past years for the nearest weather station, and the probability of the maximum flow being increased by clearing the country, if at present in forest, etc.

It is best to err on the large side, although some engineer has said that if a road has no wash-outs from too small waterways now and then, the structures are too large for ultimate economy.

ART. 16.—STRUCTURES FOR SHALLOW EMBANKMENTS.

The first consideration is to get water across the roadbed and away from it as quickly as possible, this is an axiom of good drainage. To do this where the embankment is from 6 inches to 2 feet deep, and the drainage area only nominal, is often a puzzle. We do not wish to leave an opening in the track, and pipes or stonework are impossible; the usual course is to fill in the pocket above the bank and drain through the track by track boxes (Plate 1, Fig. 20), or where there is from 18 inches to 3 feet of a bank in place of an open culvert which some engineers put in, a plank box (Plate 1, Fig. 21) is preferable, as it can be replaced easily when rotten, will stand the vibration of trains, and does not leave any opening in the track. Sometimes with a very slight drainage area, a blind or French drain is used, which consists of small flat stones placed so as to give a triangular opening of, say 6 inches high x 8 inches wide, but such a waterway is liable to get choked up with leaves, etc., and cannot be depended on indefinitely.

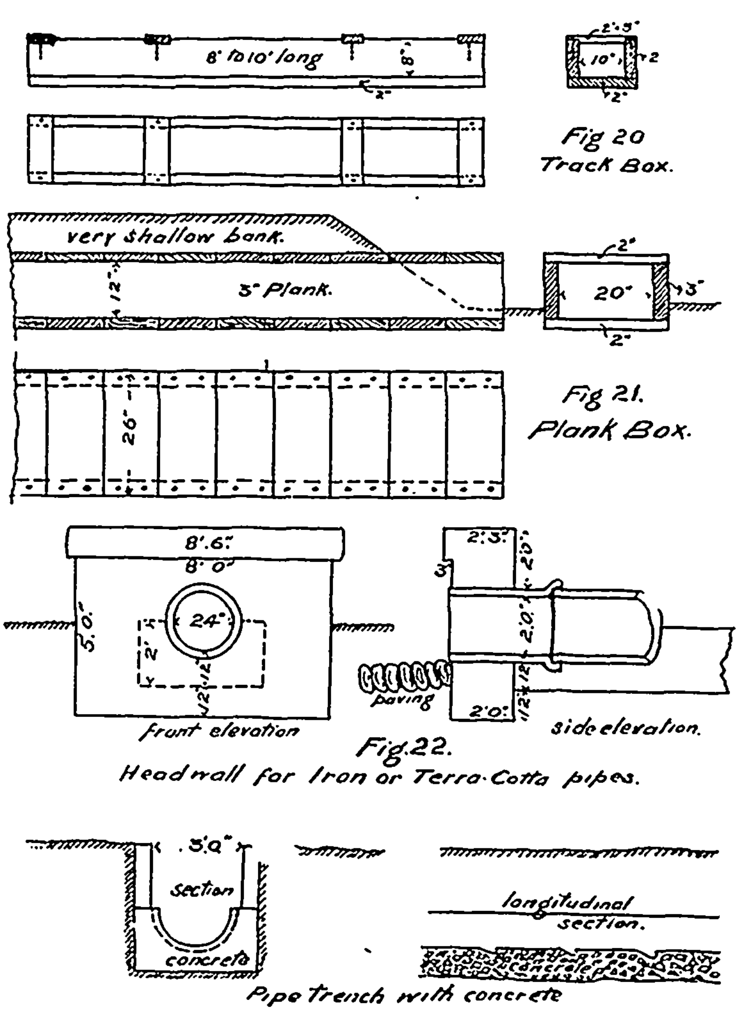
When we come to banks of from 3 feet to 6 feet in depth it is usual to employ iron, terra-cotta or concrete pipes if the waterway is small, and when a heavy flow of water necessitates it, open culverts of from 4 feet to 8 feet span. These latter may be of timber, stone, concrete or brick, but should always be surmounted by an ordinary trestle floor. The use of stringers only is an abomination and a death trap, which should not be tolerated.

Culvert Pipes.—The use of double-strength, well-burnt sewer pipe for culverts has increased rapidly of late years in certain sections. They fill a certain want, either where stone is scarce or absent, and at points distant from water or rail communication, as the cost of teaming is small compared with that of iron pipes. In a country subject to severe frost certain precautions must be taken to avoid water settling under or in the pipes, which will crack them in freezing. The grade must be ample, care taken to have the grade convex longitudinally of the pipe, rather than concave, the joints made watertight with cement mortar, and headwalls built at each end with deep aprons, to avoid having any water flow along the pipe outside of it. In southern localities of the United States, America, pipes are used more freely and carelessly, head walls and joint filling are omitted, or only a timber headwall used, but such omissions will invite trouble in Canada.

Again, if the bank is shallow, the same care is hardly necessary in ramming back the filling around the sides of the pipe before loose dumping is commenced as if it is a deep one, but in either case care should always be taken to cut a concave bed for the pipe to rest in and grooves for the spigot joints, or otherwise the load will all come on isolated spots, and the pipe will tend to crack into four segments, bulging out at the sides and down at the crown. If the bottom is solid rock or bouldery, the condition is worse, and breakage can only be avoided by filling in some soft clay well rammed to bed the pipes in, or, better still, to bed the pipe half-way in cheap concrete, as shown on Plate I., Fig. 22. This figure also shows design for a headwall and paving at the lower end. The spigot ends of the sections are always laid up grade. As with other more important structures, pipes should be laid at such a depth that the outlet ditch leads the water to a safe distance with a gentle grade, so as to prevent undermining the lower end.

In place of sewer pipes of clay, there have been isolated attempts at using concrete pipes, but only sporadically. The choice would be entirely a matter of cost. On the other hand, the use of cast-iron culvert pipes is quite common. They can be made up to six or eight feet in diameter, the lengths decreasing as the diameter increases, so as to keep down the weight of a segment. If carefully coated with tar mixture rusting is very slow; and although such pipes are not used often during construction, owing to their great weight, which is against them in hauling by teams, they have a special function which is for use, when their transportation can be by train, in replacing wooden box culverts by drawing through

Plate. I. Scale 1 in. = 8 ft



when the wooden one is about decayed, and in case this has been anticipated the wooden box culverts will have been made larger than necessary, sufficient to allow of this being done. Cast iron pipes will be laid in the same manner as sewer pipes, except that the joints should in this case be caulked and leaded as with water pipes, although sometimes this is omitted; the cost per foot for cast iron and sewer pipes at the nearest railway depot to the structure will vary somewhat with the locality, but will be approximately as follows:

TABLE XII.

APPROXIMATE COST OF PIPES (NOT INCLUDING LAYING.)

Diameter.	Sewer Pipe. (Cost per foot.)	Cast-iron Pipe. (Cost per foot.)	
12-inch	35cts.	$1 15	This does not include cost of hauling, laying, headwalls or foundations.
18-inch	70 "	1 90	
2 feet	$1 30	3 00	
3 feet		4 80	
4 feet		8 00	