being secured by 5 additional glands, made out of 2½ in x ½ in. flat bar.

The section of timber to be encircled by these glands is 13 in. x 13 in. for the sill proper, and a 13 in. x 6 in. saddle, making 13 in. wide x 19 in. high. The gland is made in 2 parts, one formed into 3 sides, to take the bottom and the 2 sides of the sill and saddle. On the ends of the 2 sides which are made to project beyond the 19 in. required, are formed good screws with nuts. The top side of the gland is then made separately, and long enough to provide for a hole in each end to fit over the screwed ends of the other piece, and the nuts screwed tightly down. The sill must be scarfed as it has to be longer than the width of the tunnel. As a sill should serve all through the work and will be taken to pieces many times, it should be well made. (See Fig. 5).

The first side length, next the shaft, let us suppose to be in and lined; this operation being similar to the following, except that sills must be used at both ends of it. But if bad ground has been encountered in sinking the shaft it will be safer to brick the crown, and third bars in the first side length, and not attempt to draw them, for fear of settlement. The fifth bars in this case must be "taking out" bars. The shaft length should not be taken out and lined until the shaft work is finished.

It has been decided to line the tunnel with 2½ ft. of brickwork. The lengths, to be got out one by one, shall be 5 yds. To support this length, 5 drawing bars shall be used, each 2 ft. diam. at the thick end. The drop shall be 1½ ft., i.e., the small end being borne upon the end of the brickwork of the last length, and the other end being set at a higher level by 1½ ft. to allow for sagging, settlement and possible breakage.

The first operation for the second side length is to drive a top heading 21 or 22 ft. long (enough to receive the crown bar) and high enough for a man to stand in it. It should be wide enough to take the thick end of the bar, say, 3 ft. in the clear under the head-tree. The distance apart of the bars is generally about 1½ ft., so that to take 2 bars, 2 ft. in diam. and 1½ ft. apart, the heading must be 6 ft. wide under the head-tree, and between side-trees. In very heavy ground 2 crown bars are sometimes used, as they together give a greater bearing for the head-trees, and support it better when the side bars are put in, or taken out. The heading must be supported by settings of head and side-trees about 1 yd. apart, and strong enough to bear the weight for 10 days or so. The heading should be poled all round.

The crown bar must be got into this heading by means of a crab and tackle.

As the top sill (Fig. 7) will be placed at about 6 ft. below the soffit of the arch, the ground at the far end of the top heading should be excavated across the heading down to a little below this level. In the bottom of this, foot blocks should be placed, on which will stand the long back props, supporting the bars until the top sill is in position. These back props should be 10 to 12 in. diam. and up to 9½ ft. long. Their length varies, of course. All props should be "collared," i.e., on two opposite sides at the top end cut off about 1 in. and run out about 9 in. down the prop; and then hollow out the top of the prop to receive the round side of the bar, which will give a good bearing surface, and prevent the outside from splitting. The props should be set with a sprag.

The crown bar being in and back propped, the next necessity is to get in the third bars, but as they must follow the curve of the arch, they are not quite so high above rail level as the crown bar. Widening out for these bars can be commenced by removing the side-trees of the heading, and the poling boards, and then excavating from the sides. When the third bars are in, short stretchers must be put in between the bars spaced about 5 ft., strutting one bar against the other, so as to distribute the pressure. Dog-headed spikes, or brobs, must be driven into the bar round the head of all props, four to a prop, to prevent slipping. When this excavation is done, poling boards must be placed transversely to the bar. The proper way, when the face of the excavation is straight, is to insert the board above the last bar put in, and hammer it into place; but as the excavation here is curved, it is sufficient if the ground be removed from behind the bar on the underside, and the board hammered upwards, until held by the bar.

The fifth of the set of drawing bars is now put into position. They hold the lower ends of the poling boards, and must be back-propped similarly to the others.

With an occasional helping hand, 2 miners and 3 laborers will get the crown and third bars into place when driving the top heading. As space widens out, and the fifth bars are got in, another miner and 2 laborers can be added. When the seventh bars are in there will be room for the whole gang, consisting of a gang boss, who must work as a miner, 3 miners, and nine laborers.

The fifth bars being in, spaced with 1½ ft. drop at their leading end, in placing the seventh bars. The extra size of mined section due to this drop allowance must be begun to be worked out, and the bars below the fifth brought gradually nearer in to the line of the extrados of the brickwork, until at a few feet below the level of the top sill, the line of the back of the brickwork is regained. The set of drawing bars occupy about 15 ft. of the circumference of the mined section, and in a 5-yd. length there are consequently 15 ft. x 15 ft. x 1 in. = 225 cu. ft., or about 8½ cu. yds. excess of mining over and above the net section of the brickwork owing to the allowance necessary for drop, before this is worked out, and the net dimensions of the bricked section regained.

No drawing bars would be required with a light tunnel, and this excess would be prevented. The seventh bars can be smaller than the drawing bars in length and diameter, as they are not under strain so long. They must, of course, be longer than the actual length to be lined, as they require back propping until the sill is in.

When the length is mined down to the top sill, which must then be got in. The front or side of it facing the length must be a little more than 15 ft. from the last toothing which extends horizontally across the length, and 2 ft. into the ground on each side behind the proposed brickwork. Working this 2 ft. is called driving the sill hole. It is an expensive piece of work in hard ground, and dynamite will be found expedient in doing it. Bring the sill into the tunnel in halves with saddle and glands loose, the ground or sill bed being levelled and the sill holes driven. Place one half in its position and level it well before slipping on half of the glands, with screwed ends pointing upwards. Set up the remaining glands in about the position they should occupy on the other half sill, and drop this half into place, fixing it over the scarf with the plates. If from wear, etc., the glands do not all fit tightly, tighten them up with wedges. Prop all the bars of this sill, taking care to collar the props and drive brobs in at both top and bottom. The back props, which have up till now been supporting the bars, may be taken out.

(To be continued.)