“Rock-Drilling Machine”

By John Darlington

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Excerpt from the above-cited article:

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**ROCK-DRILLING MACHINE.**

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Tools.—The method of fixing the tool to the end of the piston-rod has received a large amount of attention from inventors. In 1866, Jordan and Darlington introduced a loop clip. Later a binding ring came into use. Improvements on these methods are in progress, the object being to retain the tool on the axial line of the piston-rod, without resorting to rings, clips, or set screws. The form of the boring-bit has also undergone radical changes, in some instances rendered necessary, not for the purpose of drilling a round hole, but for neutralizing the imperfect action of the turning gear employed. The following figures, which will explain themselves, show “bits” of various forms, the use of which is advocated by inventors of various rock-drills.

Another form of tool for running down center or “rupturing” holes is shown in Fig. 12.

The bit, Z-shape, is the same size as the ordinary drills, but it has also an enlarged part, armed with a Z-shape cutting edge, 4 in. diameter. The length of the boring tools will depend upon the depth of the intended hole. At Ronchamp the longest hole was 9½ ft. At St. Gothard it is about 8 ft., while at Musconetcong Tunnel, New Jersey, the leading holes were usually 10 ft. deep, the longest 14 ft.

In ordinary mine headings, and in the employment of comparatively small boring machines, the diameter of the boring steel may vary from ⅝ in. to 1¼ in. For rupturing the rock with No. 1 dynamite, or Brain’s No. 1 powder, the hole at bottom need not exceed 1 in. in diameter; but if second-class dynamite or compressed powder be employed the hole in that case should be larger. In changing a boring
tool care must be taken that the cutting edge of the one to follow it is not wider than the intact cutting edge of the tool withdrawn. In the tool withdrawn it will be often found that the corners have been partly removed; the cutting edge of this tool is, therefore, that portion not rounded, but roughly parallel to the face of the hole. Many instances occurred in the rudimentary stage of boring, when machines were alleged to be useless—the fact having been that the cutting edge of the second tool was wider than that of the tool withdrawn, which, forced into a conical part of the hole, necessarily wedged itself fast, thereby stopping or retarding the working of the machine. As a common rule, the width of the different sets of boring tools at the points should vary from one-sixteenth to one-eighth of an inch from each other; or if the leading sets of tools are 1 1/4 in. wide at the point, the second or "follower" set may be 1 3/8 in., and the third 1 1/2 in. wide. No rule can be strictly laid down for determining the time and power requisite to bore holes of varying diameter; but experience seems to show that if a hole 1 3/4 in. deep and 1 in. diameter takes 4 minutes, a hole 2 in. diameter and of like depth, bored with the same machine, and under the same conditions as to pressure of air and speed, will take 16 minutes. In other words, the machine and the fluid pressure being the same, the time and power to bore holes to a given depth are as the square of the diameter of the hole. It is, therefore, of considerable importance to keep the diameter of the shot-hole as small as possible, and to supplement mechanical power by employing strong rupturing explosives.
Tunnel or Mine. | Machines employed. | Machines working together. | Machines in reserve for 1 in use. | Pressure air per sq. in. | Form of tool employed.
--- | --- | --- | --- | --- | ---
Mont Cenis... | Sommellier’s... | 10 | 7 | 90 | Z
| Ferroux’s, | 6 | 68 | 90 | X
St. Gothard... | Dubois & Frangois | 6 | 68 | 60-70 | X
| McKean’s, | 2 | 50 | Semicircular.
Musconetcong... | Ingersoll’s | 6 | 60 | 70-80 | Flat tool.
Maesteg... | Beaumont’s | 2 | 60 | X
Cwmbran... | McKean’s | 2 | 60 | Flat tool.
Port Skewet | Geach’s | 2 | 60 | Flat tool.
Saarbruck... | Sach’s | 6 | 60 | X & Z.
Ronchamp... | Dubois & Frangois | 4 | 1 | 67 | X & Z.
Blanzy... | Darlington | 4 | none | 45 | Flat tool.
Minera... | Darlington | 1-2 | none | 50 | Flat tool.
Ballacockish... | Darlington | 1-2 | none | 45 | Flat tool.

