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ALLOY STEEL

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My invention relates to alloy steels which can be surface hardened by nitriding. More particularly, it relates to alloy steels of this type which are characterized by their free machining properties.

Alloy steels containing small quantities of aluminum with certain proportions of an element or combination of elements selected from the group chromium, molybdenum, vanadium or titanium may be provided with an extremely hard case by subjecting the material to nitrogenization. But alloy steels which can be so hardened and which are generally known in the trade as nitralloy are not freely machinable. This inherent disadvantage has made the use of these alloys for parts which must be machined unreasonably expensive, and has therefore militated against their use for many purposes where otherwise they would be extremely desirable.

Articles made of nitridable steels and provided with a nitride hardened case possess surfaces having a comparatively high degree of resistance to the corrosive influences of the atmosphere and other agents.

In the production of an easy or free machining alloy steel which can be hardened by the nitriding process it is extremely desirable if not essential that the material should be susceptible to hardening to the same degree as a steel without the elements which endow it with easy machining characteristics and that its surface resistance to corrosion should not be impaired.

Therefore the objects of my invention are to provide an alloy steel which is easily machinable, which may be surface hardened by the nitriding process to the same degree as similar alloy steels which are not freely machinable, and which will possess the same high degree of resistance to atmospheric and other corrosive influences as other nitrided alloys.

With these objects in view my invention consists of an alloy steel containing as essential alloying ingredients:

	Percent
C	under 1
Cr	0.5 to 4.00
Al	0.5 to 2.00
S	0.10 to 0.25

and preferably from 0.10% to 0.50% of molybdenum.

While the advantages of my invention will be attained to some extent throughout the entire range of elements stated above, my preferred range of elements is as follows:

	Percent
C	0.20–0.60
Cr	1.00–1.75
Mo	0.15–0.25
Al	0.60–1.50
S	0.10–0.25

A carbon content in excess of about 0.60% impairs the easy machining characteristics of the alloy. When the aluminum content is reduced to 0.60% or less the hardening properties of the material when subjected to nitriding fall off rather badly, and when the aluminum exceeds about 1.50% shop difficulties are encountered with no appreciable improvement in the hardening or other characteristics of the alloy. Likewise, increasing the chromium content above about 1.75% or 2.00% increases the machining difficulties without any corresponding improvement in the hardening or other characteristics of the alloy. With the sulphur content below 0.10% the easy machining characteristics of the material are not attained, and with the sulphur content in excess of about 0.25% the physical characteristics of the steel are impaired particularly its resistance to torsion stresses. Furthermore sulphur higher than 0.25% reduces the resistance of the alloy, in the nitrided state to atmospheric corrosion.

Manganese is not an essential ingredient but may be and preferably is present in the amounts usually encountered in the steel making practice.

Silicon is not essential and is preferably kept low, that is under 1% although steels containing as high as 2% silicon have been successfully hardened by nitriding. When the silicon is high it seems to combine or react with the aluminum, probably to form aluminum-silicate, and to render the final analysis of the material somewhat uncertain.

I prefer to use molybdenum as an alloying element in my material because it affords a

convenient means of introducing the sulphur into the alloy in the form of molybdenum-sulphide. In addition to the foregoing elements there may also be present in my material in small quantities, either singly or in combination, such elements as vanadium, titanium or zirconium but these should not exceed a total of about 1.50% to 2%. Up to 2% of nickel may also be added for improving the physical characteristics of the alloy.

From the foregoing it will be apparent that the total, alloy content of my steel, including the metalloids and impurities may be about 15%. Hence, the term, "the balance being principally iron", as used in the claims is to be taken as meaning that the iron content is not less than about 85%.

What I claim is:

1. An alloy steel susceptible to hardening by nitrogenization and characterized by its easy machining properties containing carbon in effective amounts up to 1%, chromium from 0.5% to 4%, aluminum from 0.5% to 2%, molybdenum from 0.10% to 0.50%, and sulphur from 0.10% to 0.25%; the balance being principally iron.

2. An alloy steel susceptible to hardening by nitrogenization and characterized by its easy machining properties containing carbon from 0.20% to 0.6%, chromium from 1% to 1.75%, molybdenum from 0.15% to 0.25%, aluminum from 0.6% to 1.50%, and sulphur from 0.1% to 0.25%; the balance being principally iron.

3. An alloy steel susceptible to hardening by nitrogenization and characterized by its easy machining properties containing carbon in effective amounts up to 1%, chromium from 0.5% to 4%, aluminum from 0.5% to 2% and sulphur from 0.10% to 0.25%; the balance being principally iron.

4. An alloy steel susceptible to hardening by nitrogenization and characterized by its easy machining properties containing carbon from 0.20% to 0.6%, chromium from 1% to 1.75%, aluminum from 0.6% to 1.50%, and sulphur from 0.1% to 0.25%; the balance being principally iron.

5. An article of manufacture having a finished or machined surface portion which is nitride hardened and formed of an alloy containing carbon in effective amounts up to 1%, chromium from 0.5% to 4%, aluminum from 0.5% to 2%, and sulphur from 0.10% to 0.25%; the balance being principally iron.

6. An article of manufacture having a finished or machined surface portion which is nitride hardened and formed of an alloy containing carbon in effective amounts up to 1%, chromium from 0.5% to 4%, aluminum from 0.5% to 2%, molybdenum from 0.10% to 0.5%, and sulphur from 0.10% to 0.25%; the balance being principally iron.

7. An alloy steel that may be cast, forged, or rolled, having the property of free machinability, and that may be hardened by nitriding, comprising—

	Percent
Carbon in effective amounts up to	1.00
Aluminum	0.5 to 2.00
Manganese in amounts usually encountered in steel making practice.	
Sulphur	0.15 to 0.25
Phosphorus in the amount usually encountered in steel making practice.	
Chromium	0.50 to 3.50
Silicon in effective amounts up to	2.00
Molybdenum in effective amounts up to	0.50
Vanadium in effective amounts up to	0.50
Zirconium in effective amounts up to	0.20

Balance, principally iron.

8. An alloy steel that may be cast, forged, or rolled, having the property of free machinability, and that may be hardened by nitriding, comprising—

	Percent
Carbon in effective amounts up to	1.00
Aluminum	0.5 to 2.00
Manganese in amounts usually encountered in steel making practice.	
Sulphur	0.15 to 0.25
Chromium	0.50 to 3.00
Phosphorus in the amount usually encountered in steel making practice.	
Silicon in effective amounts up to	1.00

Balance, principally iron.

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