

their drainage water, which is lifted to the surface by a pair of direct-acting pumping engines, placed near the bottom of the shaft. The chamber containing the engine, which is 52.9 feet long and 20.7 feet broad, is cut out of the rock, and was at first only partially secured by walling on the sides and roof, the ground consisting of strong shales and hard coal, being sufficiently firm; but when nearly completed, a fault in the strata was cut through, which disturbed the ground to such an extent that the floor began to thrust upward, so that it became necessary to line the entire excavation with masonry. The form of the work as finished is similar to that of a railway tunnel. The sections of the roof, side walls, and floor are semicircular, the respective radii being 10.3 ft., 20.7 ft., and 17.2 ft. The walling, which is 25.6 in. thick, except where the fault is crossed, where it is increased to 32.3 in., is carried out in common brickwork, set in cement, except the keystones of the roof and the floor arch, which are in specially moulded large firebricks. The engine bed is also in brickwork and cement, squared blocks of stone being used to take the pull of the holding down bolts. Four transverse girders of wrought iron are built into the walls above the engines to facilitate the removal of any parts of the machinery for examination or repair.

The engines, which are designed to lift 695 gallons of water 623 ft. high per minute, with a working steam pressure of four atmospheres, and 149 ft. per minute piston speed, are of a horizontal direct-acting pattern, with variable expansion (Meyer's) gear and condensing. The flywheel, to which both engines are coupled, weighs 10½ tons, is 18.4 ft. in diameter, and is placed behind the steam cylinders. The pumps, having each two working barrels, with a plunger common to both, are placed between the steam cylinders and the air pumps, which are also double-acting. The steam cylinders are 33 in., the pump plungers 10.8 in., and the air pumps 12.4 in. in diameter, the length of stroke common to all these being 27.3 in. There are two valve boxes and air vessels to each working barrel of the pumps. The valves consist of metal balls, 21 in each box, 2.48 in. in diameter, and 0.315 in. lift, giving a clear water way of 1.7 in., so that at every stroke made by the pump 42 suction, and the same number of pressure, valves are put in action. The valve

6½ lbs. upon an initial pressure of 60 lbs., or 10.8 per cent., with a naked steam pipe; but when a length of 328 ft. was covered this was reduced to 5 lbs., or 8.3 per cent.

The rising pipe in the shaft is of cast iron, 12.4 in. inside measure, the thickness being tapered, according to position, in four series, proportionately to the resistances, in the following order:

19 atmospheres	.....	1.210 inch	= 30.8 millimeters
13½ "	.....	0.990 "	= 25.2 "
9 "	.....	0.798 "	= 20.3 "
4½ "	.....	0.688 "	= 17.5 "

The separate lengths are united by turned flanges with double india rubber packing rings.

The engines were started at the end of July, 1876, and delivered at the normal working speed, 757 gallons of water per minute, or about 87 per cent. of the theoretical discharge of the pumps. The variations of pressure, as observed by a gauge placed at the bottom of the rising pipe, is between 18 and 19 atmospheres. Experiments have also been made by disconnecting one pump and running the other with both engines. Under the latter conditions, when the number of revolutions did not exceed 12 to 13 per minute, the variation of pressure was very slight; at 14 revolutions it was included between 19 and 22 atmospheres; and at 19 or 20 revolutions fluctuated between 8 and 30 atmospheres. The great difference in resistance under the latter condition is to be attributed to the circumstance that when the position of the crank is between 0° and 90° the water in the rising pipe is accelerated, and similarly between 90° and 180°, retarded in its movement. It would, therefore, be necessary to put on a special counterpoise in order to work the engines effectively under this condition. In spite, however, of the great variations in resistance observed in the latter experiment, the engines worked perfectly smooth, and the fluctuations of pressure noticed could only be detected by observing the gauge. When working 14 hours out of the 24, which is sufficient to draw the water for the present extent of workings, the consumption of small slack or dust coal is about 11 tons.

The total cost of the engines and necessary works, together

hereinafter described, between the adjacent portions of the periphery of the three rollers A A A', in conjunction with the spiral projections thereon.