Cut and Sink.—In tunnelling or sinking shafts by means of rock-boring machinery, it is necessary to conduct the operation in some special manner. When machines were

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**Fig. 12.**
first introduced into our mines the miner insisted upon employing them as a mere substitute for the borer and the mallet, and boring the holes so as "to take advantage" of the ground. The result showed, however, that such a course was unsatisfactory. Not only was the time required to get a position for the machine, to fix, and to remove it excessive, but the work accomplished was not in proportion to its cost. The engineers of the Mont Cenis Tunnel were the first to recognize the fact that if power machines were to be successfully adopted the hand method of doing the work must be discarded and new conditions established. A given number, ten machines, were accordingly grouped together on a carriage, the natural rupturing lines of the rock disregarded, the holes drilled more or less with the axial line of the heading, the machines and carriage withdrawn, the holes charged, the explosive fired, and the stuff removed.

These series of operations constituted an "advance,"

while in America, and in one or two English mines, it is known as a "cut," and in shafts as a "sink." At the time when the Mont Cenis Tunnel was driven, nitroglycerin and dynamite had not been largely adopted for blasting purposes. Powder was the explosive used in the execution of that work; this, together with the great length of the machines and comparatively narrow width of the heading—9 ft. 10 in.—thereby limiting the angling range of the machines, rendered a considerable number of holes necessary for effecting the removal of the rock. A face of $83\frac{1}{2}$ square ft. was perforated with from 60 to 70 holes, $2\frac{1}{4}$ ft. to 4 ft. deep. The Musconetcong Tunnel, New Jersey, was driven with the aid of dynamite. The advance heading, 8 ft. high, was carried the entire width of the tunnel—26 ft. With two boring carriages, and strongly angling the machines on a line from the top to the bottom of the tunnel towards its axial line, holes 10 ft. deep were made for bringing out the center "cut." The methods of arranging the holes for blasting may be distinguished as—

(a).—Mont Cenis and St. Gothard.
(b).—Musconetcong and Minera.
(c).—Brain's radial system.
(a).—The face of the Mont Cenis heading, allowing for contraction towards the top and rounding corners, represented an area of about 80 square ft. This “face” was subjected to the attack of 10 machines, giving 8 square ft. of surface per machine, or nearly one hole for each square foot of surface.

The center of the face was perforated with a large hole, and immediately outside of this center 8 other holes were bored, constituting the “center or rupturing holes.” Around this set of center holes a series of 3 sets of concentric and 2 sets of semi-concentric holes were drilled. The holes were subsequently fired in volleys and removed the rock—(1) the center, and (2) the portion concentric to the center. See Fig. 16.

(b).—At Musconetcong the tunnel heading, 26 ft. wide by 8 ft. high, gave a net area of about 175 square ft. This face was perforated with 36 holes by means of 6 powerful boring machines, each cylinder 5 in. diameter. The area of the face apportioned to each machine was 29 square ft. The number and depth of the holes to obtain a cut of 10 ft., or an actual lineal advance of 9 ft., were:

<table>
<thead>
<tr>
<th>Hole Type</th>
<th>Quantity</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut</td>
<td>12</td>
<td>10½ ft.</td>
</tr>
<tr>
<td>First square up</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Second ditto</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Third ditto</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Four roof holes</td>
<td>2</td>
<td>{10}</td>
</tr>
<tr>
<td></td>
<td></td>
<td>{8}</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>36</strong></td>
<td></td>
</tr>
</tbody>
</table>

