter V, with the point in the centre of the road directed toward the ascent. From this, their usual form, they are termed *cross-mitre* drains. Their distances apart will depend upon the nature of the soil, and the kind of road covering used. In some cases, it should not exceed 18 to 20 feet, in others it may be much greater. They are constructed by digging trenches across the road bed, after the surface has been prepared for the reception of the road covering, and then filling the trench with broken stone or pebbles, leaving a small open water-way at the bottom, so constructed that it will not become choked with earth. Bricks may be used for this purpose in a variety of ways as shown in Figs. 20, 21, 22 and 23. Flat stones may be used as shown in Fig. 9, page 41.

The area of the water-way of Fig. 20, is unnecessarily large, for most cases that will occur in practice, being 16 square inches. The bottom of the road material rests on the line AB. Small drains placed close together will drain the

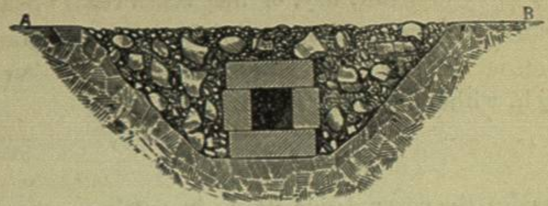


FIG. 20.

road bed much more efficiently than larger ones of the same aggregate water-way placed farther apart. A water-way of 2.5 to 4 inches sectional area, such as may be obtained with

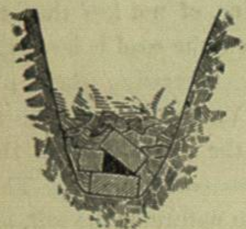


FIG. 21.

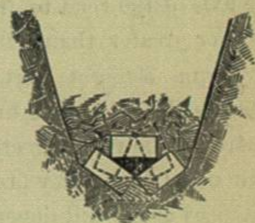


FIG. 22.

three lines of whole bricks placed end to end as in Fig 22, will generally be ample. The full lines show one method of

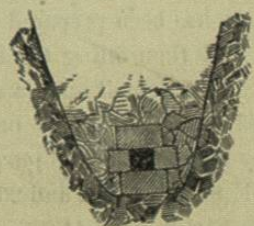


FIG. 23.

arranging tne brick, and the dotted lines another. By splitting one-third of the bricks into halves longitudinally, they

may be placed as in Fig. 23, or more economically still as in Fig. 21, by splitting one-fifth of them.

The water-way may be formed of drain tiles of 1½ to 2 inches interior diameter. Indeed, the ordinary method of tile-drainage for agricultural purposes will answer excellently for the sub-drainage of roads, and it will seldom be necessary to use tiles of larger bore than 1½ to 2 inches. With a fall of 1 foot in 100, a 1½ inch tile will discharge nearly 12,000 gallons of water, and a 2 inch tile nearly 22,890 gallons in 24 hours. The tiles are placed in contact, end to end, in a trench cut very narrow at the bottom, care being taken to give each piece a firm bed, and to arrange the axes in a continuous line, so as not to diminish the water-way by jogs at the joints. The bricks, stones or tiles used to form the water-way, should be covered over with a layer of hay, straw, tan-bark, turf, or other suitable material, to prevent earth from entering the drain ; the trench is then filled up with the earth excavated from it.

Cost of Stone, Brick and Tile Drains.

Tiles are generally a little more than one foot in length, so that making a fair allowance for breakage and imperfect pieces 1000 tiles may be relied upon to lay 1000 feet of drain. Two-inch tiles can be manufactured at profit in ordinary times for $11.00 to $11.50 per thousand, and bricks for $6.50 to $7.00 per thousand. We will estimate the tiles at $14.00 and the bricks at $8.00 delivered and distributed along the road. A cross drain under a road 30 feet wide, with one foot-path, page 60, will be about 45 feet long. The tiles will cost $0.63 for each cross drain, the brick $1.35 for the small triangular drain, Fig. 21 ; $1.62 for the triangular drain Fig. 22, or the small square drain, Fig. 23, and $3.24 for the large square drain, Fig. 20. The labor will be nearly proportional to the amount of excavation, and will therefore be the least for the tile drain, so that it is within limits to estimate the cost of the latter in labor and material, at considerably less than one-half that of the former. If the cross drains have their discharge three inches above the bottom of the side ditches, with a fall from the centre of the roadway each way of three inches—equal to 1 in 90—their average depth below the road surface will be about three feet, and the average depth of excavation below the subgrade prepared for the reception of the road materials will be a little over two feet, inclusive of the greater depth under the foot-path. The following estimates of the cost per rod of these several kinds of drains, is believed to be fair, with labor at $1.75 per day, in stiff clay soils :

