PERCUSSION ROCK DRILLS.

By ROBERT GRIMSHAW.Paper read before the Franklin Institute June 15, 1881.

The name "rock drill" is in most cases a misnomer, as the devices used for perforating rock very seldom have a drilling action proper. The French word "*perforatrice*," or perforator, is used with better reason. However, there is little more use in calling attention to this fact, than in stating our use of the word fore-plane is incorrect and the English use correct; the English meaning by fore-plane what we call a jack-plane, which is really the *before* plane.

As ordinarily known, a drill is a device which, by rotation and lengthwise advance, makes a round hole in some solid material, as wood, metal, ivory, etc.

In making holes in rock there are several ways; the oldest, by percussion only, accompanied by intermittent rotation of the drill bit. Very little rock is wrought by drills proper, having steady advance and continuous rotation, and breaking up all the material they remove. There is one type of rock drill which has continuous rotation and continuous advance, and which cuts out an annular channel, leaving in the centre a solid core which may, with care, be removed for inspection. The first and the third of these types—that is, the percussion drill and the ring or rock drill—are most generally in use. I shall in this paper treat of percussion drills only.

The drill proper is the drill bit, although usage sanctions the use of the word drill for the entire machine which guides or which drives the bit. Up to twenty years ago, there were very few drills driven except by hand power, the drill shank being either struck directly by hammer blows or raised by some machine and driven forward by a spring. We will speak of these two methods as the hand drill and the hand-drilling machine systems. So much more work can be done by hand-drilling machines than by hand drilling pure and simple, that the next step was to introduce a machine to imitate hand percussion drilling, with much greater force than by hand direct or by hand power machines. Of course the use of steam and of compressed air in a cylinder, to effect percussion by a drill bit fastened to the piston rod

of the cylinder, naturally suggests itself; the rotation of the drill bit on the back stroke and its advance lengthwise, to correspond with the depth of the cut taken at each stroke, being effected by many mechanical devices. Such a device constitutes the rock-perforating machine; or “rock drill” for short.

As ordinarily constructed, there is a double-acting steam engine, having a piston with a very long head, say 3 inches in diameter, the rod having the drill shank clamped to it direct. The valve motion of this machine, making as it does 300 strokes per minute and upwards, must be effective, simple, durable, compact and, if possible, economical of steam. Ordinarily the distributing valve is a slide valve, or its modification, the reciprocating piston valve; the cylinder having ports from each end of the steam chest in which the valve moves to and fro. The motion of the valve is effected by one of three systems; by lever, or tappets struck by the piston head, or by a boss or its equivalent upon the piston rod; by having the machine duplex; and by fluid transmission without any mechanical connection proper. Some machines have no separate external valve; the piston, or a sleeve thereon, performing the valve office.

The rotary motion is generally given by flutes upon the stem of the piston working in a fluted ratchet nut, although there are other methods; for instance, the stem may be in the back cylinder head and the ratchet nut in the piston head, etc. The forward feed of the drill bit may be by forward motion of the piston in the cylinder, the stroke getting longer each time; or by the stroke remaining the same in length, while changing its place in the cylinder bore; or the cylinder may be advanced. This feed may be either automatic, or by hand; and if automatic, it may be regular and independent of the hardness of the rock being penetrated; or it may be controlled by which this depth of feed may be regulated by hand while the actual work is done automatically; or the forward feed may be determined by the depth of the last cut taken, so that if the drill strikes a hard place and does not cut as deep as when it is working in a soft place, the feed will be lessened. Generally the cylinder heads are cushioned with rubber protected with metal discs, or else there is very great cushion of the driving air or steam, in order to prevent the heads being knocked out by the drill bit coming suddenly into a soft place or a cavity.

As regards the mounting of the machine, this depends upon the

work to be done. If in quarrying or in other surface work, where the holes are all vertical or nearly so, the most common mounting is a tripod having adjustable legs, which are weighted down to keep the machine in place, and are often extensible to allow of more perfect and steady placing. The steam or compressed air is led to the neighborhood of the drill by steam pipes of iron, and from them by flexible hose to the steam chest. If the machine is for gallery work, in which all the holes are horizontal or nearly so, the machine is generally mounted upon a column having thrust screws which jam it against the top and bottom of the heading and hold it firm. In some cases this column is threaded, to allow the machine to be adjusted in height, in others the column is smooth and the machine is clamped at the desired height. In others this column is mounted upon a carriage and has transverse motion by slides upon the carriage frame. In all cases where a column is used, the machine has free adjustment in the horizontal plane and also swings in a vertical plane, so that it has free adjustment after the column is in place, in height, in the vertical angle and in the horizontal angle.

