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ALLOY STEEL FOR METAL-CUTTING TOOLS.

No Drawing. Continuation of application Serial No. 420,432, filed October 29, 1920. This application
filed January 5, 1922. Serial No. 527,223.

To all whom it may concern:

Be it known that we, EDWIN CORNING,
a citizen of the United States, and a resi-
dent of Kenwood, county of Albany, and
State of New York, and PERCY A. E. ARM-
STRONG, a subject of the King of Great
Britain, and a resident of Loudonville,
county of Albany, and State of New York,
have invented a new and useful Improve-
ment in Alloy Steel for Metal-Cutting
Tools, of which the following is a speci-
fication.

This invention relates to alloy steel for
metal cutting tools, having properties gen-
erally intermediate between carbon steel
and high-speed steel.

The present application is a continuation
of our co-pending application Serial No.
420,432, alloy steel for metal cutting tools,
filed Oct. 29, 1920.

For small metal cutting tools, such as
drills, taps, reamers and the like, carbon
steel answers sufficiently well, takes a keen
cutting edge and produces smooth finished
work, but is limited in its application, be-
cause under heat it softens and dulls rap-
idly.

High speed steel, which is commonly used
for somewhat larger drills and similar tools
which have to withstand greater heat, is
not, of course, rapidly softened by frictional
heat, but, in addition to its high price, has
the objection that the work produced is not
so smooth and well finished as can be ob-
tained by sharp edge carbon steel tools, for
example, and a subsequent separate finish-
ing operation is usually required. For ex-
ample, drilled holes require finish reaming
to produce satisfactory work. Further-
more, in the case of taps, for example, the
teeth of the tap are often injured by the
high temperatures required for heat treat-
ment of high speed steel.

The present invention relates to the pro-
vision of an alloy steel having the desir-
able properties of both carbon steel and
high speed steel, that is, which will re-
tain a hard, keen cutting edge and which
is very strong, and at the same time will
not soften when drawn to medium tem-

peratures, such as 500-700° F. The steel of
the present invention contains chromium,
vanadium and molybdenum, and also con-
tains silicon considerably in excess of the
usual silicon content of steel, silicon being
present in our improved alloy steel prefer-
ably to the extent of from about .5% to
2.5%. When made into tools for cutting
metal, such as drills, taps, reamers and the
like, it can be used for the production of
smooth, finished work without the necessity
for separate finishing operations, and does
not require heat treatment at such high tem-
peratures as in the case of high speed steel,
so that there is practically no tendency for
any burning off of the tips of the teeth of
taps and similar tools during heat treat-
ment. This steel has other features of ad-
vantage as will appear from the following
description.

An important feature of the invention
relates to the employment of silicon as one
of the components of the alloy. The silicon
appears to serve as a sort of solvent for
other components, and causes them to form
a chemical combination with one another
and produces an alloy steel having im-
proved properties. A second function of
the silicon is to raise the transformation
point of the resulting alloy, thus imparting
to the alloy steel the very valuable prop-
erty of hardening at relatively high tem-
peratures. A third function of the silicon
is to enhance the air hardening properties
of the alloy. Silicon enables the chromium
and molybdenum in combination with the
carbon and iron to take on a tremendously
enhanced air hardening property. It also
prevents the breaking down of this hard
state when being drawn at temperatures
which would cause a straight chromium,
carbon or chromium-molybdenum-carbon
steel to soften.

According to another feature, an alloy
steel is provided having as one of its com-
ponents a predetermined proportion of va-
nadium. This alloy steel has an increased
red hard property. The use of vanadium
also creates a lag to transformation, that
is to say, when the steel is reheated for a

very short period after being quenched for hardening, it is given the quality of having a lag to the breaking down of the solid solution produced in quenching. Consequently, cutting tools made of the alloy so made can withstand overheating of their cutting edges for limited times without destruction of their cutting ability.

