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ALLOY STEELS

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This invention relates to new alloy steels having as dominant characteristics the properties of free machinability, and of being hardened, for example, by the "nitriding process".

An object of the invention is to provide a new alloy steel that may be cast, forged, rolled, and otherwise mechanically shaped and worked.

10 A further object of the invention is to provide a new alloy steel that may be freely machined, and thereby brought to a desired configuration, and thereafter hardened, for example, by the "nitriding process".

15 A further object of the invention is to provide a new alloy steel which is relatively low in cost, that has the property of free machinability and that may be hardened, as for example, by the "nitriding process", without distortion.

Other objects of the invention will be apparent to those skilled in the art after reading the specification.

Alloy steels at present in use and that are 25 susceptible of being hardened by the nitriding process, possess only ordinary machining qualities and are not suitable for fast production work. The new alloys described herein possess the advantage over the known nitridable steels in that after casting or otherwise 30 roughly shaping, they may be freely machined with a decided saving in cutting time and tool life, which feature has proved to be of considerable advantage in manufacturing 35 processes.

The new alloy may be made in the standard types of furnaces, for example, in the open hearth furnace, or in the electric arc, or induction furnaces, or other types of furnaces.

40 To a suitable charge of open hearth or Bessemer steel or molten selected scrap steel, there is added to the charge of molten metal the desired quantities of alloying elements, either as ferro alloys or as the commercial 45 forms of the desired elements, to bring the analyses up to that of the desired final alloy; the final mixture may be made either in the furnace containing the molten metal, or in a ladle, and after a thorough mixing has been 50 accomplished the molten alloy is cast into

suitable ingots for subsequent further shaping.

A general analyses of the new alloy, which may vary for special uses, is as follows—

	Per cent	
Carbon	up to 1.00	55
Aluminum	0.5 to 2.00	
Manganese	0.25 to 2.00	
Sulphur	0.05 to 0.25	
Phosphorus	0.05 to 0.10	
Silicon	up to 1.00	
Chromium, or elements having property of chromium	0.50 to 3.50	60
Molybdenum	up to 0.50	
Vanadium	up to 0.50 (optional)	
Zirconium	up to 0.20 (optional)	
Balance, iron.		

For a large number of uses, an alloy having the following composition has been found to 65 be eminently satisfactory:—

	Per cent	
Carbon	0.25	
Aluminum	1.00	
Manganese	1.20	
Sulphur	0.20	
Phosphorus	0.05	70
Silicon	0.20	
Chromium	1.50	
Molybdenum	1.50	
Balance, iron.		

To a charge of molten steel of a selected composition, or a charge of melted selected 75 scrap steel, or a mixture thereof, is added preferably as ferro alloys, the desired quantities of aluminum, manganese, chromium, molybdenum, vanadium, zirconium, and sulphur, the latter combined with either the alu- 80 minum or zirconium, or the sulphur may have been present in sufficient quantity in some of the ferro alloys added to the steel. The vanadium may be substituted in part or en- 85 tirely for the aluminum, chromium, or molybdenum. Also the chromium may be substituted in part or entirely by elements having the property of chromium in the present alloy, for example, by molybdenum, 90 vanadium, or zirconium. Zirconium also may be added either as a ferro alloy or as zirconium sulphide, if the sulphur content has not otherwise been added by the alumi- 95 num or some of the other elements. The manganese may be present in the original steel, but may be added as a ferro alloy. The phosphorus and silicon may be present in the quantities usually found in steel alloys of this general type. The carbon is also 100

generally present either in the original charge of steel, or in the ferro alloys which are added. The aluminum and manganese are present in substantially equal quantities, and the sulphur, which is higher than in other steels used for this purpose, from about one tenth to about one fifth of the aluminum. The chromium and molybdenum together are present in about twice the quantity of aluminum.

The function of the aluminum, chromium, molybdenum or vanadium, either singly or collectively, in addition to their known properties in alloy steels of this kind, is to facilitate the hardening with nitrogen during the nitriding process. The manganese also facilitates the hardening by nitriding and also facilitates the combination of sulphur with the remaining elements to produce the physical property of free machinability.

Alloy steels of the above type are relatively cheap, tough, and may be readily shaped and machined into the desired configuration, and may be hardened by the nitriding process, or other processes, by which they acquire a hard and durable surface. The nitriding may be successively practiced by heating from about 800° F. to about 1200° F. in a current of ammonia gas, which may or may not be mixed with a hydrocarbon gas, as desired.

I claim:

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

		Per cent
Carbon	in effective amounts up to	1.00
Aluminum	0.5	to 2.00
Manganese	0.25	to 2.00
Sulphur	0.15	to 0.25
Phosphorus	0.05	to 0.10
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.		

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

		Per cent
Carbon	in effective amounts up to	1.00
Aluminum	0.5	to 2.00
Manganese	0.25	to 2.00
Sulphur	0.15	to 0.25
Chromium	0.50	to 3.00
Phosphorus	0.05	to 0.10
Silicon	in effective amounts up to	1.00
Balance, principally iron.		

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

		Per cent
Carbon	in effective amounts up to	1.00
Aluminum	1.00	to 2.00
Manganese	0.75	to 1.50
Sulphur	0.15	to 0.25
Molybdenum	0.10	to 0.40
Chromium	1.00	to 2.50
Balance, principally iron.		

4. An alloy steel that may be cast, forged, or rolled, having the property of free ma-

chinability, and that may be hardened by nitriding, comprising—

	Per cent
Carbon	about 0.25
Aluminum	about 1.00
Manganese	about 1.20
Sulphur	about 0.20
Phosphorus	about 0.05
Silicon	about 0.20
Chromium	about 1.50
Molybdenum	about 0.20
Balance, principally iron.	

In testimony whereof I hereby affix my signature.

WALTER R. BEEELER.