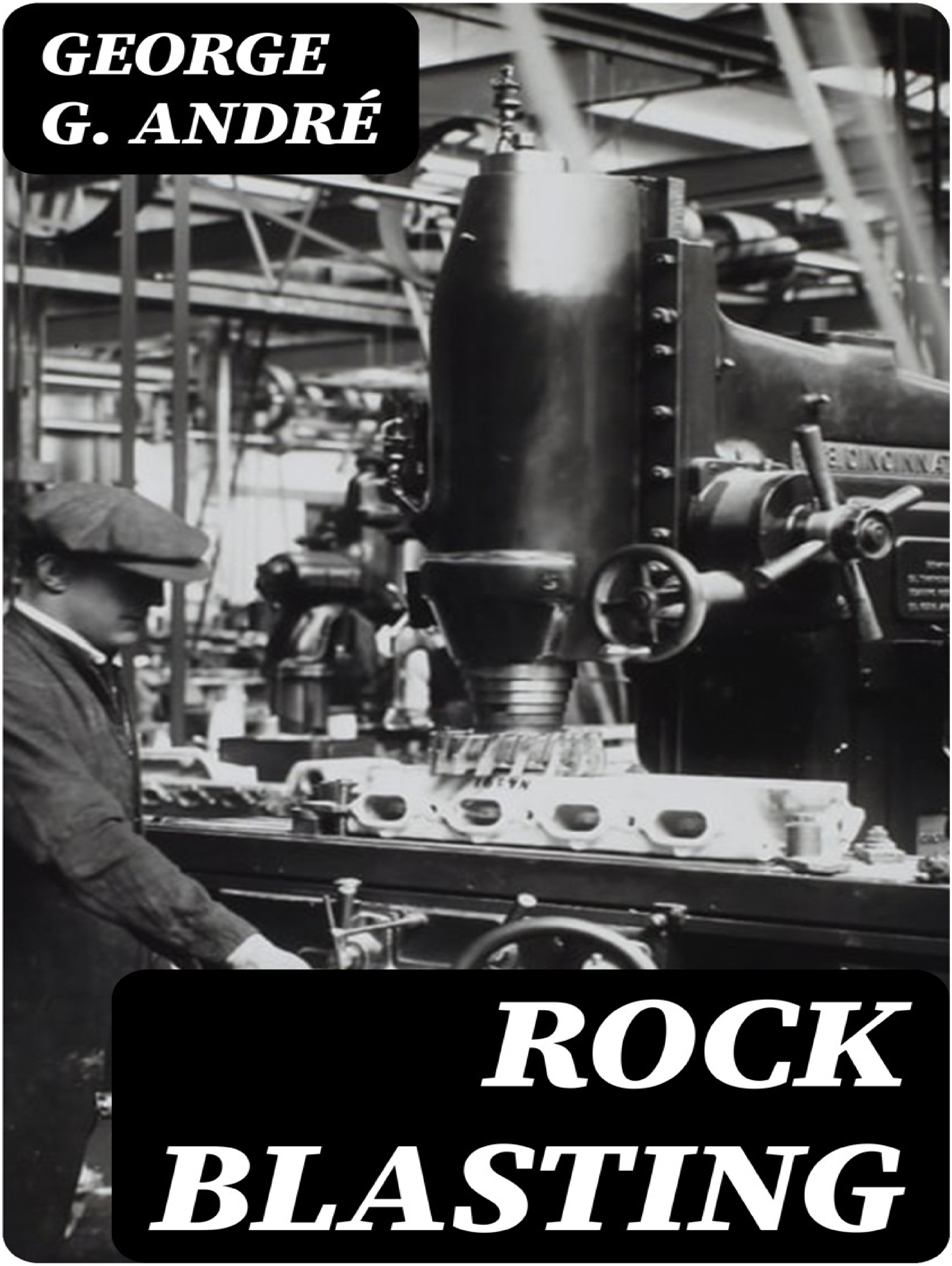
GEORGE G. ANDRÉ



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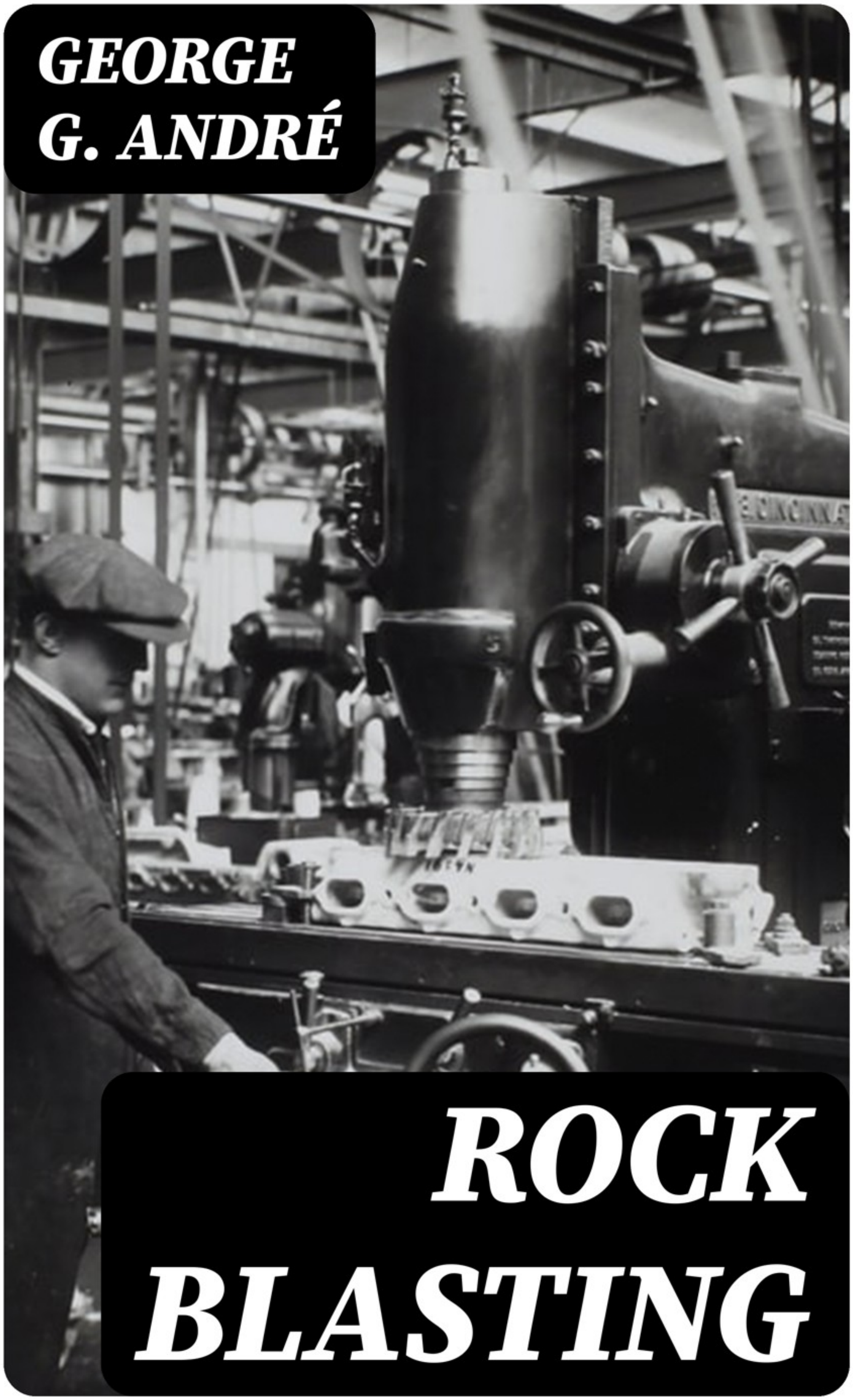

ROCK BLASTING

George G. André

Rock Blasting

A Practical Treatise on the Means Employed in Blasting Rocks for Industrial Purposes

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PREFACE.