According to another feature, an alloy steel is provided having as one of its components a predetermined proportion of cobalt. This alloy steel has qualities of the same general character as the vanadium alloy steel just described, to a different degree.

According to still another feature, an alloy steel is provided having neither vanadium or cobalt, but in which there is employed carbon, molybdenum, chromium, silicon and other components. The carbon gives desirable mineral hardness to the alloy, which may be enhanced by other components. The molybdenum in combination with the carbon and iron adds to the hardness and improves other desirable physical qualities. Chromium in combination with the molybdenum and carbon adds materially to the air hardening effect of such combination.

One example of a composition for an alloy steel in accordance with the present invention is as follows:

	Per cent.
Carbon	.50
Chromium	1.50
Molybdenum	1
Manganese	.40
Silicon	1.50
Vanadium	.75
Cobalt approximately	1

Balance iron with small amounts of phosphorus and sulfur.

In order to harden this alloy it is heated as quickly as possible to substantially 1900° F., without quenching in oil or water. Variations in manganese in this alloy will require inverse variations in the temperature to which the alloy is heated; for example, if the manganese is increased to 1% the temperature should be changed to substantially 1500° F., while if the manganese is increased to 1.5% the temperature should be reduced to substantially 1450° F.

Another example of an alloy made in accordance with the present invention is of about the following composition:

	Per cent.
Carbon	1
Chromium	2
Molybdenum	2
Manganese	.40
Silicon	1
Vanadium	1
Cobalt	1

Balance iron with small amounts of phosphorus and sulfur.

In order to harden this alloy it should be heated as quickly as possible to substantially 1800° F., and quenched in oil or water. Variations in manganese require variations in the heat treatment temperature as in the preceding example.

A third example of an alloy made in accordance with the present invention is of about the following composition:

	Per cent.	
Carbon	1.50	75
Chromium	2	
Molybdenum	2	
Manganese	.40	
Silicon	2	80
Vanadium	.50	
Cobalt	2	

Balance iron with small amounts of phosphorus and sulfur.

The heat treatment of this alloy consists of heating to substantially 1800° F., as quickly as possible and quenching in oil or water. Selection of the heat treatment temperature is made in accordance with variations in percentage of manganese as in the preceding examples.

Another example of alloy made in accordance with the present invention is of about the following composition:

	Per cent.	
Carbon	.50	95
Chromium	10	
Molybdenum	5.75	
Manganese	.40	
Silicon	2.5	100
Vanadium	2	
Cobalt	2	

Balance iron with small amounts of phosphorus and sulfur.

In the heat treatment of this alloy heat should be applied until the alloy has a temperature of substantially 2100° F. The alloy should then be cooled in the air. This alloy may be cast for use in forming cutting tools.

More or less variation is possible without any substantial detriment to the desirable qualities of the material and good results are obtained with varying quantities of the several components within substantially the following range:

	Per cent.	
Carbon	.25- 2	
Molybdenum	.50- 5.75	120
Silicon	.50- 2.5	
Chromium	.50-10	
Vanadium	0- 2	
Manganese	0- 1.5	
Cobalt	0- 2	125

Balance iron with small amounts of phosphorus and sulfur.

This represents about the outside limits, but good results may be obtained with smaller proportions of some of the alloy components.

ponents, with composition about as follows: carbon .25-2%, molybdenum .50-2%, silicon .50-2%, chromium .50-2%, vanadium up to 1%, manganese up to 1%, cobalt up to 1%, and the balance principally iron.

We have found that good results are obtained with heat treatment of alloys made in accordance with the present invention, which consists of heating the alloy to a temperature of approximately 1800° F., in as short a time as possible, after which the alloy may be air hardened or quenched in oil or water. It is preferably not held at this temperature more than a half-minute or so longer than necessary to heat the piece throughout.