In this passage of said ball it is caused to revolve in a direction with the said rollers, and, in the commencement of the action of the same, in a direction at right angles thereto, which movement results in a compound rotary motion of said ball. This result is produced by the helical projections of one or more of said rollers differing in pitch from those of the remaining rollers, or by revolving the same faster, or by a combination of both varying pitch and accelerated speed. In this manner the ball is perfectly squeezed from all sides and afterward compressed and stretched, and it emerges from the delivery end of the machine through the opening I' in a perfect condition as a round muck bar.

It will be observed that the rollers are made tapering, and have their axial lines all parallel. This may be varied, making the rollers parallel and their axial lines converging, which would produce the same result of making the space between the adjacent portions of the rollers tapering, and would, therefore, be a mechanical equivalent of the arrangement heretofore described.

The revolution of the ball in a direction with that of the rollers is caused by frictional contact therewith, in combination with the notches z in the spirals, the former movement thereof by the spiral projections, and the revolution at right angles to the plane of the rollers by the varying pitch of said spirals. It is therefore evident that, for simply revolving the ball in a direction with the rollers, plain or longitudinally grooved rolls would answer this purpose perfectly well; but, to insure the compound forward movement and rotary motion, at least one of the rollers should be spirally grooved; and to produce the compound rotary and rectilinear motion, two rollers, at least, must be spirally grooved, and one of these must have spirals of greater pitch than the remaining one. For this reason it is obvious that, while all the rollers may be spirally grooved, it is not absolutely necessary that they should be so constructed, but that one may be a plain or longitudinally grooved, and the remaining two spirally grooved, and their pitch made to vary in any one of the manners hereinbefore described. It is further

FIG. 1.

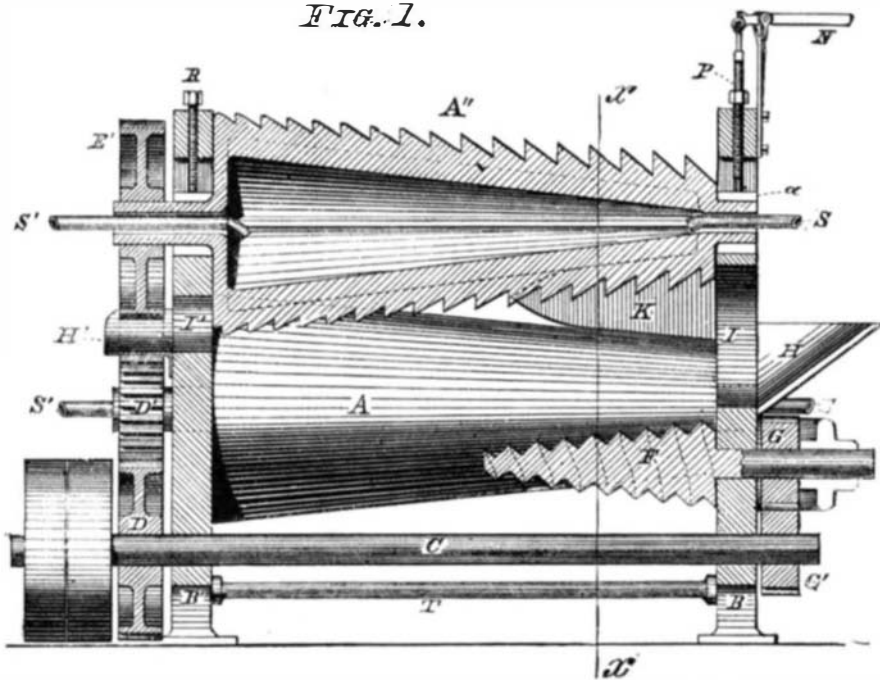
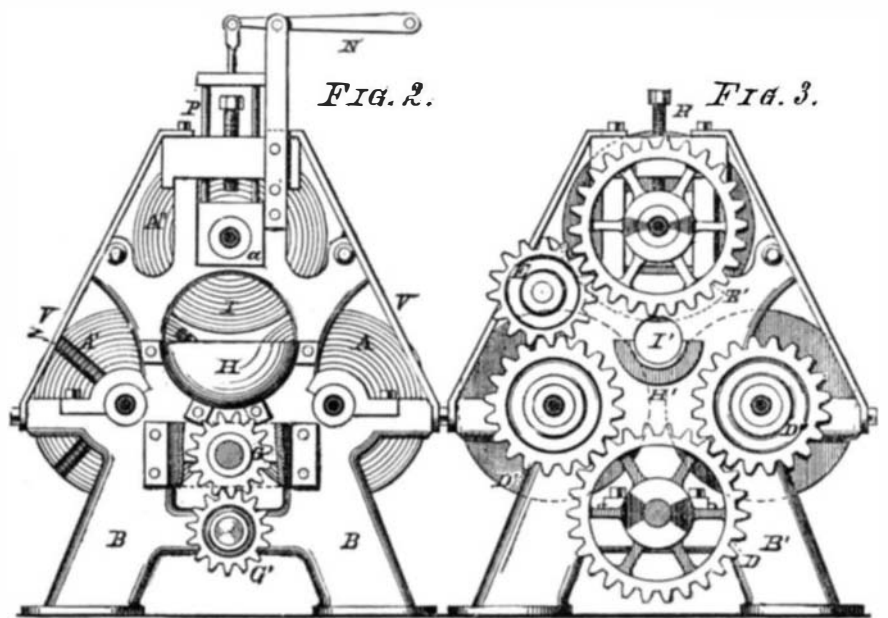