	Tile drain. 2-inch pipe tiles.	Brick triangular drain. Fig. 21.	Brick drain. 3 courses end to end. Figs. 22, 23.	Brick drain. 4-in. x 4-in. Fig. 20.
	$ cts.	$ cts.	$ cts.	$ cts.
Cutting and filling per rod..........	.25	.30	.30	.35
Cost of tiles, or bricks	.23	.55	.594	1.188
Total cost per rod...	.48	.85	.894	1.538

The trenches for stone drains must be excavated to a width of at least 21 inches on the bottom. They may be cut with vertical sides. At least one-half of the earth must be hauled away to make room for the stone, so that there

will be more than one cubic yard of earth to be carried away and a like amount of stone collected and brought to the road for every rod of drain. If stones of the right kind are near at hand it would not cost more than 25 cents per cubic yard to collect them, while twice that amount would not be excessive if they have to be brought from a distance or dug from a bank or pit. Assuming that the stones can be collected within a quarter of a mile of the road, the following estimate is submitted as a near approximation :

Cost of Stone Drains per lineal rod.

Cutting trench and hauling away the surplus earth.........	50 cents.
Collecting and hauling 1 cubic yard of stone...............	25 "
Laying the stone and filling in..	25 "
Total per lineal rod.....	$1.00

A standard work on Farm Drainage (Henry F. French) estimates that with tiles at $10.00 per M,—1 cent per foot—and labor at $1.00 per day, the cost of a tile drain 4 feet deep will be for cutting and filling 33⅓ cents, and for the tiles 16⅔ cents, or a total of 50 cents per rod. At the same price for labor, the cost of a stone drain is set down at $1.25 per rod, viz., for cutting and filling trench 21 inches wide 50 cents, for hauling stone 50 cents, and for laying the same 25 cents. And the conclusion is that "drainage with tiles will generally cost less than one-half the expense of drainage with stones, and be incomparably more satisfactory in the end."

As tile drains are more liable to injury from frost than those of either bricks or stones, their ends at the side ditches should not, in very cold climates, be exposed directly to the weather, but may terminate in blind drains, reaching under the road a distance of about 3 to 4 feet from the inner slope of the ditch.

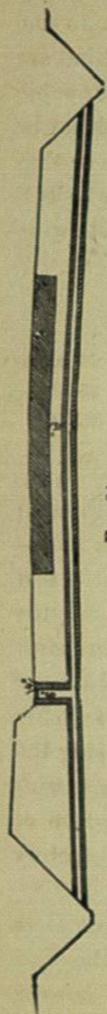


Fig. 24.

Another method of draining the road-bed, offering security from frost, is by one or more longitudinal drains, discharging into cross-drains placed from 250 to 300 feet apart, more or less, depending on the contour of the ground. With a roadway and foot path 45 feet wide at the level of the bottom of the side ditches, two such drains of 1½ to 2 inch tiles will be required in most kinds of clayey soils. They should be placed at equal distances from the side ditches and from each other, and will therefore be 15 feet apart. Their depth below the surface should be not less than 3 to 3½ feet, and the cross-drains into which they discharge should be of ample dimensions.

All roads upon clayey soils in flat level countries should be amply provided with drains under the road covering. For deep, marshy, soils, as already mentioned, they are indispensable.

Surface Drainage.

The drainage of the road-surface is provided for by making it a few inches higher in the centre than at the sides, sloping it gently in both directions to the side gutter, and is also greatly facilitated by giving the surface an inclination longitudinally not greater than 1 in 34 nor less than 1 in 125. A series of gentle undulations may be

established, even in a perfectly level country, without adding materially to the cost of construction.

