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JOHN A. NELSON, OF ROCKFORD, ILLINOIS, ASSIGNOR TO BARBER-COLMAN COMPANY, OF ROCKFORD, ILLINOIS, A CORPORATION OF ILLINOIS

ALLOY STEEL

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This invention relates generally to alloy steels. The primary object of the invention is to produce a steel suitable for cutting tools, especially those having fine teeth such as thread mills, taps, and the like.

In making tools of this character, the tools are first cut or formed before the hardening or heat-treating process. The steel heretofore employed requires a high temperature and the combined effect of the character of the steel and of the heat treatment has been such as to cause a deformation of the tool from the form and dimensions in which it was initially prepared. In the heat treatment the tool may warp or twist and is usually so distorted that it requires a truing process to make it an accurately formed tool suitable for machine work. This is usually done by a grinding process. To prepare the tool for the heat treatment there is provided for the subsequent grinding operation a sufficient excess of material, or an allowance in dimensions is made in the initial formation of the tool for the customary deformation.

The object of the present invention is to provide a composition of steel which is less subject to distortion on heat treatment and which has a lowered upper temperature limit for the heat treatment wherein the distortion is likely to take place. By the use of alloy steels embodying the invention, the tool may be accurately formed prior to the heat treatment so that no truing or finishing operation is required. Of course it is to be understood that this condition represents the ideal attainment of the object of the invention and may be limited to a definite composition and to a correspondingly proper heat treatment. But it is to be further understood that there may be variations in the composition within certain ranges, and variations in the heat treatment which will yield the same character of results and in which some slight distortion of the tool is permitted, or in which a slight amount of refinishing may be necessary depending upon the degree of accuracy required for the tool. It is, therefore, to be understood that the invention is not limited to the ideal condition but contemplates those alloys which exhibit an improvement over alloys of the prior art in the direction of the ideal condition.

The invention comprises a fundamental or base alloy steel having the following range of composition for the chief ingredients other than iron:

Carbon	1.00%	to	1.75%
Chromium	4.00		10.00
Tungsten	6.00		10.00

However, in order to improve the above base alloy for use in making cutting tools, a quantity of vanadium is added to improve the cutting qualities, but without affecting the desirable qualities of the base alloy. Therefore, for cutting tools the alloy is preferably of the following composition:

Carbon	1.00%	to	1.75%
Chromium	4.00		10.00
Tungsten	6.00		10.00
Vanadium	0.50		2.00

Alloys according to the above range are very suitable for thread mills, taps and other tools which are not operated at high speeds. High speed tools, of course, are subject to greater wear in use per unit work time, and require, therefore, a composition giving long life. While the base alloy above described might be used for high speed tools, it is preferable that it be used for the slower type of tools. However, when a second metal of the iron group is added, the steel becomes better suited for high speed work. Cobalt is the second metal which is preferably added since this increases the life of the cutting edge and does not appear in any way to alter the hardening temperature or the non-shrinkable qualities of the alloy. The following shows the range of composition when cobalt is employed:

Carbon	1.00%	to	1.75%
Chromium	4.00		10.00
Tungsten	6.00		10.00
Vanadium	0.50		2.00
Cobalt	3.00		15.00

Within the above range of cobalt, 7% to 8% is the preferable upper limit so far as economic cost is considered, for an increased

percentage over that amount does not improve the quality in proportion to the cost.

In addition to cobalt, as a metal of the iron group, nickel may be added as this may increase the toughness of the tool. It also lowers the hardening temperature. The nickel preferably may vary from 0.75% to 2.00%.

Carbon as an element of the alloy is also related to the heat-treating process. In general carbon lowers the hardening temperature, but below 1% carbon a raising of the hardening temperature commences. For example, a 1% carbon alloy can be satisfactorily treated at 1875° F. to 1900° F., quenched in oil, and drawn to 1000° F. A 0.9% carbon alloy must be hardened at 2000° F. to give satisfactory results and a considerable increase in distortion takes place over that which occurs in the 1% carbon alloy. For an alloy of this invention it is preferred to use a carbon content varying from 1.05% to 1.15%, because as the carbon content increases the brittleness also increases. It is to be understood, however, that this preference does not exclude higher percentages of carbon.