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During the past decade, numerous and great changes have taken place in the system followed and the methods adopted for blasting rocks in industrial operations. The introduction of the machine drill led naturally to these important changes. The system which was suitable to the operations carried on by hand was inefficient under the requirements of machine labour, and the methods which had been adopted as the most appropriate in the former case were found to be more or less unsuitable in the latter. Moreover, the conditions involved in machine boring are such as render necessary stronger explosive agents than the common gunpowder hitherto in use, and a more expeditious and effective means of firing them than that afforded by the ordinary fuse. These stronger agents have been found in the nitro-cotton and the nitro-glycerine compounds, and in the ordinary black powder improved in constitution and fired by detonation; and this more expeditious and effective means of firing has been discovered in the convenient application of electricity. Hence it is that the changes mentioned have been brought about, and hence, also, has arisen a need for a work like the present, in which the subjects are treated of in detail under the new aspects due to the altered conditions.

GEO. G. ANDRÉ.

London, 17, King William Street, Strand,
January 1st, 1878.

CHAPTER I.
THE TOOLS, MACHINES, AND OTHER APPLIANCES USED IN BLASTING ROCKS.

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Section I.—Hand Boring.

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Drills.

—The operations of blasting consist in boring suitable holes in the rock to be dislodged, in inserting a charge of some explosive compound into the lower portion of these holes, in filling up, sometimes, the remaining portion of the holes with suitable material, and in exploding the charge. The subjects which naturally first present themselves for consideration are: the nature, form, and construction of the tools, machines, and other appliances used. Of these tools, the “drill” or “borer” constitutes the chief. To understand clearly the action of the rock drill, we must consider the nature of the substance which has to be perforated. He who has examined the mineral constitution of rocks will have recognised the impossibility of *cutting* them, using that term in its ordinary acceptation, inasmuch as the rock constituents are frequently harder than the material of the tools employed to penetrate them. As a rock cannot be cut, the only way of removing portions of it is to fracture or to disintegrate it by a blow delivered through the medium of a suitable instrument. Each blow so delivered may be made to chip off a small fragment, and by this means the rock may be gradually worn away. To effect this chipping, however, the instrument used must present only a small surface to the rock, in order to concentrate the force, and that surface must be bounded by inclined planes or wedge surfaces, to cause a lateral pressure upon the particles of rock in contact with them. In other words, the instrument must be provided with an edge similar to that possessed by an ordinary *cutting* tool.

The conditions under which the instrument is worked are obviously such that this edge will be rapidly worn down by attrition from the hard rock material, and by fracture. To withstand these destructive actions, two qualities are requisite in the material of which the instrument is composed, namely, hardness and toughness. Thus there are three important conditions concurring to determine the nature and the form of a cutting tool to be used in rock boring—1, a necessity for a cutting edge; 2, a necessity for a frequent renewal of that edge; and 3, a necessity for the qualities of hardness and toughness in the material of the tool.

In very hard rock, a few minutes of work suffice to destroy the cutting edge, and then the tool has to be returned to the smithy to be re-sharpened. Hence it is manifest that the form of the edge should not be one that is difficult to produce, since, were it so, much time would be consumed in the labour of re-sharpening. Experience has shown that the foregoing conditions are most fully satisfied in the steel rod terminating in a simple chisel edge, now universally adopted.

This form of drill is exhibited in Fig. 1, which represents a common “jumper” borer. It consists of a rod terminating at each end in a chisel edge, and having a swell, technically described as the “bead,” between the extremities to give it weight. The bead divides the jumper into two unequal portions, each of which constitutes a chisel bit, with its shank or “stock.” The shorter stock is used while the hole is shallow, and the longer one to continue it to a greater depth.

Fig. 1.