If there are no sidewalks the surface drainage is discharged directly into the side ditches. When there are sidewalks the drainage is into the side gutters, from which it must be carried into the side-ditches by small covered drains of stone, brick, or tile, see Fig. 25, and dotted lines, Fig. 18, or conducted by vertical shafts into the cross-drains, if that method of draining the road-bed has been

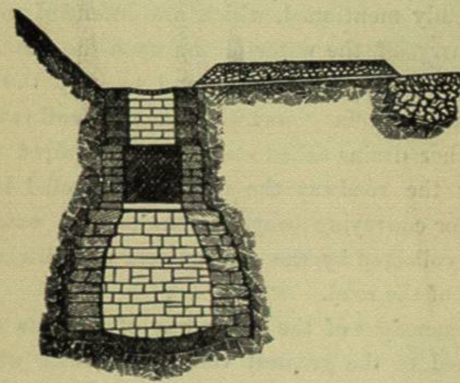


Fig. 25.

adopted. These vertical drains (Fig. 24) are covered at top by a grating to arrest coarse earth, leaves, etc., and may have beneath them a small vault lined with masonry, termed a silt basin, to collect the fine sediment which flows in from the roadway, which should be removed from time to time and restored to the road surface.

The covered side-drains (Fig 19) may if desirable, be constructed with a roof of concrete or of brick or stone laid in mortar, in which case the filling of broken stone, gravel, etc., above, for filtering purposes, would be omitted, and arrangements made for conducting the water into the drain through vertical shafts placed at suitable intervals. These vertical openings should be placed over *silt-basins*, and be large enough to admit a boy, so that the sediment can be removed as often as necessary. (Fig. 25.) This method of construction is much used in cities and towns, but not on country roads.

Culverts.

Besides the *side gutters, side drains, cross drains*, and *small drains* already mentioned, which are intended more especially to carry off the water falling upon the roadway, and upon the side slopes in cuttings, and to keep the road bed and subsoil dry in flat countries where the soil is clayey or marshy, other drains called *culverts* are required for carrying under the roadway the stream intersected by it, and generally for conveying away into the natural water-courses the water collected by the side gutters and ditches on the upper side of the road.

The dimensions of the water-way of culverts should be proportioned to the greatest volume of water which they may ever be required to carry off, and should in all cases be large enough to allow a boy to enter for the purpose of cleaning them out. Eighteen inches square, or if circular, twenty inches in diameter, will suffice for this purpose. They should have an inclination on the bottom of not less than one in one hundred and twenty, nor greater than one in thirty. Small culverts may be constructed of the same cross-section, and in substantially the same manner as the covered side drains, Fig. 19, with the exception that no arrangement need be made for receiving the water from above through a filter of stone fragments or gravel. The sides and roof may

therefore be laid in mortar, and the floor had better be in the form of an inverted arch.

In localities where stone and brick are expensive, small culverts may be constructed of four slabs or planks (Fig. 26) forming a long box open at both ends. To prevent the side pieces from being forced together by the pressure of the surrounding earth, they should rest against small blocks of wood nailed at intervals into triangular notches cut on the inner faces of the top and bottom pieces, or the edges of the side pieces may be inserted into longitudinal grooves cut in the top and bottom pieces.

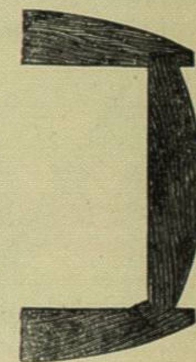


Fig. 26.

It will be found advantageous to use hydraulic concrete for culverts, especially for those of large dimensions, unless bricks can be procured at a low cost, or stone in suitable form is plenty in the neighborhood. Most localities will furnish sand, coarse gravel and pebbles. With these and a liberal addition of common lime to the hydraulic cement, a concrete suitable for work of this description can be prepared at moderate cost. The following proportions will answer :

1 measure of Rosendale, (or any equivalent) cement.

1 measure of slaked lime in powder.

4 to 4½ measures of clean sharp sand.

9 to 10 measures of pebbles, small fragments of stone or brick, oyster shells, or a mixture of them all.

