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Report No. 315/9

# TOOL BITS AND DRILLS FOR MACHINING ARMOR PLATE

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May 4, 1937
WATERTOWN ARSENAL
WATERTOWN, MASS.

Rept. No. 315/9
Watertown Arsenal

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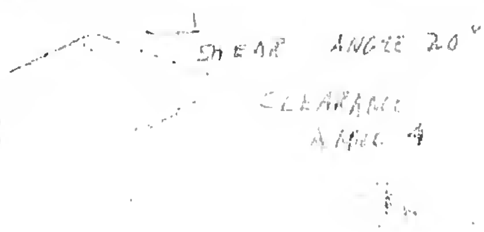
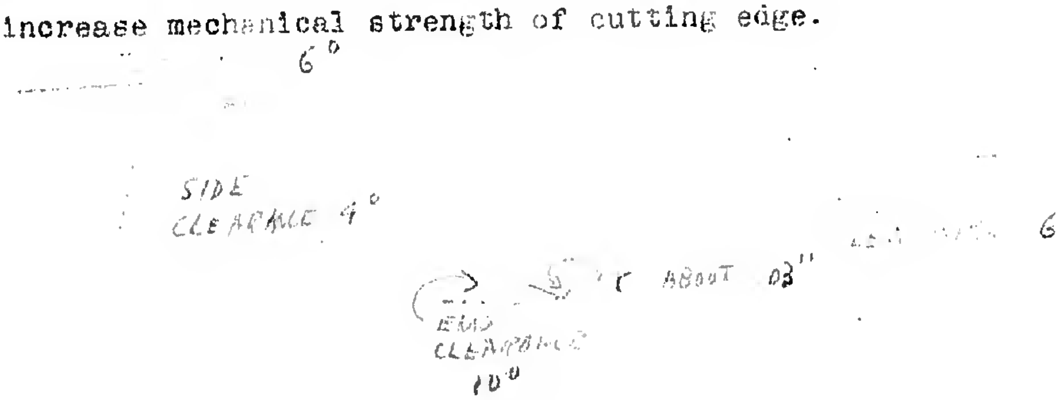
Memorandum to: Major Guion

Submitted herewith are two drills and one H. S. steel bit ground specially with angles found most efficient in drilling and cutting armor plate. Note the lengths of the twist drill its shear angle decreased from the normal 40° to 20°. The tip of the drill ground off to give a 0° rake angle and the very flat clearance angle of 4°.




Note that flat drill has a shear angle of 30°, a clearance angle of about 8° and that the rake angle is about 2° negative.


Note that tool bit is ground with minimum cutting of angles to give heat conductivity away from cutting edge and to increase mechanical strength of cutting edge.



Radius of nose of tool will increase with tool cross section. These values gave excellent results when used on Armor Plate castings between 420 and 470 Brinell hardness. The twist drill values were for that same grade material. I had no experience with the flat drill but understand that it performed efficiently on material of more than 500 Brinell.

In general it may be said that when hardness of material to be cut goes up, cutting angles as measured in these sketches go down. However, it is doubtful that a shear angle less than 20° will be of any advantage. Clearance angles must be kept greater than 0° and positive. Rake angle may be 0° or negative. Rigidity of both the tool and set up of work is essential. In tapping it was found that gun taps having only 2 flutes were more rigid and gave longer service than the standard 4 fluted tap.

The tool bit shown above is ground for general service in a lathe, shaper or planer. It requires a straight tool holder and cannot be used in the 15° Armstrong bit holder. The Armstrong holder is not advisable for machining Armor Plate as it introduces a 15° rake angle without the grinding of any rake into the bit. In finishing intricate parts it is often necessary to use tool points of more complex form than that shown. For instance, the diamond pointed bit is used to finish 90° and re-entrant angles. The same principles in grinding apply. If possible grind the diamond point with a 90° tip angle rather than the usual 60°, and keep rake and clearance angles small.

It was found that proper grinding had more to do with tool life than the composition of the tool steel. In other words, either 18-4-1 Tungsten, standard Molybdenum or Cobalt steels gave good service if properly ground. The 6% Cobalt compositions have about 80°C higher red hardness temperature but are capable of being hardened to only 62-63 Rockwell C while both 18-4-1 and 8% Mo compositions are capable of being hardened to 66 Rockwell C or better. Cobalt compositions are in general more brittle than the other two. It may be found that in going to Armor Plate hardness of more than 500 Brinell, tool hardness is the critical factor. No controlled studies were ever made on the relative merits of the different compositions. The varying hardness and abrasiveness of the sand castings cut here makes shop opinion of little value. Hercules Major drills, a Cobalt composition, put out by Whitman-Barnes, were found to be excellent. Circle C tool bits, a Firth-Sterling Cobalt composition were very good. Several makes of 18-4-1 in common use in the shops here were found to be satisfactory, as also were several makes of Molybdenum tool steel.

In setting up a program to determine machinability of Armor Plate compositions, I would suggest that you first standardize on some composition and make of tool steel and a set of tool angles which give optimum results on a standard composition of rolled Armor Plate heat treated to say 520

Brinell hardness. Crucible Steel's Rex AA (18-4-1 Tungsten), Firth-Sterling's Circle C (Cobalt) and Cleveland Twist Drill's MoMax (Molybdenum) are suggested as good standard brands to use in the program. You might include the Hercules Major drills and a slow spiral manganese rail drill which I believe is made by the Cleveland Twist Drill Company. All bits should be purchased hardened and Rockwell hardness checked upon receipt. A hardness of 64 Rockwell for Molybdenum and 18-4-1, and 62 for Cobalt is satisfactory. Better check these figures, however, for developments released during the past eighteen months may have placed better grades of material on the market. Do not waste much time on anything but standard brands and compostions. A freak composition may look good but there is always the question as to whether it can be consistently reproduced.

Having standardized upon the brand of tool steel and cutting angles to be used, maintain these cutting conditions by having all grinding done by machine in the tool room rather than by hand on the shop floor. Heat treat samples of all Armor Plate compositions to the same hardness. In cutting, <u>depth of cut</u>, <u>feed</u>, <u>surface speed</u> and <u>tool life</u> between grinds are the critical factors. These first three factors determine the cubic inches of stock removed or square inches of surface finished per unit of time <u>while the machine is running</u>. The last factor determines <u>idle time</u> on the machine. You will probably find it desirable to maintain the first three factors constant and let <u>tool life</u> become the critical factor in machinability.

As to coolants, we found liquid soap to be the most satisfactory. It can be prepared by dissolving any cheap soap powder in water. Oils and emulsions show a greater tendency to glaze or work harden. Drilling of very hard materials is often best accomplished dry.

If the preliminary program suggested above is too heavy, you will be safe in selecting any one of the standard brands suggested and proceeding. I believe, though, some further study of cutting angles should be made on a standard composition of Armor Plate at about 520 Brinell before going ahead on the experimental compositions. Merits of hand tapping of cutting edges after grinding should also be investigated.

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Capt., Ord. Dept.

May 4, 1937