UNITED STATES PATENT OFFICE.

JOHN OLIVER ARNOLD, OF SHEFFIELD, ENGLAND.

HIGH-SPEED STEEL.

1,345,732. Specification of Letters Patent. Patented July 6, 1920.

No Drawing. Application filed November 9, 1918. Serial No. 261,739.

To all whom it may concern:

Be it known that I, JOHN OLIVER ARNOLD, a subject of the King of Great Britain and Ireland, residing at 6 Beach Hill road, city of Sheffield, county of York, England, have invented certain new and useful Improvements in High-Speed Steel, of which the following is a specification.

This invention relates to improvements in high speed steel and has for its objects to provide a high speed steel without tungsten and one which will give a higher cutting efficiency than those at present manufactured.

According to this invention I add to the usual constituent elements of high speed steel (minus the tungsten) certain percentages of vanadium and molybdenum.

By the usual constituent elements (minus the tungsten) I mean carbon, maganese, silicon, sulfur, phosphorus, chromium and iron and often a very little aluminium.

The best ranges for the constituents of my improved steel I have found to be as follows:—

Carbon, from	0.5	to	0.8 %
Maganese, from	0.1	to	0.3 %
Silicon, from	0.2	to	0.5 %
Sulfur, from	0.05	to	0.15%
Phosphorus, from	0.01	to	0.03%
Chromium, from	2.75	to	3.75%
Vanadium, from	0.5	to	2.0 %
Molybdenum, from	5.0	to	10.0 %

Iron, the approximate difference between the sum of the above and 100.

As an example of my preferred proportions of alloying and other elements, I give the following:—

Carbon	0.65%
Maganese	0.20%
Silicon	0.35%
Sulfur	0.10%
Phosphorus	0.02%
Chromium	3.25%
Vanadium	1.25%
Molybdenum	7.50%
Aluminium	a trace
Iron (nearly)	86.68%
	100.00

Where aluminium is used it should not exceed appreciably 0.01%. The addition of this element would decrease the percentage of iron by an equivalent amount.

The hardening temperature of the new steel should be between the range of 1250 to 1350 degrees centigrade, my preferred temperature from which to harden being about 1300 degrees centigrade, this temperature being preferably obtained by means of pyrometrically controlled bath of pure barium chlorid, in which the reading error should not exceed plus or minus 10 degrees centigrade. From the range of temperature specified, the noses of the yellowish-white-hot tools may be quenched out in hot water, in whale oil, or in a powerful blast of compressed air, but my preferred heat-treatment for hardening is to combine the hardening mediums, water and air by well blackening at an angle the cutting edge of the tool, to a moderate depth, in hot water at a temperature of about 60 degrees centigrade, and then quickly finishing off the hardening operation in a blast of compressed air.

I have found that the hardening power of molybdenum is theoretically in high-speed steels about 2.3 times as great as that of tungsten; therefore, 7.5% the specified preferred percentage of molybdenum is theoretically equivalent in hardening power to 17.25% of tungsten which at present is the almost universally used basic element for producing high-speed steel. I have, however found that the practical cutting value of molybdenum exceeds this theoretical ratio of 2.3 and is actually about 2.75 provided that when the tungsten is replaced by molybdenum about 1.25% of vanadium is also present, in such case 7.5% of molybdenum is equivalent to say 20.6% of tungsten. This observation illustrates the fact that hardening power and cutting efficiency are not necessarily identical.

Vanadium when present in the specified quantities nullifies the erratic influence well known to be associated with molybdenum when it is used in very considerable percentages in high-speed steels, and the vanadium also renders the operation of water quenching feasible without any undue danger of causing the tool to crack during such hardening operation.

I have found that the steel constituted as described and properly heat-treated is at

least 10% more efficient in the lathe than any high-speed steel at present on the market and an increased demand for molybdenum metal (or pure ferro-molybdenum) will lower its price and so in addition considerably cheapen the cost of producing best high-speed steel.

I claim:—

1. A high-speed steel containing as a hardening agent vanadium and molybdenum approximately in the proportion of 1.25 per cent. and 7.50 per cent. respectively.

2. A high-speed steel containing vanadium and molybdenum in the approximate proportions of 1.25 per cent. and 7.50 per cent. respectively, and also containing aluminum and iron in the approximate proportions of 0.01 per cent. and 86.67 per cent. respectively.

3. A high speed steel containing carbon, maganese, chronium, vanadium, molybdenum and iron in the approximate proportions of 0.65 per cent., 0. 20 per cent., 3.25 per cent., 1.25 per cent., 7.50 per cent. and 86.68 per cent. respectively.

In witness whereof I have hereunto set my hand in presence of two witnesses.

JOHN OLIVER ARNOLD.

Witnesses:
ENSOR D. DRURY,
JOHN M. SAVAGE.