When Portland cement of standard quality is used, the proportions may be :

1 barrel Portland cement, as packed for market.

1 barrel common lime, producing $2\frac{1}{4}$ to $2\frac{5}{8}$ barrels slaked lime powder.

9 to 10 barrels sand.

15 to 17 barrels of the coarse materials.

It must be borne in mind that the addition of common lime weakens, and also retards the induration of the concrete. The quantity added must, therefore, be governed by the importance of the work, and the length of time it will have to harden before being subjected to heavy weight or pressure.

A form of cross-section for culverts, which admits a min-

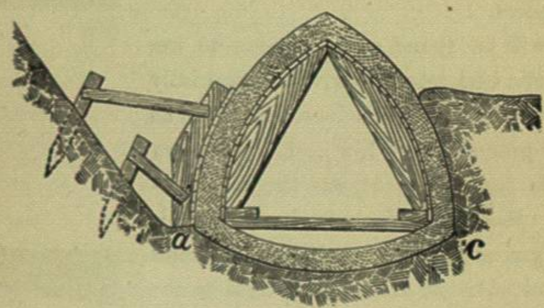


Fig. 27.

imum thickness in the concrete floor and sides is shown in Fig. 27. In constructing a culvert of this form, a trench, concave at bottom, is first excavated to the width of the base *a c*, and the concrete floor, four to five inches in thickness, is formed thereon in one layer. Upon the floor cross pieces are placed at intervals of a few feet, to support the two detached segments of centering for the sides, which should rest upon wedges, to facilitate their removal for further use. The centering may be made in lengths of from twelve to twenty feet, and of such weight that three or four men can easily

handle them. Convexity is given to the exterior surfaces by a movable form, made by nailing narrow strips of boards to cross pieces cut to the required concavity. It is kept in place by wooden braces nailed to stakes driven into the side slopes of the trench. For a culvert of twenty-four inches interior width at the base, arched as in Fig. 27, with circular segments whose centres are in the vertices of the opposite angles, the sides need not exceed five to six inches in thickness, in case of ordinary depth.

For culverts with a gentle inclination on the bottom, the concrete floor may generally be safely replaced by a layer three to four inches in thickness of broken stone or pebbles of half an inch to two inches in diameter, grouted with hydraulic cement to keep them in place, and protect the foundation from undermining. For the same reason, the foundations should be started lower than when the bottom of the water way is well paved, or when formed of a monolith of concrete in the manner last described. For the discharge of large volumes of water, the masonry must be proportionally massive, but may still be made of concrete, which may be considerably cheapened by embedding in it, as the work progresses, fragments of rock of various shapes and sizes. A section of such a work is shown at Fig. 28.

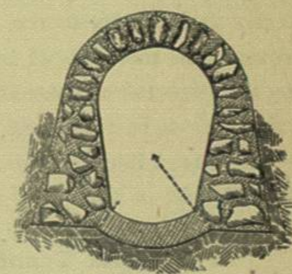


Fig. 28.

The ends of culverts passing through embankments should be protected against the undermining action of the water. This may be done by a sheet piling of flagging-stones or stout planks, sunk well into the soil, or, by an apron of rip-rap stone, or a good pavement, so as to prevent all percolation of water under or at the sides of the culvert. The length of the covered portion of a culvert is equal to the distance through the embankment, on a line with the crown of the arch or roof, and it should be extended out and finished at each end by two wing walls spread out in fan shape, and finished on top in steps, by courses or in a surface parallel with the side slope, but rising a few inches above it, to prevent the earth washing over.

In order to give greater stability to the wing walls, and increase the power to resist the pressure of the earth behind them, their plan may be that of an arc, with either the convexity or concavity to the front, the object being simply to increase the moments of inertia without materially increasing the amount of masonry in the wall. One end of the culvert given in transverse section in Fig. 28, is shown with wing walls in longitudinal vertical section and elevation in Fig. 29, and in horizontal section and plan in Fig. 30.

Width and Transverse Form of Roads.

