measures. The larger trepan (Fig. 2) is of the same construction as the smaller one, but the blade is deeper towards the centre. The central part is toothless, and a U-shaped guide which fits the smaller hole, is fastened to it. This tool often weighs as much as 15 tons. It may cut the shaft to its full width, or it may be followed by another similar reamer. The broken material, most of which is quite fine, is hoisted from the smaller hole in a sludger (Fig. 3 and 4). The operations of drilling and widening the hole take place alternately, the tubing being simultaneously lowered by a separate engine.

A record of the preliminary shaft 4.5 feet in diameter, showed for 508 feet an average progress of 3.3 feet per 24 hours; 51 per cent. of the time was spent in drilling, 19 per cent. in raising and lowering the tools, 20 per cent. in dredging, and 10 per cent. in repairs and delays. Widening the shaft to 14 feet, and sinking to a depth of 460 feet took ten months, reaming 46 per cent. of the time; altering and operating the tools, etc., 14 per cent.; dredging 22 per cent.; repairs and delays 18 per cent. A tall derrick is necessary at the surface for lowering the tubing, and from which extra lengths of rods may be attached as required. Three skilled laborers and six ordinary hands are employed about the works. The cost of installation of machines, tools, etc., all of which are portable, is from $13,000 to $20,000.

The tubing consists of iron sheeting, built on in 6 feet sections with leaded joints, suspended by rods (Fig. 5.) The flanges come on the inside of the tubing *bb*, leaving a perfectly smooth exterior. The joints are bolted together. An example of tubing is one 12 feet 7 inches internal diameter, 280 feet high, one inch thick at the top, 1⅝ inch at the bottom, and weighing 400 tons. The sections were 5 feet high; the flanges 3½ inches wide, 2 inches thick, having leaden wedges between them 4⅝ inches wide and ⅛ inch thick, and 20 bolts 3 16th inch diameter. At the bottom of the iron cylinder are the before mentioned appliances for controlling the linking of the tubing and hermetically sealing the bottom. The latter is a moss box, *a*, and the form consists in a false bottom, *f*, which is attached to the tubing, with the lower section of which it forms a diving sill that floats the whole system. The greater the head of the water coming from the strata, the more complete is the balance and the greater the relief of the rods *dd*, which support the tubing. The safety pipe *g* is an equilibrium column, operated from above by cocks and plugs, which regulate the speed of the sinking. If the cocks are opened and water allowed to escape, sinking proceeds rapidly, and when closed the mass of iron is upheld by the pressure of the water on *f*. When the plugs are opened, water is discharged into the tubing, thus weighting it, and at the same time relieving the pressure below. By these means a complete control of the lowering of the tubing is maintained. The lower flange of the bottom section *bb* turns outward, and forms an annular piston to a lower section *aa*, whose upper flange turns inward and lower one outward. Between these flanges is packed moss, in the annular space between the rock and the moss box.

When the water-bearing strata has been traversed, a seat having been scraped for the moss box, the pipe *g* is opened at the surface and the entire weight allowed to fall on *bb*. The rods *ss* slide in their bearings. The moss is pressed to a compact hard mass, forming a perfectly water-tight joint.

There is now a certain amount of water in the shaft which may be pumped. Often, however, a cement backing is first inserted by means of a closed spoon, holding a barrel or so of cement and curved to fit the annular space. Three sets of six men do this work, burying 400 cubic feet per day, at a cost of about forty cents per square foot area of lining. Subsequently a solid foundation of wrought iron curbing is built on a stout ledge to receive the weight of the iron mass. Where this method of sinking has been employed, it has never yet met with failure, and it is considered surprising that American engineers, usually so progressive, have not adopted it in cases where attempts to sink by other means have proved futile. Objections to it are that the diameter of the shaft is limited to 14 feet or thereabouts, and also that there is no means of knowing when the watery stratum has been sunk through, except by preliminary geological observation. A short while ago a pair of shafts were sunk in Samlund, Prussia, for amber, by a variation of this method, through 147 feet of clay and sand. The drill tools, weighing 1,700 lbs., cut a 4 foot 6 inch space. No moss was necessary, as the ground was not wet. Four feet lengths of tubing were forced down by jack screws. The total weight of tubing was 45 tons, and the cost $17,500.

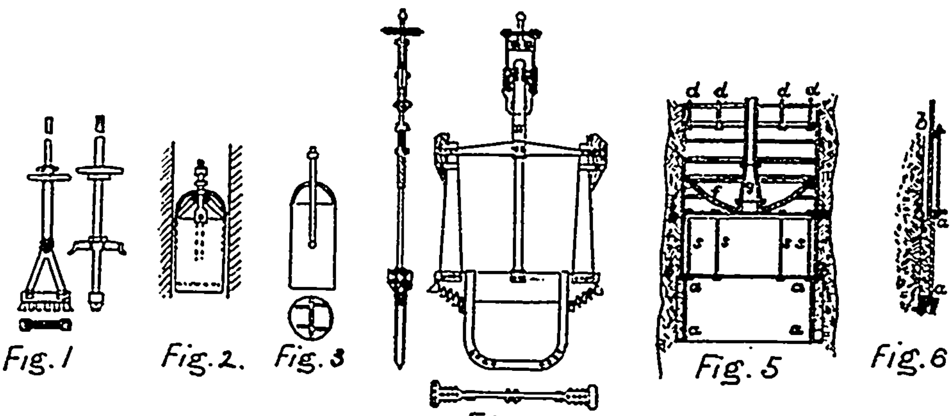

Fig. 1 Fig. 2. Fig. 3 Fig. 4. Fig. 5 Fig. 6

BURLINGTON CHANNEL SWING BRIDGE.

Burlington channel, or canal, is simply a cutting through a piece of low land, about 700 feet wide, first formed as a sand-bar, which separates Lake Ontario from a large sheet of deep water called Burlington Bay. It enables vessels to reach the city of Hamilton and the Desjardins Canal, the latter being a private work and leading to the town of Dundas. The canal is protected on both sides with crib-work extending out into the lake at one end and into the Burlington Bay at the other.

After the cutting was made in 1825, a ferry was