FIG. 2.

FIG. 3.



### IMPROVED MACHINE FOR SQUEEZING PUDDLERS' BALLS.

seats, also of metal, are arranged in a step form, and the boxes are placed to the right and left of the working barrels so as to get the largest amount of clear water way without making any part of undue size. The valve boxes in each pair are united below by a suction pipe 5.7 in. in diameter, and the four sets of pressure valves in each engine discharge into an overhead main of 8.85 in., which is connected by a similar one from the other engine, with the common rising pipe of 12.4 inches in the shaft.

The condenser valves, of which there are eight to each engine, are india rubber disks, 6.63 inches in diameter, and the air pump is so arranged that it may act as a suction lift to the main force pump, the latter being, however, provided with independent suction pipes in order to lift directly from the sump, if necessary; the height of the suction lift is about 16.4 feet.

The exhaust steam from the engines is admitted to the condenser by a mouthpiece containing three conical diaphragms, having a clear annular aperture of 7.28 in., within which the main suction pipe is placed concentrically. The water from the latter causes a rapid flow of steam through the conical tubes; and both currents, being brought into intimate contact by the diaphragms, rapid and complete condensation is effected. The condensers are so arranged, however, that the exhaust steam may be diverted and passed out by a waste pipe to the surface, when the engines are worked without condensation. The actual height to which the water is lifted is only 570 ft., but as it is intended to establish coal-dressing machines at the surface, which will require the point of discharge to be placed at a higher level in order to obtain the necessary head for the washing water, the engines have been constructed to work under 623 ft. head, corresponding to the pressure of 19 atmospheres, under which conditions the total pressure upon each plunger is about 10 tons, and that on the steam pistons, with an absolute steam pressure of 5 atmospheres, about 20 tons. The net power required, apart from all resistances, is about 130 horse power. The pump barrels, valve boxes, and air vessels, which are of cast iron, strengthened with rings and feathers, have been proved to a pressure of 40 atmospheres, and all surfaces of contact are united by turned shoulders fitting into corresponding sockets. The cranks, piston rods, cross heads, and similar moving parts, are of Bessemer steel. The total weight of the engines, exclusive of flywheel and connecting pipes, is about 55 tons.