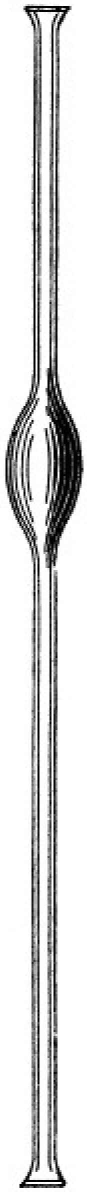


Fig. 2.

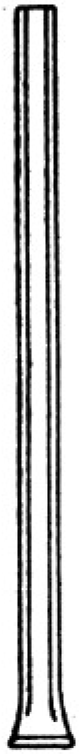
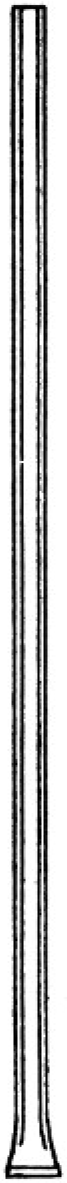


Fig. 3.



With the jumper, the blow is obtained from the direct impact of the falling tool. The mode of using the instrument is to lift it with both hands to a height of about a foot, and then to let it drop. In lifting the jumper, care is taken to turn it partially round, that the edge may not fall twice in the same place. By this means, the edge is made to act most favourably in chipping away the rock, and the hole is kept fairly circular. So long as the holes are required to be bored vertically downwards, the jumper is a convenient and very efficient tool, and hence in open quarrying operations, it is very commonly employed. But in mining, the shot-holes are more often required to be bored in some other direction, or, as it is termed, “at an angle;” that is, at an angle with the vertical. Or it may be that a shot-hole is required to be bored vertically upward. It is obvious that in any one of these directions the jumper is useless. To meet the requirements of such cases, recourse is had to the hammer wherewith to deliver the blow, and the drill is constructed to be used with the hammer. We have a suitable form of tool for application in this wise when we cut out the bead of the jumper and leave the ends flat for a striking face, as shown in Figs. 2 and 3. The form of the two chisels thus obtained is that adopted for the ordinary rock drill.

It will be understood from these descriptions that a rock drill consists of the chisel edge or *bit*, the *stock*, and the *striking face*. Formerly drills were made of wrought iron, and steeled at each end to form the bit and the striking face. Now they are commonly made of cast steel, which is supplied for that purpose in octagonal bars of the requisite diameter. The advantages offered by steel stocks are numerous. The superior solidity of texture of that material renders it capable of transmitting the force of a blow more effectively than iron. Being stronger than the latter material, a smaller diameter of stock, and, consequently, a less weight, are sufficient. This circumstance also tends to increase the effect of the blow by diminishing the mass through which it is transmitted. On the other hand, a steel stock is more easily broken than one of iron.

The cutting edge of a drill demands careful consideration. To enable the tool to free itself readily in the bore-hole, and also to avoid introducing unnecessary weight into the stock, the bit is made wider than the latter; the difference in width may be as much as 1 inch. It is evident that in hard rock, the liability of the edge to fracture increases as the difference of width. The edge of the drill may be straight or slightly curved. The straight edge cuts its way somewhat more freely than the curved, but it is weaker at the corners than the latter, a circumstance that renders it less suitable for very hard rock. It is also slightly more difficult to forge. The width of the bit varies, according to the size of the hole required, from 1 inch to 2½ inches. Figs. 4, 5, and 6 show the straight and the curved bits, and the angles of the cutting edges for use in rock.

Fig. 4.

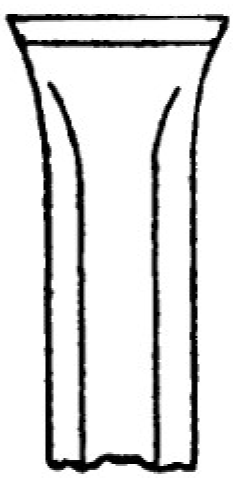


Fig. 5.

