UNITED STATES PATENT OFFICE.

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HIGH-SPEED STEEL.

1,370,020. Specification of Letters Patent. Patented Mar. 1, 1921.

No Drawing. Application filed December 12, 1919. Serial No. 344,330.

To all whom it may concern:

Be it known that I, CHARLES M. JOHNSON, residing at Avalon, in the county of Allegheny and State of Pennsylvania, a citizen of the United States, have invented or discovered certain new and useful Improvements in High-Speed Steel, of which improvements the following is a specification.

My invention relates to high-speed steels, and proceeds from the discovery that, consequent upon the presence of the two elements molybdenum and vanadium within certain ranges of percentage, a steel of high cutting efficiency may be produced without resort to some of the more expensive alloying metals such as cobalt and uranium, a steel which in performance excels all high-speed steels known to me—even those which depend for excellence upon the presence of other expensive ingredients.

I refer particularly in what has just been said to cobalt and uranium. In general estimation at present, high-speed steel compounded with cobalt in quantities up to 5% is considered the best. And this cobalt steel is relatively speaking very costly, because cobalt is an expensive ingredient, and because of its cost this cobalt steel is less widely used than otherwise it would be. As I have just intimated, the steel of my invention, lacking cobalt, still excels cobalt steel.

Study of the results of many tests of these high-speed steels led me to observe that those containing molybdenum were, some of them, very excellent, while others were not; and that those which were very excellent invariably contained vanadium while those which were inferior did not contain vanadium, and, finally, that steels containing vanadium but no molybdenum, when classed together, were not so remarkable. These observations led to a study of the molybdenum-vanadium combination, with the resulting discovery that if vanadium be present in percentages of 1.10 and greater (preferably 1.15–1.50) accompanied by molybdenum, preferably in quantities less than 1%, the composition conforming otherwise to recognized standards for high-speed steel, the product under test reveals outstanding merit.

High-speed steels ordinarily contain most of the following character-giving ingredients:—Carbon, manganese, silicon, chromium, vanadium, tungsten, and occasionally molybdenum; sometimes cobalt in amounts ranging up to 5%, and sometimes relatively small amounts of uranium. In the following tabulation I give the ingredients of the steel of my invention; the first column of percentages is the range permissible in the practice of my invention, the second the range of preferable practice, and in the third the specific composition of a typical specimen of my improved steel—

Carbon	.20–.75%	.60–.70%	.67%
Silicon	.35–.80	.35–.55	.63
Manganese	.35–.55	.35–.55	.44
Tungsten	12–18	15–17	15.3
Chromium	3–5	3.75–5	4.77
Vanadium	1.10–1.50	1.20–1.40	1.20
Molybdenum	.25–1	.60–.80	.60

Molybdenum, if present in percentages greater than those recommended, has, I find, the tendency to cause the steel to chip at the cutting edges; if the percentage is very much greater than recommended, then the molybdenum tends to volatilize and to leave the steel with softened surface. Under existing conditions this tendency to volatilization of molybdenum appears as the molybdenum content approaches and exceeds one per cent., and it becomes more pronounced as the molybdenum content increases in value beyond that point. Under existing conditions my invention will not be realized if the molybdenum content greatly exceeds one per cent. and will certainly not be realized if it rises as high as two per cent.

On the other hand by keeping within the limits defined, the results will excel other steels of the same components as heretofore compounded in a ratio of 9:6 or 9:8. Steel has not heretofore been compounded of the elements and in the proportions which I have given in the foregoing analysis.

A specific test will illustrate what has been said. A specimen of steel of my invention distanced all competitors and gave under test a total travel of $58\frac{1}{4}''$; its nearest competitor, a cobalt steel, gave $53\frac{7}{8}''$, while the "field," all high-grade high-speed steels, followed, with these records: $47\frac{5}{8}$, $43\frac{1}{4}$, $43\frac{1}{2}$, $41\frac{7}{8}$, $38\frac{1}{2}$, $39\frac{5}{8}$, 39, $36\frac{5}{8}$, $37\frac{1}{4}$, $33\frac{5}{8}$, $32\frac{1}{8}$, 32, 17, $19\frac{5}{8}$.

In a companion application for Letters Patent, Serial No. 344,329 I have described and claimed a method of producing high-speed steel, beginning with high-speed scale, and proceeding in uninterrupted operation to the finished product. I do not mean to

limit my invention to any particular method of production, but in order to give full advice, how my improved steel may be produced, I give the following description.

A furnace charge of the following composition is introduced into and smelted within an electrical furnace:

High-speed scale	300	pounds
Ferro-chromium	20	pounds
Ferro-silicon	27	pounds
Charcoal	46	pounds
Powdered molybdenum, of 78% purity	2½	pounds
Powdered tungsten, of 82% purity	4½	pounds

The powdered molybdenum and powdered tungsten just mentioned are in metallic form, uncombined and unalloyed. The powder is adulterated chiefly with iron, also in metallic form, and there are minor impurities such as carbon and silica present, in quantities less than one per cent.

When the reactions have occurred the metal is tested and, according to test, carbon is added in the form of coke introduced through the slag and stirred into the bath, until the carbon content reaches about .50%. Finally, just before tapping, the following ingredients are added—

Ferro-silicon, (50% silicon)	3	pounds
Ferro-manganese, (70 to 80% manganese)	2	pounds
Ferro-vanadium (39% vanadium)	5½	pounds

The carbon test employed is preferably the fracture test.

The furnace of the run of the foregoing specific figures was heated by a current of a pressure of 40–45 volts; the operation continued through 6 to 7 hours; the current consumption for the complete run amounted to about 400 kilowatt-hours; the resultant ingot weighed 225 pounds, besides the test pieces, which aggregated 15 pounds more. The analysis of the product is that given in the third column of the first tabulation above.

It will of course be understood that the additions of molybdeum and of tungsten, made to the initial charge, and the final additions of ferro-silicon, ferro-manganese, and ferro-vanadium, may be varied, to meet the end in view, conditioned only in this particular: that the proportions of vanadium and of molybdenum shall be such as to afford the ultimate percentages given. In these and in other respects the operation described is illustrative, but not exclusive of modifications. Manifestly, my invention is applicable to a wide range of alloy steels—a wide range, that is to say, in the number and proportion of non-ferrous components, exclusive of vanadium and molybdenum.

I claim as my invention:

1. A high-speed steel of the following composition, so far as concerns the elements named: carbon, .20%–.75%; silicon, .35–.80%; manganese, .35–.55%; tungsten, 12–18%; chromium, 3–5%; vanadium, 1.10–1.50%; molybdenum, .25–1%.

2. A high speed steel including in its composition vanadium and molybdenum each in some one of the percentages that will form high speed steel, the vanadium content exceeding 1.1% and the molybdenum content ranging from a minimum where its presence is revealed in increased toughness of product to a maximum where volatilization under the hardening operation begins, substantially as described.

In testimony whereof I have hereunto set my hand.

CHARLES M. JOHNSON.

Witnesses:
BAYARD H. CHRISTY,
FRANCIS J. TOMASSON.