The cost of structures of these styles will be approximately as given in Table XIII., taking masonry at $10 per cubic yard, including foundations; paving at $3 per cubic yard; sawn timber at $30 per M.B.M., in place including iron; cedar lagging and timber walls at $25 per M.B.M. in place, and piling at 30 cents per lineal foot, driven, say, 10 feet into the ground.

TABLE XIII.

APPROXIMATE COST OF OPEN CULVERTS.

Structure.	Height of Waterway.	Clear span in feet being 6 feet.	8 feet.	10 feet.	12 feet.	15 feet.
		$	$	$	$	$
Timber opening.	4 feet.	106	116	126	135	148
Timber walls.	6 "	157	167	177	186	201
(Fig. 23.)	8 "	212	222	233	243	259
Timber opening,	4 feet.	110	118	125	133	145
piles and lagging.	6 "	144	152	158	167	179
(Fig. 25.)	8 "	168	176	183	191	203
Three span.	4 feet.			170	203	251
Opening on piles.	6 "				208	256
(Fig. 26.)	8 "					267
Stone opening.	4 feet.	317	341	365	389	426
Trestle floor.	6 "	457	481	505	529	566
(Fig. 24.)	8 "	608	632	656	680	717

From which it is evident that piles with lagging are slightly the cheapest, except with the smallest height and span, and that at 8 feet high and 15 feet span the three-span opening comes to about the same as the other timber structures. The cost of the stone opening is from two to three times as great as the timber ones in first cost, at $10 per cubic yard, but in many cases this could be materially reduced by using concrete at $6 to $8 per cubic yard, at which price a very superior quality can be made even in small quantities. An interesting feature of this table is the deduction that the length of span affects the cost so slightly, it will hardly pay to risk anything in size of waterway for such trifling economies.

ARTICLE 17.—SMALL WATERWAYS WITH HEAVY EMBANKMENTS.

Under these conditions pipes may still be used, if care is taken in laying them; up to any height, if the waterway is very small; but for cross-section areas of four square feet to twenty square feet, the structure commonly used is the box culvert, which may be made of timber, stone, concrete or brick. The two latter, however, being used, usually, in the arch form, as otherwise stone covers are necessary.

Timber Box Culverts.—These are used where cheap structures are desired, or often in undeveloped districts where construction is hurried, timber plentiful, and stone scarce, they should not be put under embankments more than 12 feet to 15 feet high, unless built large enough to admit iron pipes that will carry the rainfall after the timber culvert has begun to decay, which will be in six to twelve years, depending on the timber, etc. If the bank is a shallow one, it will not be very expensive to replace the decayed timber culvert by another similar one, or by a stone box culvert, at a time when stone can be cheaply delivered by rail and the company can afford the outlay, and if the covers are made long, as in Plate IV. (Fig. 27), they will hold up for a year or so after the side timbers have started to rot. Of the two styles shown, the one (Fig. 28) is superior in some respects. It is fastened by iron drift bolts, instead of oak tree nails. It has a row of sheet piling driven at the ends to prevent underflow and undermining, and has solid paving laid between the mud-sills, all of which are distinct improvements. For such structures, probably, cedar is the most durable wood, and pine next. A distinct advantage of timber box culverts is that on soft swampy foundations, all that is necessary is to make a wide solid floor of timber instead of mud-sills, and even lay this floor on several sills running lengthwise of the culvert to distribute the loads over the whole area. Even though some settlement should occur, the elasticity of the timber will save the structure from damage, whereas with a stone or brick culvert any serious settlement means destruction to the masonry.

Stone Box Culverts.—Typical plans are given (Figs. 29, 30, 31, 32) on Plates IV. V. and VI. to illustrate essential differences in stone box culverts.

(*a*) Fig. 30, Plate V., shows a solid stone floor under walls and for paving, while the others have the walls independent, which is much preferable because the loads are carried symmetrically to the foundation, *i.e.*, the centres of pressure are opposite the centres of resistance, because the paving may become dislodged without the walls being injured and because the walls may, if desired, be carried lower than the paving, as in Fig. 29.

Plate III

scale 1 in. = 8 ft.

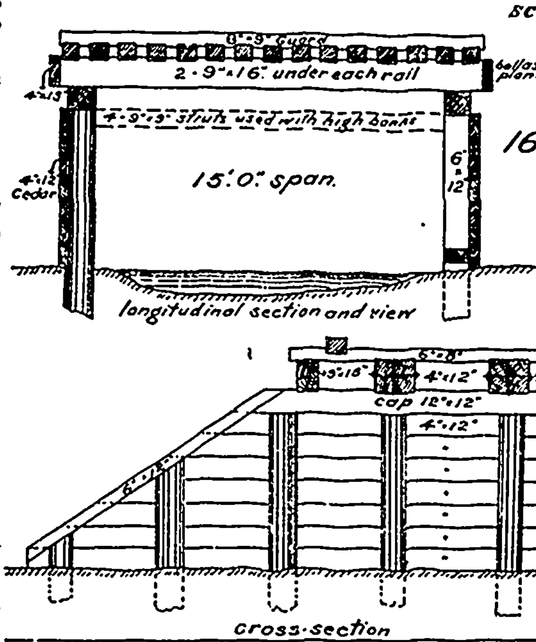

Fig. 25
16' Pile Culvert.

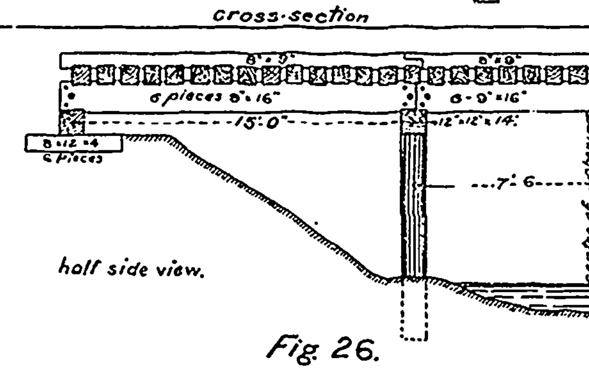

Fig. 26.
Three-span Opening.
(in place of one 15' span pile culvert.)

(*b*) Figs. 30 and 32 show head-walls while the others have straight-stepped wings, the latter is better practice because no amount of sliding or thrusting of any kind from above, can dislodge more than the parapet wall, which is only an ornament, whereas head-walls as in Figs. 30 and 32 can be easily cracked or thrown down by slides in the embankment.

(*c*) Fig. 31 illustrates the use of corbelling where a wide span is required and stone for long, heavy covers is scarce, this method may be developed into a complete gothic.

(*d*) Fig. 29 has a distinctive feature in the *well* formed by the projecting upper wings, which will effectually prevent blocking the mouth with debris, because if any collects here it will merely form a dam, over which the water will pass safely and fall into the well thus formed, whereas