Another alloy steel may comprise, for example, components within substantially the following range:

	Per cent.
Carbon	.25- 2
Molybdenum	.50- 5.75
Silicon	.50- 2.5
Chromium	.50-10
Vanadium	.25- 2
Manganese	0- 1.5

Balance iron with small amounts of phosphorus and sulfur.

Heat treatment substantially as given for previously described alloy steels.

The cobalt steel may comprise, for example, components within substantially the following range:

	Per cent.
Carbon	.25- 2
Molybdenum	.50- 5.75
Silicon	.50- 2.5
Chromium	.50-10
Manganese	0- 1.5
Cobalt	.25- 2

Balance iron with small amounts of phosphorus and sulfur.

Another modification comprises components within substantially the following range:

	Per cent.
Carbon	.25- 2
Molybdenum	.50- 5.75
Silicon	.50- 2.5
Chromium	.50-10
Manganese	0- 1.5

Balance iron with small amounts of phosphorus and sulfur.

The steel works well in the mill, is substantially free from seams, and can be cast into very smooth ingots. In rolling the temperature should not be carried unduly high and should preferably be kept under 2100° F. After rolling the steel should preferably be cooled slowly as, for example, in lime, thereby removing strains which may result from rapid cooling. This becomes more important as the alloying constituents are increased. The steel will anneal and

becomes quite easy to machine when properly annealed. There is very little tendency for this alloy combination to move, that is to say, to exhibit tendency to warping, or other malformation upon heating up and quenching, which is a feature of great advantage in heat treatment of tools. The characteristic grinding spark given off in grinding articles made of our improved alloy steel, which does not contain tungsten, is markedly different from the tungsten colored spark. This is a feature of marked advantage both in manufacture and use, as this alloy steel can be readily distinguished from high speed steels by observation of the spark produced upon grinding. The foregoing applies whether the alloy steel is in the annealed or hardened state.

We claim:

1. As a new composition of matter, an alloy steel of analysis having substantially the following range: carbon .25-2%, chromium .50-10%, molybdenum .50-5.75%, silicon .50-2.5%, vanadium 0-2%, manganese 0-1.5%, cobalt 0-2%, and the principal part of the remainder iron.

2. Metal cutting tools made from alloy steel as claimed in claim 1.

3. Drills for drilling metal made from alloy steel as claimed in claim 1.

4. As a new composition of matter, an alloy steel of analysis having substantially the following range: carbon .25-2%, molybdenum .50-5.75%, silicon .50-2.5%, chromium .50-10%, vanadium .25-2%, manganese 0-1.5%, and the principal part of the remainder iron.

5. Metal cutting tools made from alloy steel as claimed in claim 4.

6. Drills for drilling metal made from alloy steel as claimed in claim 4.

7. As a new composition of matter, an alloy steel of analysis having substantially the following range: carbon .25-2%, molybdenum .50-5.75%, silicon .50-2.5%, chromium .50-10%, manganese 0-1.5%, cobalt .25-2%, and the principal part of the remainder iron.

8. Metal cutting tools made from alloy steel as claimed in claim 7.

9. Drills for drilling metal made from alloy steel as claimed in claim 7.

10. As a new composition of matter, an alloy steel of analysis having substantially the following range: carbon .25-2%, molybdenum .50-5.75%, silicon .50-2.5%, chromium .50-10%, manganese 0-1.5%, and the principal part of the remainder iron.

11. Metal cutting tools made from alloy steel as claimed in claim 10.

12. Drills for drilling metal made from alloy steel as claimed in claim 10.

13. An air hardening alloy steel adapted to withstand temperatures of about 500-700° F., without material softening, of analysis

within substantially the following range:
carbon .25-2%, chromium .50-2%, molybde-
num .50-2%, silicon .50-2%, vanadium up
to 1%, manganese up to 1%, cobalt up to
1%, and the balance principally iron.

14. Metal cutting tools made from alloy
steel as claimed in claim 13.

15. Drills for drilling metal made from
alloy steel as claimed in claim 13.

In witness whereof, we have signed our
names hereto.

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