The determination of the width and transverse form of a country road presents questions of great importance. Some engineers recommend narrow roads, on the erroneous presumption that the cost of maintenance, like that of construction, varies directly or nearly so with the area of the road surface, while in point of fact, unless in special and extreme cases, it varies with the amount of traffic upon it, increasing, however, more rapidly than the traffic. It may be assumed that the quantity of material required to repair a road is about the same, for the same amount of traffic, whether the road be twenty-five feet or thirty feet in width,

although there is a small saving in the labor of spreading it, in favor of the narrow road. A narrow road is less exposed

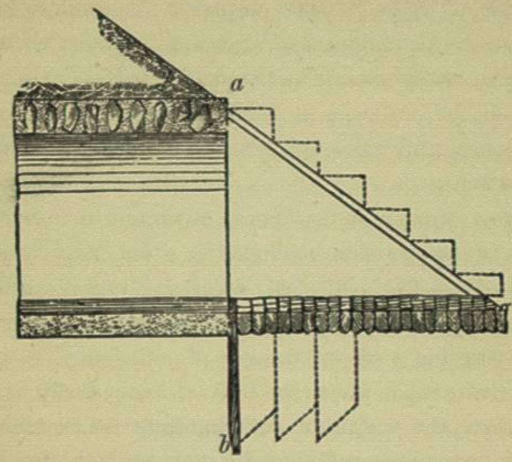


FIG. 29.

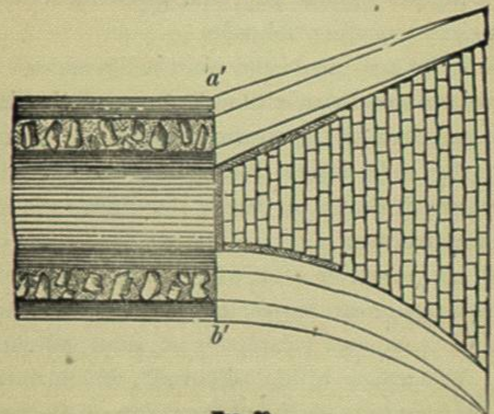


FIG. 30.

to the drying action of the wind and sun than a wide one, and also requires more constant supervision and more frequent repair, in consequence of the traffic being more closely restricted to one track.

A width of 27 to 30 feet, prepared for vehicles, will be ample for the principal thoroughfare between cities and large towns, which should be increased, within or near the cities, to 40, 50, or even to 60 feet, where the amount of traffic is large, and there is a great deal of light travel and pleasure driving.

For cross, branch, and ordinary town and country roads, the width of the portion bedded with stone may usually be reduced to from 16½ to 17 feet, which will amply suffice for two carriages of the widest usual size to pass each other upon the road-covering without danger of collision. In special cases of private roads where the bulk of heavy traffic is all in one direction, the width of covering may be restricted to 8 or 9 feet, or what is sufficient for one carriage, the loaded vehicles having the right of way, and requiring those travelling light to turn out upon the sides.

Side-walks for foot passengers are usually omitted in new or thinly settled countries, although always desirable, if for no other reason than the protection they afford against upsetting into the side ditches during the night, in localities where there are no fences, or where the ditches are between the fences and roadway.

At least one paved or otherwise properly covered side-walk is necessary near towns and villages. When the natural soil is composed principally of sand and gravel it may form the surface of the side-walk, which should be established at about the height of the centre of the roadway. In heavy clayey or loamy soils an excavation to the depth of five or six inches should be made to the proper width of the

foot-path, and filled in with coarse sand or gravel, or with a layer of well-compacted broken stone topped off with one to two inches of gravel. The inner edge of the side-walk should be protected against the wash of the side-gutters by a facing of sods or dry stone.

In cities the side-walks are paved, and the surface slopes toward the street at the rate of not less than one inch in ten feet, in order to secure the prompt discharge of the surface water into the side-gutters, and the edge next the gutters is faced with slabs of stone called *curb-stones* set on edge, with their top edges flush with the side-walk pavement, and their lower edge six to eight inches below the bottom of the gutter.

(The construction of side-walks will be described hereafter).

In France, four classes of roads are prescribed as follows: *First*, 66 feet wide of which 22 feet in the middle are paved or stoned. *Second*, 52 feet wide of which 20 feet are stoned. *Third*, 33 wide of which 16 feet in the middle are stoned; and *fourth*, a width of 26 feet of which 16 feet in the middle are stoned.