The boilers, five in number, are placed above ground, and the steam is conveyed to the engines by a pipe 9.84 in. in diameter, coated with non-conducting material to prevent loss of pressure as much as possible. The loss of pressure between the boilers and the engine, which are 715 ft. apart, was

with that of an engine of equal power above ground working pumps in shaft, is given as follows (the florin taken at 2s.):

1. Sinking engine shaft and connecting level.	£2,223
2. Cost of engine chamber.	1,413
3. Five boilers, boiler house, and stack.	3,875
4. The pumping machinery, complete.	1,798
5. Raising pipe in shaft.	722
6. Main steam pipe in shaft.	398
7. Exhaust steam pipe in shaft.	113
8. Suction pipe to pump.	59
9. Freight, cartage, and erection charges.	683

Total amount.....£11,284

The following estimate of cost of engine at the surface is calculated for a 70 in. single cylinder direct-acting engine, with a stroke of 106 in., placed above the mouth of the shaft, working two plunger lifts of 2.06 ft. in diameter at four strokes per minute, the excess weight of the main rod being counterpoised by a balance box:

1. Cost of shaft and connecting levels, the former being of 68.9 square feet section.	£2,500
2. Five boilers, as above.	3,870
3. Engine house and foundation for the steam cylinder (wrought iron girders above the mouth of shaft).	1,550
4. Wrought iron main rods and connections for pump lifts (about 70 tons).	1,540
5. Cast iron rising pipe, 23 6 in. internal diameter, tapered in thickness as before.	1,280
6. Steam pipe and connections.	30
7. Cost of engine.	2,000
8. Cost of two plunger lifts.	1,200
9. Cost of counterpoise for rods.	130
10. Freight, carriage, and erection.	1,020

Total amount.....£15,125

The underground engines have, therefore, been erected at a smaller cost of about £3,840. H. B.

### MACHINE FOR SQUEEZING PUDDLERS' BALLS.

By EDMUND SUCKOW, Buffalo N. Y.

THE puddler's ball, as it comes from the furnace, is placed into the receiver H, from whence it will roll between the rollers, and there travel toward the rear end of the rollers, whereby it is compressed and squeezed, in a manner as

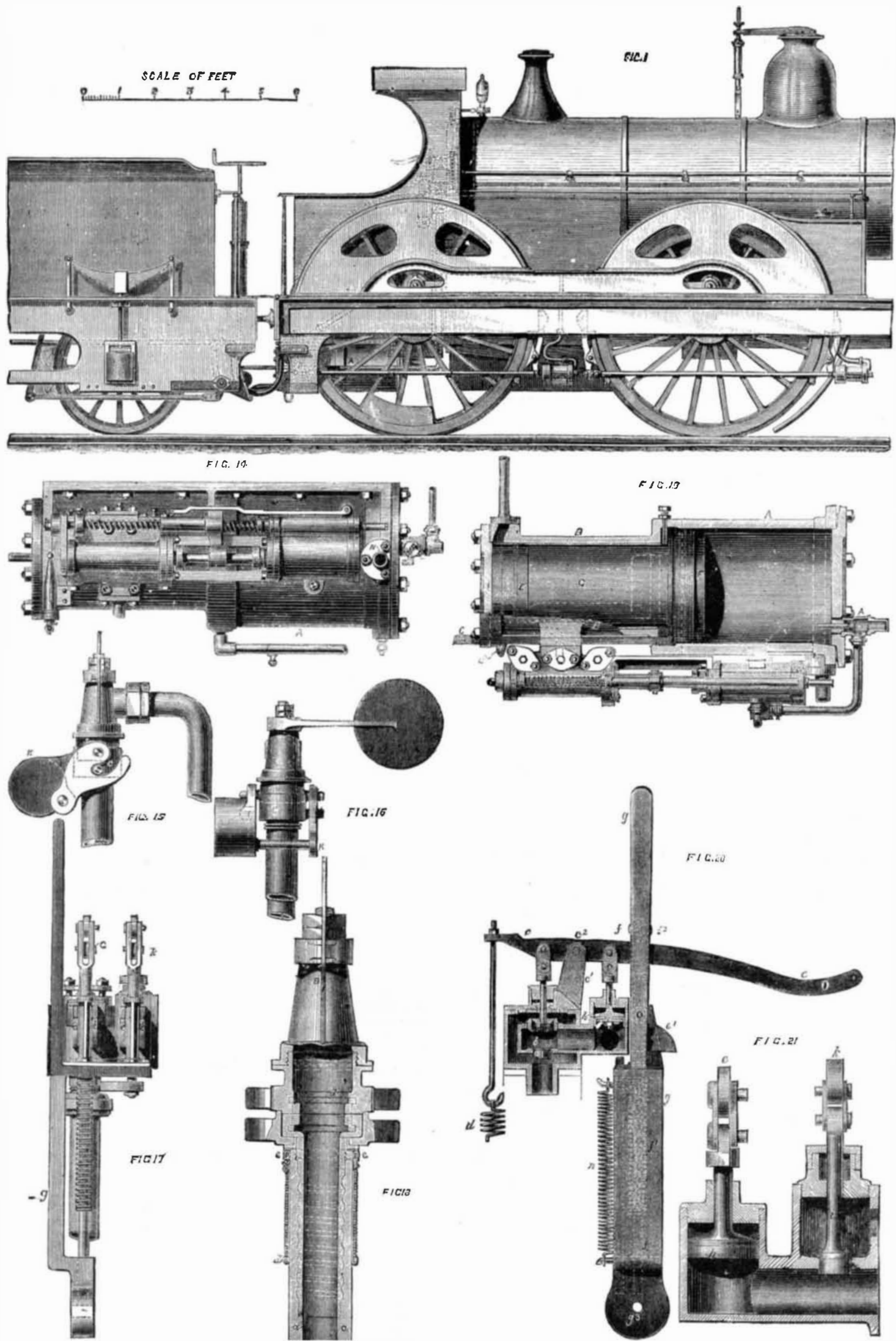
more obvious that the diameters of the rollers may be varying without interfering with their action.

