TUNNEL. A tunnel is simply a hole bored through a hill, in order to carry a canal, a road, or a railway, in an advantageous course, and is generally resorted to as a means of lessening the expense which would ensue if an open cutting were made. There are other reasons which may render this mode of proceeding advisable; such as gaining the consent of a landholder, who would object to a cutting through his property, but would have no dislike to a tunnel ; and various other local causes : but the general reason for such a mode of proceeding is the consideration of expense. In order to enter into this inquiry, the first step is to make plenty of borings, for the purpose of examining the geological structure of the proposed hill. If these are con­sidered satisfactory, trial shafts should be sunk quite to the intended bottom, as by these the quantity of water to be expected will be discovered. It should be particularly at­tended to, as water is one of the greatest annoyances to be encountered in tunnelling. The readiest way is to measure the water into a cask, and ascertain the number of gallons per minute. To do it readily, the shaft should be about four feet in diameter, rather more than less ; and no loss will be occasioned by making it large, as, if the situation is pro­perly chosen, it may afterwards be converted into a working shaft.

The necessary power to drain being taken into account, and the geological structure of the ground being ascer­tained by the borings, we have thus the elements for making an estimate of the relative expense of forming a tunnel or an open cutting. Questions of expediency will also have to be taken into the account ; such as, how the spoil from a tunnel can be deposited, and at what expense in the pur­chase of land ; whether earth in large quantities is requisite for an adjacent embankment ; and if we lose this by making a tunnel, at what price can a side-cutting be made to com­plete the embankment ; and various other questions con­nected with the locality, which can only be determined on the spot. Sometimes the earth for the tunnel can be taken out laterally, the working shafts being horizontal ; and in this case the work is called a gallery, and not a tunnel. This process will in general lessen the expense.

In the present state of civil engineering, a tunnel can be made through any object, from a rock to a quicksand ; and the question of making it turns chiefly on the expense, which will vary from L.20 a yard in sandstone, which is easy to cut, and which will stand without brick-work, up to L.100 and L 140 a yard in quicksand and bad ground, requiring twenty-seven inches thickness in the brick-work, and mostly to be laid in concrete. The Thames tunnel has cost about L.1200 a yard. Here, however, there have been severe difficulties of a peculiar nature to contend with, and it is a double tunnel. In general the rocky strata will be cheapest, as no brick-work will be required. Hard shale, and in fact any thing which will not cut by a spade, is best re­moved by blasting, and not by the pickaxe. In some cases tough clays will be found, against which a pickaxe is nearly useless, as it merely indents a hole where it sticks, without loosening any thing. Blasting will have no effect on this : hatchets will answer very well, and cross-cut saws best of all. The borings should be numerous, so as to give all the strata. Chalk, for instance, will often contain large holes filled with gravel, which on being opened during the execu­tion of the work, will pour in on the unsuspecting miner like water.

After due consideration, having determined on a tunnel at the place proposed, the engineer next decides on the size and shape, both being in some measure regulated by

what the tunnel is intended to carry. But, as respects the shape, this is also dependent on the nature of the ground, and the degree of weight which the brick-work will have to support. For instance, in a wet quicksand, which ap­proaches the nature of a fluid, with an equal pressure all round, the shape should approximate as nearly as possible to that of a circle ; and for any other kind of pressure, the form of the tunnel should be proportionally modified. Curves and rises or falls should by all means be avoided if practicable.@@1

In setting out a tunnel, the engineer should have a tran­sit instrument, placed in a fixed observatory, and standing on a pier insulated from the building ; and if there is any road near it, the pier must be insulated from the ground to a depth of six, eight, or ten feet, according to the nature of the traffic on the road, in order to insure stability and a freedom from vibration. A distant mark should then be taken in the line of the tunnel, and a fixed point placed as the adjusting spot for the line of direction : the farther this is off the better. Intermediate marks for the working and ventilating shafts may then be set out correctly ; and as these are sunk, plummets, suspended from points accurately set out by the transit instruments, may be constantly tried as to the proper direction. These plummets should be of iron, and should be let down into buckets of water, to check the vibration ; or, what is better, they should hang in cups of mercury. When the shafts are cleared out to the bottom, other transit instruments may be placed in them, the plumb-line and transit being kept as far from each other as possible. The intersection of the vertical hairs in the transit with the plumb-line, will then enable the engineer properly to set out the work.

Tunnels have been known to draw water off the wells as far as a mile distant. This may generally be remedied in every case except that of a canal containing salt water, by sinking the wells deeper, which for the most part restores them to nearly their original state. When a salt-water canal is to pass through a tunnel, compensation had better be made to the parties as soon as it is discovered that an injury has been done. In all cases of canal tunnels, care must be taken that they are run deep enough to insure a pro­per supply of water to allow for waste, lockage, and leak­age, where the supply is contingent on a tideway. It will be very expensive to remedy this afterwards, and will most probably require the erection of a steam-engine to pump up a sufficient quantity.

Some of the old canal tunnels, through an injudicious eco­nomy, were constructed without a towing-path. The boats are in these cases pushed through by men lying on their back on the deck, or on a projecting board placed for the purpose. They then set their feet against the side-walls of the tunnel, and advancing them alternately, foot the boat along, the helmsman steering against them. This bar­barous plan, which has occasioned serious loss of life, is now generally abandoned ; but no tunnel or canal can be call­ed perfect unless it has a towing-path on both sides. In the tunnels, an iron hand-rail should invariably be set up next the edge of the towing-path ; and if there is but one of these, its width should be so increased as readily to ad­mit the horses to pass each other. Some of the old tunnels above described were completed for less than four pounds per yard ; and one, the old tunnel on the Grand Trunk Canal at Harccastle, in Staffordshire, constructed by Brind­ley, only cost L.3. 10s. 8d. It was ten feet in diameter, and consisted merely of a semicircular brick arch, which sprung from the water-line of the canal. The variation in

@@@\* When it is for a canal, the form is generally an entire: oval, tile lower portion forming the water-way ; and on one or both side· a retain­ing wall is built, and filled in behind, to form the towing-path. Sometimes a wood camsheet is substituted for the wall, and cross sleepers laid on it. In a canal, of course, every thing must be level from lock to lock.