

The Tunnelling Machines

Extracted from W.F.Cooke's paper read to the Society of Arts, May 15th 1867

I will now describe the machines for cutting stone etc., out of the living rock in the quarry itself. The principle here is, I believe, new. The cutting tools, instead of being placed in a single row around the rim of a thin blade, are fixed in rows of twos and threes alternately across the margin of a wheel like disc, so as to clear away a wider space. The outer portion of this wheel-like disc is a ring of fine malleable cast-iron armed on the out-side with tools, and carrying a cog-wheel within. Not to enter into small details of fittings, this cogged wheel is made to revolve on a broad metal plate as its axle. This broad plate is of great strength, and forms four-fifths of the diameter of the entire cutter, and can be firmly bolted to the machinery frame by any part of its surface nearest to the cogged wheel which carries the tools, and the latter so held is made to revolve by a pinion around it. This arrangement allows eccentrically held cutters to penetrate the rock to a depth exceeding the semi-diameter of the disc. In the circular saw with a central axle, the blade can only penetrate to so much of its semi-diameter as is clear of the axle and collar, and great force would be required to hold such a cutter up to its work in the rock, but in the machine now before us, the cutter-wheel is buried in the cut up to the point at which it is held, and practically allows of a cutter of 3ft 4in diameter burying itself to a depth of 2ft 3in; and as the cutter cuts out at a chord smaller than the diameter, the tendency of the outcoming tools is to draw the cutter into the cut, instead of forcing it out. A machine of this kind, cutting horizontally, works with great freedom, and advances rapidly through slate rock upon which it is employed. But when a cutting wheel on this principle is applied to make a vertical cut, a still smaller surface of the broad axle plate is occupied by the holder, as it can in that position be grasped on both sides, and the axle, carrying the pinion, can be passed though the wheel and supported upon double bearings.

The machinery, including the cutter wheel, for vertical cutting, is fixed on a carriage running upon rails, and worked by a wire rope. The cutter wheel is gradually brought down from its travelling position by a worm and worm-wheel to press upon the rock till it buries itself up to the holder, when it is fed forward by a self-working screw, attached by chain and swivel to some point in advance, or by winding directly upon a chain.

A tolerable level having been first obtained on the face of the quarry, and a line of rails pinned down in the direction of the cut to be made across the greatest length, the machine commences its advance, leaving a deep groove behind it two or three inches wide, and two, three or four feet deep. A series of parallel cuts may afterwards be made, or two disc cutters on the same carriage frame may be advantageously used to make two cuts at a time. An opening at the commencement of the first cut end must then be got out by blasting or otherwise, but afterwards, if the rock has any sort of cleavage or layering, it may be wedged up from below. The rock from between the first two cuts being thus removed, the vertical cutter may readily be applied to cross-cut the longitudinal grooves into squared blocks, to be removed by under wedging, or partial undercutting, when there is not a favourable cleavage. The principle of the undercutting machine is precisely the same as that of the vertical cutter. The cutter plate, however, has to be held horizontally by one side only. The cutter lies under the frame that carries it, and is advanced into its cut by a worm-screw and worm wheel as already described. When buried up to its holder in the rock, the cutter traverses along a slide frame twelve feet long; at the end of the twelve feet the slide and its carriage frame are pushed forward on the wheels for another length, and there fixed so as to leave the cutter free in its previous cut; it again proceeds on its journey, and so on to the end of the opening. *The photographs of this machine exhibit all the details of its construction, which cannot be properly explained without illustrations.* The exposed parts of all these machines are very strong, and although shattered pieces of rock coming down upon the cutter disc may momentarily impede its working, no injury to the machinery follows. The masses of stone cannot crush the disc, and the power employed in working the machine is not sufficient to break the wheel-work.

There are other applications of these movable cutters which I would gladly have introduced to the attention of the Society this evening, especially the coal-cutter, but the time allotted is too short for my venturing upon them on the present occasion. *There are some photographs, however, which display the*

formidable character of the tunnelling machines. One form includes in its construction two parallel borers, cutting two tunnels each 5ft 4in in diameter, side by side, and freeing more than two tons each at every cut. The slab of slate, still marked at its ends by the cutting tools, indicates the size of the pieces of slate that may be won by it. From one core, and that one the first ever cut by that machine, 23 slabs of more than one ton in weight were made, besides a considerable number of slates. Its rate of progress in cutting is eight inches per hour and the depth of cut allowed by the cutting blades is twenty-one inches forward. This machine has penetrated many yards into the solid slate bed, and is destined, I fully believe, to revolutionise the present system of quarrying that valuable material.

Other photographs represent another form of the tunneller, which is now being erected in a quarry in the Ffestiniog Valley. It will cut a single tunnel six-feet nine inches in diameter, and penetrate twenty-eight inches at each cut. The principle explained in the “under-cutting” machine is employed here, only the solid central holder, for the axle-plate is here open in the centre as a ring, round which the cog-toothed cutter ring revolves; and the latter, instead of carrying the movable tools on its periphery, in the same plane, carries three segment blades of steel, projecting forward, at the extremity of which a series of cutting tools are fixed, as in the saw blades. The carriage of this machine is fixed in the tunnel immovably by bolt screws, and the massive working parts gradually screw themselves forward as the cutters penetrate the rock. The open passage is preserved through the centre of the ring frame and ring cutter, to the front of the work, even whilst the machine is in action; owing to this, the core after cleaving up, is more readily removed than from the double tunnelling machine. This machine will excavate more than five tons at a cut.

A high authority in engineering has lately condemned this principle of “planing” out a rim round a core as a mistake. I hope before the end of this month to prove, by a second marvellous success with a second machine, that practice is better than theory.

Five feet to 6 feet 9 inches will be no trifling advance in a second tunnelling machine; but a much larger diameter for mere tunnel driving will only facilitate its working, as it will admit of more space for strength. At all events, this machine admits of the greatest facility for replacing the tools, if blunted or worn by encountering hard matter in the rock. The feeding screw is simply run back and the tools are examined and replaced without removing the framework from its fixed position. Generally the tools retain their sharpness throughout the cut. It must be remembered that these machines were made expressly for slate rock tunnelling, and have not yet been tried on sandstone or limestone rock for tunnelling purposes, which may offer fresh difficulties, only, I hope, to be mastered, and the usual means, perseverance and resolution, never fail us in this country.

End of Extract

Before anyone asks, I have never seen the photographs, and do not know if they exist anywhere. If they did, it would be a remarkable find.

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