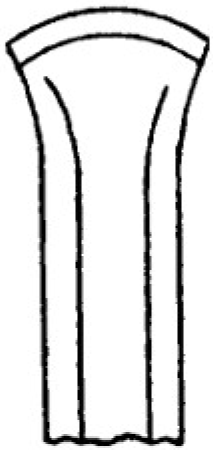
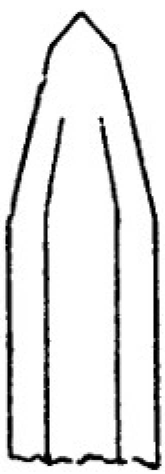


FIG. 6.



The stock is octagonal in section; it is made in lengths varying from 20 inches to 42 inches. The shorter the stock the more effectively does it transmit the force of the blow, and therefore it is made as short as possible. For this reason, several lengths are employed in boring a shot-hole, the shortest being used at the commencement of the hole, a longer one to continue the depth, and a still longer one, sometimes, to complete it. To ensure the longer drills working freely in the hole, the width of the bit should be very slightly reduced in each length. It has already been remarked that the diameter of the stock is less than the width of the bit; this difference may be greater in coal drills than in rock or “stone” drills; a common difference in the latter is 3⁄8 of an inch for the longer. The following proportions may be taken as the average adopted:—

Width of the Bit.			Diameter of the Stock.		
1		inch		5⁄8	inch
1	1⁄8	„		3⁄4	„
1	1⁄4	„		7⁄8	„
1	1⁄2	„	1		„
1	3⁄4	„	1	1⁄8	„
2		inches	1	3⁄8	„
2	1⁄4	„	1	1⁄2	„
2	1⁄2	„	1	5⁄8	„

The striking face of the drill should be flat. The diameter of the face is less than that of the stock in all but the smallest sizes, the difference being made by drawing in the striking end. The amount of reduction is greater for the largest diameters; that of the striking face being rarely more than one-eighth of an inch.

The making and re-sharpening of rock drills constitute an extremely important part of the labour of the mine smith. The frequent use of the drill, and its rapid wear, necessitate a daily amount of work of no trifling proportions, and the judgment and skill required in proper tempering render some degree of intelligence in the workman indispensable; indeed, so much depends upon the smith whose duty it is to repair the miners’ tools, that no pains should be spared to obtain a man capable of fulfilling that duty in the most efficient manner possible.

When the borer-steel bars are supplied to the smith, he cuts them up, as required, into the desired lengths. To form the bit, the end of the bar is heated and flattened out by hammering to a width a little greater than the diameter of the hole to be bored. The cutting edge is then hammered up with a light hammer to the requisite angle, and the corners beaten in to give the exact diameter of the bore-hole intended. As the drills are made in sets, the longer stocks will have a bit slightly narrower than the shorter ones, for reasons already given. The edge is subsequently touched up with a file. In performing these operations, heavy hammering should be avoided, as well as high heats, and care should be taken in making the heat that the steel should be well covered with coal, and far enough removed from the tuyere to be protected from the “raw” air. Overheated or “burned” steel is liable to fly, and drills so injured are useless until the burned portion has been cut away.

Fig. 7.

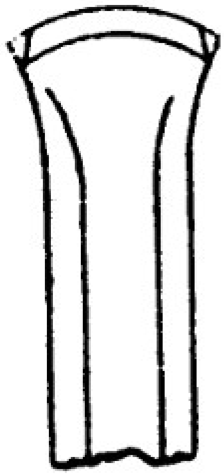


Fig. 8.

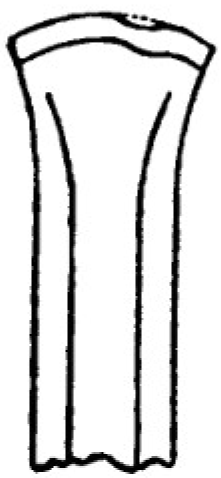
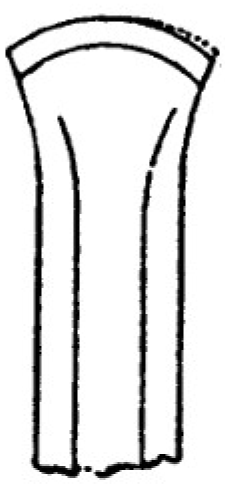


Fig. 9.