In order to deeply indent the ball when first introduced, and in a nearly liquid state, and to knead the same thoroughly, and also to assist in the revolving of the ball, and to prevent it from separating on account of the shifting action of the spirals, these are made of V shape, with their forward or leading side very steep, or nearly at right angles to the plane of the rollers, and on the forward end very high, so as to imbed themselves sufficiently into the pliable mass of iron to insure its being properly worked. For this reason, also, one of the rollers is provided with scores or notches in the spirals, as shown in Fig. 2, into which the soft metal forces its way, forming, as it were, projections, which act, in conjunction with said scores or depressions, in a manner similar to that of cog-wheels, thereby aiding in revolving said ball; but since the ball while advancing becomes more solidified, and therefore capable of better withstanding such action, these scores or notches, as well as the spirals, are made shallower and closer together, so as not to feed the bloom too fast, and not to leave marks therein when it leaves the machine.

To compel parts of the ball detached during the squeezing and kneading process—should such take place notwithstanding the precautionary measures taken in the peculiar construction and shape of the spirals—to reunite, I have located the lower roller F in its indicated position, to prevent the detached parts from falling through, and thereby enabling them to attach themselves again to the bulk of iron, which, at that stage of the process, is still at a welding-heat, and also to assist in the revolution of the ball, while the sides between the middle and upper rolls are protected by shields K to prevent their escape through the space covered by these shields.

To enable the proper "criping" of the rollers on varying sized balls, I have made the upper one self-adjusting by means of the sliding boxes a in said frame. The forward end of this roller is allowed to rise and fall freely, and of its own accord, so as to adapt itself to the varying contour of the ball, a lever, N, and connecting-rods, P, being provided to lift that end for a free-introduction of the ball. But the rear end of this roller should, preferably, be adjusted by means of the screw R, so as to produce muck bars of uniform diameter, the difference in size of the balls evidencing itself in their length.

To keep the rollers cool during operation, I make them hollow, and introduce a current of water through the trunnions or bearings thereof by means of the pipes S. To strengthen them, they are internally provided with radial ribs, as shown in Fig. 1.



BARKER'S IMPROVED HYDRAULIC BRAKE, MIDLAND RAILWAY, ENG.