lation near every shaft ; and should the situation of any shaft require for its protection a larger ditch in the line of fencing, or a puddled ditch round its site, the contractor should be required to make it at his own cost.

When ventilating shafts are necessary, they may be built of any required size. In railway tunnels from 2000 to 2500 yards long, two shafts sixty feet diameter will he suf­ficient. They are best built from the top; for instance, excavate ten feet down, and build the shaft for that height, then divide the circumference into parts about ten feet wide, and excavate every alternate one of these, leaving the others to support the ring of brick-work ; and when these al­ternate ones are bricked up to the ring above, the remain­ing earth is all taken away, and the bricking continued till the second ring is completed and connected with the first, when the same process is repeated till the whole is con­tinued to the required depth.

The thickness of the brick-work is of course in propor­tion to the size and height. For a shaft sixty feet diame­ter and 120 feet high, the following would be sufficient in unfavourable ground. The tunnel, where the shaft inter­sects it, should be entirely of stone, and on this a course of stone four feet square, on which the shaft stands ; then the first forty-six feet to be three feet thick ; the next seven­teen feet, two feet eight inches thick ; the next seventeen feet, two feet three inches thick ; and the last or upper sixteen feet, one foot ten inches thick, coped with stone for the railing. the boundary wall might be one foot one and a half inch thick, with footings, and an increase in the foun­dations, if thought necessary.

They should be built in alternate courses of headers and stretchers, each brick being well flushed up ; and where the tunnel intersects the shaft it should be faced with stone, each stone to be eighteen inches upon the curve of the soffit, toothing into the brick-work in the soffit of the tun­nel by being three and four feet long alternately ; the whole truly fitted in their beds, and neatly hammer-dressed, each being secured to the adjoining one with malleable iron dowels run in with lead.

Stone coping should be set upon the shafts a little above the level of the ground, into which iron railing may be fixed. The stones to be secured by lead joggles, three fourths of an inch square, and run one inch into each stone. The iron railing should be about three feet high, of malle­able iron, three fourths of an inch square, and five inches distant from centre to centre, set three inches into the cop­ing, and run with lead. A half-round hand-rail should be riveted on each upright, an inch and a half wide, as a finish.

Shafts of the above size should be enclosed with a circu­lar wall seventy-two feet in diameter, twelve feet high, and fourteen inches thick, with a plinth of eighteen inches, and a stone coping sixteen inches wide and four inches thick, weathered and throated. In this wall there should be a doorway. The space or path between the wall and the shaft should be paved with bricks, having a gentle slope outwards, with holes through the wall about every three feet, to let out the water.

The whole bottom of the shaft should be soundly filled in, sufficiently deep, with good concrete beaten firmly down ; and whenever the excavation is larger than the dimensions of the shaft, the space should be filled perfectly solid with brick-bats, and grouted with Roman cement, with which the shafts are to be built ; but the enclosing wall may be built with mortar. Whenever water occurs in sinking any of the shafts, it must be completely excluded from them by a lining of puddle, or Roman cement if necessary.

In short tunnels it may sometimes be advisable to drive a heading, about four feet wide and five feet high, right through, before excavating it ; and the contractor should be allowed to sink what air-shafts he thinks proper, provid­ed they are not in the line of any road, nor within fifty feet of any working shaft. They may be from three to four feet diameter in the clear, supported on iron curbs, carried up ten feet above the surface, and coped with stone.

To determine the number of working shafts, regard must be had to the time allowed for the completion of the work, and the nature of the part to be excavated. The shafts must be just so close together that every face can be raised and bricked half the distance to the next shaft, two months before the given time for completion, leaving these two months for building the fronts, and laying the way if for a railway ; and in all cases a larger allowance had better be made, in case of accidents.

the number having been determined on, their places should be shown on the drawings. They should be nine feet in diameter inside, and nine inches thick ; the bricks to be all heading, and to be well bedded in Roman cement. The shafts should be kept free from all bulges and imper­fections ; they should rest on an iron curb-ring, forming a key between the bottom of the shaft and the top of the tun­nel ; and they should be carried up ten feet above the sur­face, and coped with stone.

In excavating where the ground is bad, the contractor should not, without permission, advance beyond the com­pleted brick-work more than six feet. Ten feet will in most cases be a convenient length ; but in this the engineer must form his judgment from the nature of the ground. The space excavated must be well secured, in the maimer to be here­after stated. The dimensions of these supports are to be approved of by the engineer. The invert, sides, and roof, should be cut out as nearly as possible of the size the tun­nel will be when finished. When more than this is taken out, it should be securely made good ; in every case one man being employed at each face solely in filling and ram­ming in, if under the invert, with well-pounded clay, and if on the sides or top, with suitable materials, rammed in with every other course of bricks at the sides, and, as soon as the succeeding excavation will allow it, at the top. But when the ground is very bad, the bars are to be left in, at the pleasure of the engineer. The cills should not in ge­neral rest on the brick-work, but on trestles, so as to be in­dependent of the side-walls. If this is not done, the holes where they have rested should be made good, whenever they are withdrawn, with brick and cement.

When any two faces are within fifty yards of each other, a heading should be driven to connect them, and insure the proper direction of the line at the junction. The contractor should also be bound to drive any headings the engineer may direct, either for drainage or' otherwise. The en­gineer should, at the contractor’s expense, from time to time give the contractor marks, in the way to be hereafter shown, to let him know how the line of the work is to be regulated.

Twenty-seven inches thick in the sides and top, and eighteen inches in the invert, in Roman cement, will be the most ever required, even in a quicksand ; and as the na­ture of the ground improves, this may be lessened, till we arrive at the point where it will stand of itself. Each brick should be well bedded with a wooden mallet, and every joint thoroughly flushed when mortar is used. When the shape of the tunnel requires it, the bricks must be moulded taper. In the arch they are laid in concentric rings, half a brick thick, taking care that the additional number of bricks requisite for each additional ring is put in, which is easily calculated. In a tunnel twenty-seven feet high, and twen­ty-three wide, it will be five more for every ring. A course of stone should be laid in at the springing of the side-walls from the invert ; the stones about three feet long, well bedded in mortar, on four courses of very sound and hard bricks.

It will generally happen that excavations are to be made