masonry or concrete; but if the fill is not deeper than 12 or 14 feet, a wooden box could be put in temporarily and replaced with stone or concrete at some later date when more funds are available. When the opening is as large as 50 square feet, with a fill of 5 or 6 feet, a two-bent pile trestle will cost about the same as a reinforced concrete box, and as the size of the opening or the depth increases, the trestle becomes the cheaper. At the same cost, a wooden box will have a larger opening than a pipe but, of course, will have to be replaced or renewed at some later date.

Cast iron pipe is not as much used as formerly. It is more costly than either vitrified tile or concrete, but is less liable to breakage, though the larger sizes must be handled with care on account of their weight. The smaller sizes are useful on side-hills where there is a small continuous flow of spring water, and the ends can be protected in cold weather.

The writer installed some corrugated iron culverts in the neighborhood of Copper Cliff, Ontario, where the fumes from the reduction plant are very bad, and after being in use for a year they appear to be untouched, and there seems to be no reason why they should not remain so.

These pipes are light in weight and easy to handle. They can be laid closer to the surface than any other kind of pipe, without danger of breakage; but under deep fills and in the larger sizes, are liable to deformation. This can be prevented, however, by placing a scantling top and bottom inside the pipe, separated by struts, all of which can be removed when the embankment is fully settled. Fig. 1 shows such an arrangement.

Vitrified tile, when used for culvert purposes, should be of the kind known as "double strength," thoroughly glazed. They need to be carefully bedded; joints should be packed, preferably with oakum and cement. If they are set closer than three feet below grade, the impact of passing trains is liable to break them, and even when used on highway work a very heavy wagon or a steam roller will destroy them in the same manner. It may seem superfluous to mention that the bell end should be placed upstream, but though this is so self-evident, the writer has seen workmen put them in the other way about. In themselves, vitrified tile are indestructible, but great care must be taken in their laying.

In concrete pipe, like all concrete, the personal element is a most important item in their construction, and unfortunately the inspection of the finished article is often left to inexperienced persons. They should be reinforced with suitable steel wire or mesh, not as is sometimes the case, with common iron wire, which is unsatisfactory. The best shaped pipe are those with a flat bottom; they can be better bedded and are more easily handled in a narrow trench.

All pipe must be well bedded, and should be set a few inches below the natural surface of the ground, and on as steep a grade as possible up to about 1 in 10, although cast iron and corrugated pipe, on account of its being in longer and more solid units, can be laid on a much steeper grade with safety. In backfilling, as much care should be given to the tamping of the earth on the sides as on the top. To enable the pipe to resist deformation, the pressure of the earth should be equally distributed all round it. On no account should any stones, lumps of hard-pan, boulders, or frozen earth be placed next the pipe. As a preventative against wash-outs the ends of the pipe are best protected with end walls, and an apron extending at least three feet from the end of the pipe. If the ground is at all soft, the intake end should have an apron three feet deep (Fig. 2), and the pipe had better be laid with a camber of 1 in 300 to allow for settlement of the embankment.

The best material for a wooden box is cedar, but if this cannot be obtained Norway pine, jack pine or even white pine will do, as the last three will be good for 12, 8 and 6 years respectively; while good cedar has been known to last for 20 years before requiring renewal. The timber should be flatted on at least three sides, and be good and sound all through, except in cedar, when a small amount of heart rot up to about two inches in diameter will do no harm. No length less than four feet should be used, and holes should be bored for the drift bolts 1/16 inch smaller than the size of bolt. The drift bolts should be driven every four feet, and extend through two sticks to the third. The sills should be sunk on a level or an inch or two below the bed of the stream, and the spaces between them preferably filled with flat stones set on edge. If the bottom is soft, then the ends should be paved and an apron placed at the intake. (Fig. 3.)

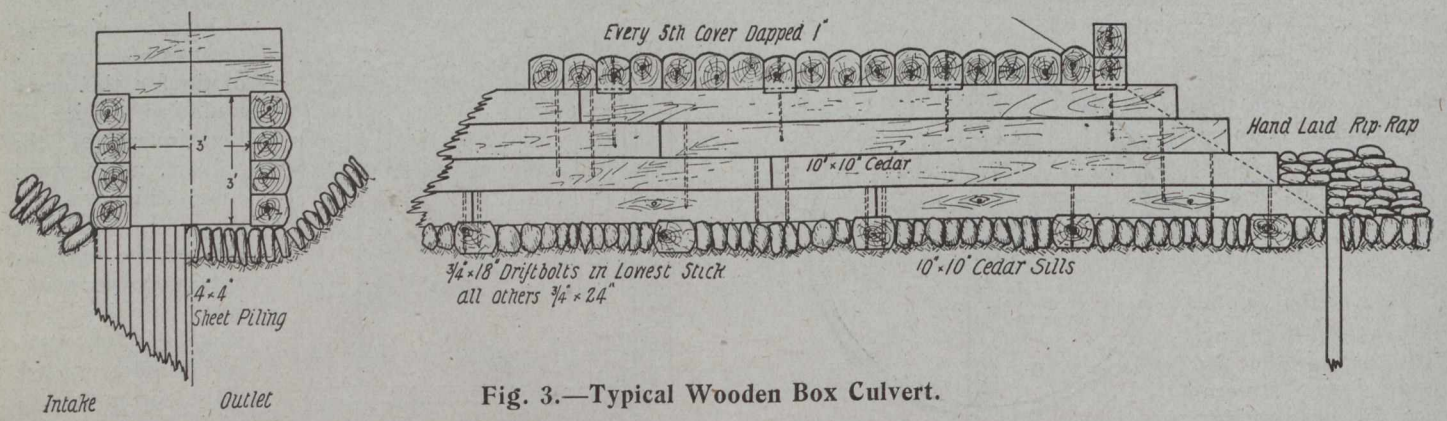

Fig. 3.—Typical Wooden Box Culvert.

Stringer Culverts.—If, in the case of a railway culvert, an opening is necessary at less than three feet below the base of rail, the best temporary method is to build two cedar walls two to five feet apart in the clear, and place under each rail a stringer either of wood or of three old rails bolted together, the opening being covered with timbers to carry over a car or velocipede. (Fig. 4.) For a permanent culvert so close to rail level, two dry stone walls can be built and covered with old rails. Fig. 5 shows a type of wooden culvert suitable for highways.

Dry Masonry.—Where stone is plentiful, and slabs large enough for covers can be obtained, this type of construction is cheaper than concrete, and can be built with ordinary blasting tools and a stone hammer.