For that class of surface work where it is desirable to channel, or cut a number of holes in a line close together, there is an arrangement permitting this to be done. In some cases, for tunnel work, several drills are mounted upon a carriage and all are given lengthwise advance at the same time by this carriage, although each one may cut at any desired angle in the vertical or horizontal plane. For those situations where it is necessary to cut down close to the floor, a special type of frame must be used, and in some cases a special type of machine. I show on the screen several types of drills and several styles of mounting them. Some of the illustrations are from working drawings of the makers.

It can be said about the tappet system of working a valve, that, while giving a positive motion to the valve, there is liability to and there always has been trouble from breakage of the tappets and their slight working parts, which are struck so many times a minute with such great force. This trouble is increased in frosty weather and this brings the repair bill up very high. Some opponents of tappets think that because the piston has to strike the tappet on the working stroke, the full force of the blow is not delivered upon the rock; but it seems to me that this is but a trivial matter.

The duplex system is not in use in this country. Because of the

very rough usage that the rock perforating machine has to undergo, it is well that there be as few exposed working portions as possible.

In reference to automatic feed; this is not generally applied to small machines, because these being used underground, light weight and simplicity is desirable. Where automatic feed is used, but one man is needed to work the machine.

In reference to steam or air cushion, those who oppose it do so on the ground that the motive fluid must be introduced by this means, in front of the advancing piston; so that, although the head is preserved from being knocked out, the blow is lessened in force and deepness.

Rotation is for two purposes; first to make a perfectly round hole, and second to make the bit work not only by mashing away the rock in front of it, but also by wedging off a portion of rock between the new cut and the last old one. To this a third reason may be added, that it preserves the edge of the bit, thereby lessening the wear and saving cost of sharpening.

The bits are of various shapes; the most common being in the form of an X. For loose, seamy rock, a Z shape is found to answer well.

The adjustability of the tripod may seem a very little thing, but it means a great deal. A machine properly mounted will work where two men cannot work with hammers upon the face of the cut. In a seam only two feet thick, like that at Port Henry, New York, the machine has to work nearly flat, with the legs spread apart.

By employing a lateral arm clamped to the column, the drill may be moved in or out on the arm, and the arm moved up or down or moved around, thus commanding a large portion of the breast without moving the column. The column should thrust against short pieces of timber at top and bottom. Columns over 8 feet long are apt to give give trouble from vibration. For a very large work, as tunnels, the column may be used to work out a drift of considerable size in extension of the line of the roof, and the tripods used to take up the bottom. This has the advantage of dividing the drilling ground and enabling more men to be used.

The disadvantage of the carriage is that the ground must be cleared before the carriage can be run up to the heading.

As regards the size of drills to use: 5-inch is used for submarine work, mounted upon a scow or frame; for deep heavy tunneling,

mounted upon a carriage; and for deep rock cutting, mounted upon a tripod. This size will drill from 1 to 40 feet deep and from 2 to 6 inches in diameter.

The 4-inch is for tunneling, heavy straight grading and quarry work, and where 12 to 20 feet holes, 2 to 4 inches in diameter, are to be made in very hard rock.

The $3\frac{1}{2}$ -inch and the 3-inch are the most used; being found in quarries, railroad tunnels, grading, sewers and mining; the $3\frac{1}{2}$ -inch drilling a 12 feet hole, $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in diameter, and the 3-inch drilling an 8-feet hole, 1 to 2 inches in diameter. Below this size there are the $2\frac{3}{4}$ and $2\frac{1}{2}$ -inch drills.

For horizontal drilling the capacities are about $\frac{1}{2}$ less. As regards the capacity of these drills, I annex some figures showing what they will do in various kinds of rock, and in some cases showing the rate of hand work in the same rock.

There is some work, such as cutting slate, granite and marble, where blasting cannot be used for fear of breaking the stone, and in this case 2-inch holes are drilled in a row, two inches apart, and the connection broken down by throwing out the rotation gear, and working out the stone between the holes with a drill bit having a flat point.

As far as possible, the drilling machine should be light, compact, strong, portable, quickly set up and moved, simple in construction, readily repaired at the shaft-head, economical of steam or compressed air, rapid in motion, free from trouble in freezing up where compressed air is used. If possible, the drill should be withdrawn automatically when desired. The machine should strike the blow variably according to the rock being entered. It is desirable that the hole be churned out by the machine itself, and that the bit shank may be quickly attached to the piston rod. Some like self-feed, some do not. The machine must be readily taken apart and kept clean and in working order. It must drill deep at one setting up. The heads should not knock out, and the tappets, if there be any, should not break. The piston rod should be large.

In the Johnson machine there is self-feed and steam or air pull-back. The whole cylinder may be slipped through the body clamp to or from the rock, thus adding to the length of the feed.