Chromium is believed to increase the solubility of the carbides upon hardening, and in conjunction with the carbon lowers the hardening temperature and also increases the hardness. It has been found that there is little change in the cutting properties by varying the chromium content from 5% to 8%. However, when chromium rises above 10% the movement of metal upon hardening is greatly increased and there is in addition a loss of hardness on tempering. It is believed that 10% is a proper upper limit for chromium. When quenched from 1875° F. to 1900° F. and then drawn to 1000° F., the proper hardness is not obtained when there is less than 4% chromium. 4% then is preferred as a lower limit for the chromium range in this invention.

In general tungsten increases the hardness and raises the temperature at which tempering can be effected after hardening, without destroying the hardness. Tungsten produces little change when varied from 6 to 9%. Above 10% it is found that the distortion is so great as to render the alloy useless for the desired advantages. Therefore, 10% is believed to be a proper upper limit for tungsten.

Vanadium does not materially change the desired physical properties of the alloy, but it has been found to increase the cutting efficiency of tools employing it when alloyed with the other components. This is, of course, of great importance when the alloy is used for tools.

In steels as commercially prepared, there is of course, a tolerance of industrial impurities, such as silicon, manganese, phosphorus, and sulphur, the presence of which affect the properties of the alloy either beneficially or detrimentally depending upon the particular property to be considered and the amount of the particular impurity present. Of course in the commercial production of these alloys these industrial impurities are understood as entering into the composition. A suitable composition of alloys which serves to illustrate one preferred successful composition in which the various commercial impurities are considered on a percentage basis is outlined as follows:

Carbon	1.05% to	1.15%
Chromium	7.50	8.50
Tungsten	8.00	9.00
Vanadium	1.00	1.50
Cobalt	7.00	9.00
Silicon	0.20	0.30
Manganese	0.20	0.30
Phosphorus	below	0.030
Sulphur	below	0.030

In all of the above tables it is understood that the remainder of the percentage is iron. The last mentioned alloy has been found to be very valuable for thread mills. A tool made of alloy of this composition is preferably heat-treated as above indicated that is, heated throughout at 1875° F. to 1900° F., quenched, and drawn to 1000° F. But it may also be cooled in air from a heat treatment between 1700° F. and 2050° F. and still be file-hard. Other conditions of heat treatment may also be found satisfactory for alloys within the range of composition hereinafter claimed.

The invention consists primarily of the said alloy of iron, carbon, chromium and tungsten which is adapted to resist distortion and to be non-shrinkable during heat treatment like other steels. It is susceptible to improvements in its cutting properties by the addition of vanadium in the amount stated, without affecting its desirable distortion-resisting properties and furthermore, it is subject to additional improvements in high speed cutting properties by the addition of cobalt, and this likewise, without influencing its specially desirable properties, when the cobalt is limited as stated.

In the appended claims, the invention is defined so as to include not only the base alloy per se, but such combinations of the base alloy with other metals as preserve the desired qualities of the iron-carbon-tungsten-chromium-alloy, such combinations having, in addition, various improved characteristics in other directions.

I claim as my invention:

1. A steel alloy containing carbon 1–1.75%, chromium 4–10%, tungsten 6–10%, vanadium 0.5–2%, as the chief ingredients, and the principal part of the remainder being iron.

2. A steel alloy containing carbon 1–1.75%, chromium 4–10%, tungsten 6–10%, vanadium 0.5–2%, and cobalt 3–15%, as the chief ingre-

dients, and the principal part of the remainder iron.

3. A steel alloy containing carbon 1.05–1.15%, chromium 7.5–8.5%, tungsten 8–9%, as the chief ingredients, and the principal part of the remainder iron.

4. A steel alloy containing carbon 1.05–1.15%, chromium 7.5–8.5%, tungsten 8–9%, vanadium 1–1.5%, cobalt 7–9%, as the chief ingredients, and the principal part of the remainder iron.

5. A steel alloy containing carbon 1.05–1.15%, chromium 7.5–8.5%, tungsten 8–9%, as the chief ingredients, and containing silicon 0.2–0.3%, manganese 0.2–0.3% phosphorus below 0.03%, sulphur below 0.03%, and the remainder iron.

6. A steel alloy containing carbon 1.05–1.15%, chromium 5–8%, tungsten 6–9%, vanadium 0.5–2%, cobalt 7–8%, and the principal part of the remainder iron.

7. A substantially undistorted heat-treated metal-cutting tool made of an alloy according to claim 3, said tool being formed accurately prior to heat treatment.

8. A substantially undistorted heat-treated metal-cutting tool made of an alloy according to claim 6, said tool being formed accurately prior to hardening.

In testimony whereof, I have hereunto affixed my signature.

JOHN A. NELSON.