The aggregate depth of the 36 holes was 408 lineal feet; number of square feet of heading to one hole about 4·8. The following is Mr. Drinker’s description of driving by the
cut system: "The method of blasting by cuts is based on the extraordinary force developed by a comparatively small bulk of explosive matter. It consists in first blasting out an entering wedge or core, about 10 ft. deep at the center, and subsequently squaring up the sides by several rounds. To do this 12 holes are first drilled by 6 machines, 3 on a side, the holes placed as shown in Fig. 13, and marked C; A
being the floor of the heading. Then 12 holes are drilled, 2 and 2, 6 on a side, with from $1\frac{1}{2}$ to $2\frac{1}{2}$ in. "bits," the two sets being started about 9 ft. apart, and at such an angle (see Fig. 17) as to meet or cross at the bottom, the largest bit being put in first. The holes are then charged with about 25 lbs. No. 1 and 50 lbs. No. 2 dynamite, and fired simultaneously by electricity. No. 1 is only used for cuts, inasmuch as in them a quick, strong powder compressed in a small bulk at the bottom of the holes is required where the greater resistance will be found, while the No. 2 added serves in filling up the holes, so starting the sides of the cut as the apex moves—the cut, $a$, being out, a second round of holes is started for the first squaring up, as shown by the numbers 1, 1, 1, 1, Figs. 13 and 14.

In these and subsequent rounds, 2, 2, 2, 2 and 3, 3, 3, the resistance is pretty equally distributed along the whole length of the holes, and as it is not so great as in the cut,
No. 2 is used, as in it, the nitroglycerin being mixed with a larger proportion of absorbent matter, the force is thereby distributed over a greater space. In the first and second squaring up rounds from 50 to 60 lbs. of No. 2 are charged, and in the third, from 80 to 90 lbs., the holes getting stronger as the arch falls at the side. There are generally, also, one or two additional roof-holes in the third round that are not shown in the figure, their position being variable, according to the lay of the rock. The top holes in the first round are also designed to bring down the roof not shaken by the cut, and are, therefore, given a strong angle towards the center, and always drilled from 12 to 14 ft. deep. The plan, Fig. 14, shows the cut holes, 4, 5, and 6 the squaring up rounds.

"As to the relative depth the holes of the first squaring up round are always drilled a foot or more deeper than the cut-holes, and when blasted they generally bring out a foot additional of shaken rock at the apex of the cut."

(c).—Brain's radial system.—This system, devised by Mr. W. Blanch Brain, of St. Annal's, Cinderford, was introduced about three years ago at the Drybrook Iron Mines, in the Forest of Dean. The main object of the inventor was to perforate the face of a level without once shifting the stretcher-bar when placed at its proper height. M. André, in his work on Coal Mining, thus notices the radial system: "The fundamental principle which constitutes its distinctive character is to make the holes of a series to radiate from a fixed point. The object of this radiation is twofold—to utilize the face of the heading as an unsupported side, and to reduce to a minimum the time consumed in changing the position of the stretcher-bar. It will be obvious on reflection that if these ends are attained
without incurring a compensating loss the merits of the system are beyond question, since their attainment leads to rapidity of progress, which is the main purpose of machine labor. It is evident that if the holes are made to radiate from a fixed point, and the horizontal position be avoided, none of them can be perpendicular to the face of the heading, and, consequently, the lines of fracture from each charge tend to reach this face. A consequence of this fact is that no unkeying of the face is necessary, since each shot tends to blow outwards. Let it be assumed that the drift to be driven is 6 ft. 8 in. in height. The width in this case is immaterial to the operation of the system. The stretcherbar, which is to serve as a support to the machine, is fixed at a certain height from the floor, and at a certain distance from the face, as shown in Fig. 15. The height of the bar above the floor, with slight modifications to suit existing conditions, will be the same in all cases; but the distance of the bar from the face will be determined by the length of the machine, or at least by the distance from the centre of the clamp to the end of the piston-rod, into which the bit is fixed. It is obviously desirable to reduce the distance between the face of the heading and the stretcher-bar to the least possible, since the angle of the holes will rapidly increase as the distance is diminished. From the figure it will be observed that the stretcher-bar is fixed 1 ft. 8 in. from the top, 5 ft. from bottom, and 2 ft. 4 in. from the face. The first and second series of holes are 3 ft. 1 in. deep; the third, 3 ft. deep; the fourth, 3 1/2 ft.; and the fifth, 4 ft. deep. The bottom or lifting holes are 3 ft. long.

In a heading 6 ft. 8 in. by 6 ft. 8 in., giving an area of 44 square feet, 29 holes were bored, representing a total lineal length of 69 ft. 8 in. As the cut or advance was about 3 ft., it follows that each hole removed nearly 7 cubic feet of rock.—Mining Journal.