Both in making and in re-sharpening drills, great care is required to form the cutting edge evenly, and of the full form and dimensions. If the corners get hammered in, as shown in Fig. 7, they are said to be “nipped,” and the tool will not free itself in cutting. When a depression of the straight, or the curved, line forming the edge occurs, as shown in Fig. 8, the bit is said to be “backward,” and when one of the corners is too far back, as in Fig. 9, it is spoken of as “odd-cornered.” When either of these defects exist—and they are unfortunately common—not only does the bit work less effectively on the rock, but the force of the blow is thrown upon a portion only of the edge, which, being thereby overstrained, is liable to fracture.

The hardening and tempering of steel is a matter requiring careful study and observation. It is a well-known fact that a sudden and great reduction of temperature causes a notable increase of hardness in the metal. The reason of this phenomenon is not understood, but it is certain that it is in some way dependent upon the presence of carbon. The degree of hardness imparted to steel by this means depends upon the amount of the reduction of the temperature, and the proportion of carbon present in the metal, highly carburetted steel being capable of hardening to a higher degree, under the same conditions, than steel containing less carbon. Thus, for steel of the same quality, the wider the range of temperature the higher is the degree of hardness. But here we encounter another condition, which limits the degree of hardness practically attainable.

The change which takes place among the molecules of the metal in consequence of the change of temperature causes internal strains, and thereby puts portions in a state of unequal tension. This state renders the strained parts liable to yield when an additional strain is thrown upon them while the tool is in use; in other words, the brittleness of the steel increases with its hardness. Here again the proportion of carbon present comes into play, and it must be borne in mind that for equal degrees of hardness the steel which contains the least carbon will be the most brittle. In hardening borer-steel, which has to combine as far as possible the qualities of hardness and toughness, this matter is one deserving careful attention. It is a remarkable fact, and one of considerable practical value, that when oil is employed as the cooling medium instead of water, the toughness of steel is enormously increased.

The tempering of steel, which is a phenomenon of a similar character to that of hardening, also claims careful consideration. When a bright surface of steel is subjected to heat, a series of colours is produced, which follow each other in a regular order as the temperature increases. This order is as follows: pale yellow, straw yellow, golden yellow, brown, brown and purple mingled, purple, light blue, full clear blue, and dark blue. Experience has shown that some one of these colours is more suitable than the rest for certain kinds of tools and certain conditions of working.

The selection of the proper colour constitutes a subject for the exercise of judgment and skill on the part of the smith. For rock drills, straw colour is generally the most suitable when the work is in very hard rock, and light blue when the rock is only of moderate hardness.

The processes of hardening and tempering drills are as follows: When the edge of the bit has been formed in the manner already described, from 3 to 4 inches of the end is heated to cherry redness, and dipped in cold water to a depth of about an inch to harden it. While in the water, the bit should be moved slightly up and down, for, were this neglected, the hardness would terminate abruptly, and the bit would be very liable to fracture along the line corresponding with the surface of the water. In cold weather, the water should be slightly warmed, by immersing a piece of hot iron in it, before dipping the steel. When a sufficient degree of hardness has been attained, the remainder of the hot portion is immersed until the heat is reduced sufficiently for tempering. At this stage it is withdrawn, and the colours carefully watched for. The heat which is left in the stock will pass down to the edge of the bit, and as the temperature increases in that part the colours will appear in regular succession upon the filed surface of the edge. When the proper hue appears, the whole drill is plunged into the water and left there till cold, when the tempering is complete. When the edge is curved or “bowed,” the colours will reach the corners sooner than the middle of the bit. This tendency must be checked by dipping the corners in the water, for otherwise the edge will not be of equal hardness throughout. As the colour can be best observed in the dark, it is a good plan to darken that portion of the smithy in which tempering is being carried on.

The degree of temper required depends upon the quality of the steel and the nature of the work to be performed. The larger the proportion of carbon present in the metal, the