In the Bryer drill there are but two working parts—the piston and the rotation bar, the piston being its own valve, regulating the admis-

sion, cut-off and exhausts by annular grooves in the cylinder and piston. It is steam-cushioned at each end.

Place or works.	Diameter of piston. Size of hole. in.	Material passed through.	Feet drilled per hour, day or month.	Cost per ft. (Drill hole.)		Savings over hand drill- ing Per cent.
				Power.	Hand	
Yellow Jacket Silver Mining Co.....	.....	Conglom., Feldspar, Porph. and Quartz.	1160 ft. mo.	{ 81- .024 }	.....	50
Overman Min- ing Co.....	.....	( Hard blast- ing rock & Quartz.)	2000 ft. mo.	.183	.....	33½
Musconetcong Tunnel.....	5 in.	.....	25 to 40 ft. per day.	.....	.....	.....
Sierra Nevada Mining Co.....	.....	Porphyry.	.....	.32	.....	50
Eagle Harbor and Ahnapee.	5 in.	(Trap and Limestone.)	{ 5387 work- 4491 ing seasons '75, '76, '77. }	.....	.....	.....
Ausable Forks, N. Y.....	1½	{ Feldspar, ore and Felds- pathic rock. }	.....	.....	.....	50
Canada Pacific R. R., Mani- toba.....	5 in.	.....	{ 207 ft. 7 in. in 3 days. }	.....	.....	.....
Millstone Point, Conn.....	2	.....	7 ft. 8 in. per hr.	.....	.....	.....
Iron Mountain Co., Mo.....	3½	{ Iron ore, Porph. and Limestone. }	{ 45 ft. per d. of 10 hours. }	.233	.83	66
Knoxville, Tenn.	.....	Marble.	{ 140 ft. P. D. 23 " " " (hand 3 men.) 22 in., 1 man 10 hours. 5 ft. in 30 min., P. Drill.	.....	.....	.....
Chicago & Col- orado Mining Co.....	4 in.	.....	{ 45 ft. P. Dr. 8 " hand. 40 ft., P. D. 3 ft. 4 in. by (hand, 1 man) 80 ft in 10 hours. 9 ft. with 2 hands.	.12	.50	75
Paxton Furn'e., Pa.....	2½	Limestone.	.....	.....	.....	.....
Leesport.....	3½ in.	Limestone.	.....	.....	.....	.....
Denver & South Park R. R.....	3½ in.	(Granite, Iron rock. )	.....	.....	.....	.....
Wakefield Mar- ble Quarries.....	3 in. 2	Marble.	65 ft. per day.	.....	.....	.....
Diamond Hill Granite Co.....	3 in.	Granite.	40 " " "	.....	.....	.....
Steelton, Pa.....	.....	Limestone.	100 " " "	.04½	.61	.....
Georgetown, Col.	.....	.....	90 " " "	.....	.....	.....

In the Rand drill the tappets are moved by the piston instead of by projections upon the piston rod. The feed in the machine is by hand, a square-threaded screw carrying the cylinder along on its bed-plate, which latter has a vertical pivot.

In the Burleigh tappet drill there is a trough with ways on each side, in which the cylinder slides. The screw feed is automatic. The piston rod, which has a double annular cam and spiral grooves, controls the valve, effects the feed, and causes bit rotation. It is sometimes mounted in gangs in a frame or carriage, two on a horizontal bar across the top and two at the bottom, each having adjustability in these planes.

The single drill is mounted on a threaded telescopic iron column, having a single sharp point at the bottom and an iron thrust claw at the top. This column may also be used horizontally for shaft work.

The new Sergeant drill, made by the Ingersoll Rock Drill Co., was described at length, and illustrated, by Mr. F. L. Miller, in a paper before the Engineers' Club of Philadelphia, September, 1880. I show upon the screen the working drawings of the latest form. The principal peculiarities are in the valve and the ports and passages. The valve is a cylinder, having flanges somewhat smaller than the cylindrical steam chest, in which the valve slides upon a central bolt, which serves to hold the chest heads together. The chest heads have rubber cushions. The piston is of great length, and has a cavity as long as the piston stroke, so that it will always register with the ports and allow the steam exhaust from the valve to be exhausted therein. We will suppose the valve at one end of the stroke and steam let into the chest; the steam will pass to the cavity between the flanges, the steam being exhausted at the other end there will be no opposition to the valve moving towards that end, by reason of the steam rushing past the flange nearest the valve cylinder end. The cavity in the main piston prevents the valve being shifted until the main piston is nearly at the end of its stroke, when it will uncover the exhaust port of the valve cylinder in which the steam is confined, the steam passing into the upper port then to the opposite end of the chest, then by the lower port to the cavity in the piston. Rotation is by a fluted bar and nut; and feed by hand.