Telford's Hollyhead road, which runs through a hilly country, is 32 feet wide between the fences on flat ground, 28 feet on side cuttings not exceeding three feet deep, and 22 feet along steep and precipitous ground.

The Cumberland or National road in the United States has a prescribed width of 80 feet, but the prepared roadway is only 30 feet wide.

The Roman Military roads were narrow, being only 12 feet wide on the straight portions, and 16 feet upon curves.

Wide roads are sometimes finished with a road-covering in the middle only, of just sufficient width for the vehicles to pass each other upon it, while the sides are maintained as *dirt roads*, for light and fast travel during the season when the soil is comparatively dry and firm. The objection to this method is that during the wet season the road covering is injured by the large quantity of mud conveyed to it from the sides.

Opinions differ as to whether that portion of the carriage way to be finished and maintained as a dirt road, should be at the sides or in the middle. Heavy loads are apt to seek the sides, in order that the driver may walk upon the foot path, which favors metaling the wings rather than the middle.

It has been mentioned that the drainage of the road should be provided for by making it higher in the middle, and also by sloping it longitudinally. Engineers differ as to the most advantageous form of cross-section, some recommending a convex curve approaching to a segment of a circle, or a semi-ellipse, while others prefer two planes gently sloping toward the side-gutters, and meeting in the middle of the road by a short connecting convex surface. The latter method seems to carry the weight of testimony, the obvious objections to the convex road being that the water will stand in the middle of the road unless carried off by longitudinal slopes; that carriages will keep in or near the middle, and cause excessive wear along one line, in order to run on a level and avoid the tendency to overturn near the side-gutters; and that when travel is forced to take the sides, the labor of the horses and the wear of the wheels and of the road covering are greatly increased, in consequence of the oblique action of the weight, and the tendency of the vehicle to slide upon the road surface.

It is recommended therefore that the cross-section of the road surface be formed of two straight inclined lines connected at the centre by an arc of a circle about five feet long, drawn to a radius of from 85 to 90 feet. The highest point of the arc should be in the middle of the carriage way. The degree of inclination toward the sides may be at the rate of 1 in 20 for rough roads, 1 in 30 for ordinary well-maintained gravel or broken stone roads, as in Fig. 18, and 1 in 40 or 50 for good paved roads. The drainage of the surface should, when practicable, be further facilitated by giving it an inclination longitudinally of not less than 1 in 125. In a level country this may be done at a trifling cost by a series of short gentle undulations.

Catchwaters.

Upon a long stretch of continuously descending road *catchwaters* should be placed at intervals. They are also necessary at the depressions where an ascending and descending grade meet, their province being to collect the water which runs down the surface of the road longitudinally, and convey it into the side-drains, thereby preventing the formation of furrows and gullies in the road surface. They are broad shallow paved ditches constructed across the road, and so formed that vehicles can pass over them without sustaining a severe shock. They may slope toward one of the side ditches only, or incline each way from the centre toward both, and, if located in a depression, will be placed at right angles to the line of the road. When placed upon a grade they should cross the roadway diagonally, in a straight line, when their discharge is on one side only, and if on both, their plan should be that of a broad letter V, with the angle pointing toward the ascent, so that they will arrest and divide the surface water and convey it to the two side ditches.

The catchwaters may have a descent of from 1 in 30 to 1 in 40, and, as their cross-section should be as nearly uniform as possible, the direction to be given to them in relation to the axis of the road will be governed by the steepness of the grade upon which they are placed, and the transverse form of the road surface. They should never be so located that one rear wheel and one forward wheel, on opposite sides of a vehicle, will enter them at the same time.

A mound of earth erected across the road, either in a straight line, or in a V shape pointing up the ascent, is a cheap substitute for a catchwater drain, and will answer very well if so proportioned that vehicles can pass it without inconvenience and with very little shock.

The pavement of catchwaters should extend to the point where the surface water is received—by the side-ditches or otherwise—to be conveyed away to the natural water-courses.

Tools and Implements.

The most necessary *small tools* and *implements* used in the construction and repair of roads are hammers for breaking stone, forks for handling it, levels for adjusting the transverse form of the surface, and shovels and picks for general use.

The *stone hammers* are made of iron or steel, with wooden handles, and are of two sizes, one to be used sitting and the other in a standing posture. The first has a head 5½ to 6 inches long, weighing about 1 pound, fixed to a handle 18 inches long. The other hammer head weighs 2 pounds and

may be 7 inches long, and has a handle about 3½ feet long. See Fig. 31.

The *fork* (Fig. 32) used in taking up the stones from the pile to load them into barrows or carts, or spread them upon the road, is made with ten or eleven stout steel prongs each 13 to 14 inches in length, set with their points 1½ to

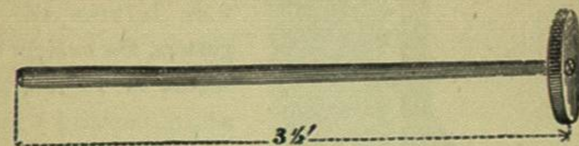


FIG. 31.

1½ inches apart. The whole length of the fork inclusive of handle should be about 4 feet 8 inches. Broken stone can be taken up with greater ease and rapidity with a fork than with any kind of shovel, leaving the detritus and earthy matter behind.

The *pick* is the one in common use, consisting of a bent

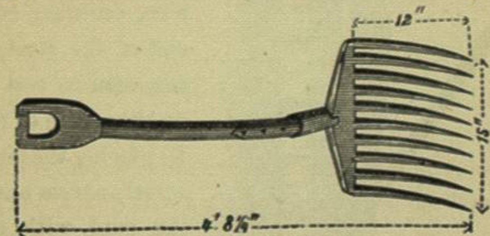
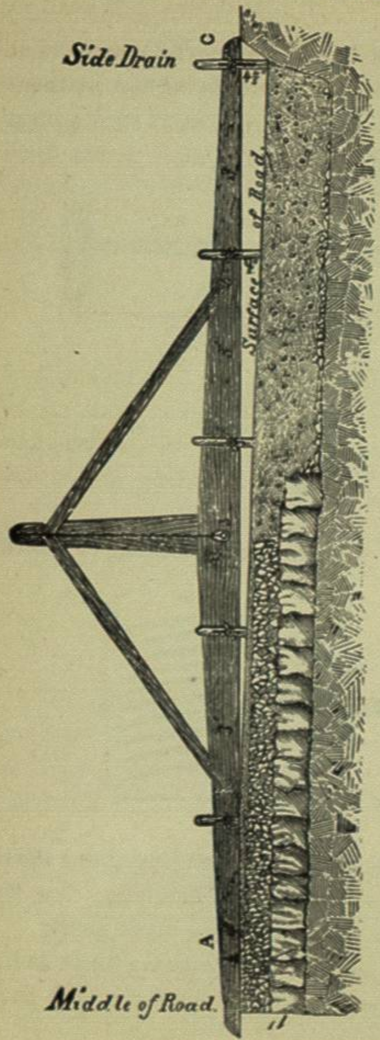


FIG. 32.

iron head tipped with steel at both ends and weighing about 10 pounds, set to an ash handle about 2½ feet long. One tip in fashion like an adz, and the other into a blunt point.

The ordinary pointed *shovel*, with a concave blade and a bent wooden handle, is the most useful kind for road purposes.

The *level*, Fig. 33, is of great value in adjusting the cross-section of the road. It consists of a wooden straight edge A C with a plummet D at its centre. For a road 30 feet wide between the side gutters, the straight edge should be 16 feet long, which, omitting 6 inches at each end, may be divided into equal spaces — say five spaces of 3 feet each. Sliding gauges, set transversely in dove tail grooves, are placed at the several points of division, omitting one at the end of the straight edge intended to rest directly on the centre of the road. By placing the level transversely across one half of the road, with the end, not occupied by a gauge, resting on the road surface at the crown, or at the precise height to which the crown is to be finished, and then mak-



ing the straight edge horizontal by the plummet, the lower ends of the several gauges—previously adjusted and fixed to the required transverse slope—will indicate five points of the required road surface. the outer point being the bottom of the side gutter.