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AUSTENITIC STEEL SUITABLE FOR EXHAUST VALVES SUBJECT TO GREAT STRESSES

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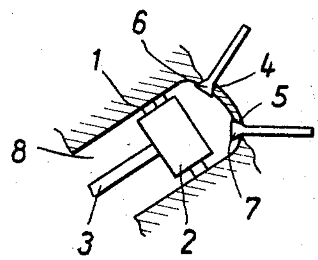

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1

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AUSTENITIC STEEL SUITABLE FOR EXHAUST VALVES SUBJECT TO GREAT STRESSES

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U.S. Cl. 75—125 8 Claims
Int. Cl. C22c *41/02, 39/26, 39/10*

ABSTRACT OF THE DISCLOSURE

Austenitic steel alloy suitable for exhaust valves characterized in that cobalt and copper are included in the alloy. The alloy can be heat treated by annealing at about 1,150–1,250° C. for about 30–3 minutes, and precipitation hardened at about 900–1000° C. for 60–30 minutes.

The austenitic chrome-nickel-solicon steels used hitherto as valve material have insufficient resistance to the attack of lead compounds which are brought into the combustion gases by the antiknock agent. This has lead in recent years to the development of austenitic chrome-manganese-nickel steels which show an increased resistance to damage by lead oxides and better hot strength. To improve the tensile properties and the austenite stability, these steels have been alloyed with higher carbon contents (up to 1.2%) and nitrogen contents (up to 0.7%). By suitable heat treatment followed by hardening, complex carbides ($M_{23}C_6$) are segregated. In the case of low carbon and nitrogen contents, there exists the danger with these steels, after a long period of operating stresses, of embrittling by the segregation of intermetallic phases (sigma phase and chi phase). By increasing the carbon and nitrogen contents the tendency towards the segregation of intermetallic phases is reduced, but an increasing carbon content impairs hot-forming qualities, and an increasing nitrogen content impairs weldability.

The problem to be solved consists in making available for exhaust valves subject to high stress appropriate steels which, on the one hand, meet the working requirements of high lead resistance, hot strength and low tendency to embrittlement, and on the other hand, eliminate the manufacturing difficulties encountered in the former steels.

The invention is based upon the new discovery that it is possible in valve steels to replace in part the elements C and N with cobalt and copper, as far as their effects are concerned. In this manner, the heat-forming qualities and welding qualities are substantially improved and, furthermore, better wear resistance and oxidation resistance are produced. Optimum hardening conditions are achieved when the ratio of cobalt to copper is made about 3 to 1.5 parts cobalt per 1 part copper, preferably, a cobalt to copper ratio of about 3:1. Resistance to the attack of lead oxides is about three times as great as in the previous chromium-nickel-silicon steels. The good welding properties may be utilized in armored valves of valve parts consisting of steels according to this invention where this parts are clad with the usual valve armor materials, for example with stellites. It may be further utilized in composite valve parts, the valve disk of them consisting of a steel according to the invention, whereas the valve stem is made of a steel of less value.

2

Austenitic hardening valve steels contain, according to the invention, approximately:

	Percent
Carbon	0.30 to 0.50
Silicon	0.20 to 0.35
Manganese	7 to 15
Chromium	23 to 26
Nickel	1 to 2
Cobalt	1.5 to 5
Copper	0.5 to 3
Nitrogen	0.25 to 0.35

The balance is iron containing the usual impurities.

In the newly developed material, embrittlement in the engine can hardly occur, and the familiar chipping at the edge of the valve is eliminated.

The steels of the invention and valves made therefrom can be produced by the known procedures for, respectively, producing the said austenitic chrome-manganese-nickel steels and producing valves therefrom. Heat treatment of the steel alloys of the invention can involve a solution annealing at about 1150–1250° C. for, respectively, 30–3 minutes, and the precipitation hardening step can be at about 900–1,000° C., preferably about 950° C. This precipitation hardening temperature is (contrary to the precipitation temperatures applied to the known austenitic valve steels) so high that it is at least 100° C. above the max. working temperature of the valve within the motor. Such a high precipitation hardening temperature is applicable without imparing the desired strength, due to the high chromium and cobalt content. By the high precipitation hardening temperature applied to the steels according to the invention, the advantage is obtained that there is no further precipitation of embrittling inter-metallic phases (sigma phase) during working of the valve within the motor.

Extension tests have proved that, in a steel composed according to the invention, of 0.4% C, 25% Cr, 7.4% Min, 2.6% Co, 1.4% Ni, 0.85% Cu and 0.3% N, and precipitation hardened at 950° C., for 45 minutes, no phenomena of embrittlement occurred after 300 hours of heating at 760° C. (max. working temperature), and an elongation of 21% and a reduction of area of 25% were maintained.

After the customary heat treatment (1,150° C.) of the prior art valve steels made on a chrome-manganese-nickel basis with increase carbon and nitrogen contents, the elongation fell from 11 to 5%, and the reduction of area from 12.6% to 3% after 300 hours of heating at 760° C.

The invention is further described with respect to the accompanying drawing, wherein:

The drawing is a schematic showing, in cross-section, of a portion of an internal combustion engine outfitted with an exhaust valve according to the invention.

The cylinder block **1** is provided with the cyinder bore **8**, in which a piston **2** on piston rod **3**, is positioned. The block includes intake opening **4** and exhaust opening **5**, and these ports are provided with suitable valves. The intake port **4** is provided with an intake valve having body portion **6**, while the exhaust port **5** is provided with an exhaust valve having body portion **7**. The exhaust valve is of an alloy according to the invention.

While the invention has been described with respect to particular embodiments thereof, these embodiments are merely representative and do not serve to define the limits of the invention.

What is claimed is:

1. Austenitic, hardening steel alloy suitable for exhaust valves consisting essentially of about:

	Percent
Carbon	0.30 to 0.50
Silicon	0.20 to 0.35
Manganese	7 to 15
Chromium	23 to 26
Nickel	1 to 2
Cobalt	1.5 to 5
Copper	0.5 to 3
Nitrogen	0.25 to 0.35
Iron	Balance

wherein the ratio of cobalt to copper is maintained at a value of about 1.5 to 3 parts of cobalt per 1 part of copper.

2. Steel according to claim **1**, and containing about:

	Percent
Carbon	0.4
Chromium	25
Manganese	7.4
Cobalt	2.6
Nickel	1.4
Copper	0.85
Nitrogen	0.3

3. Process of heat treating steel alloy which comprises solution annealing an alloy according to claim **1**, at about 1,150–1,250° C. for, respectively, about 30–3 minutes, and precipitation hardening at about 900–1,000° C. for 60–30 minutes.

4. Exhaust valve for an internal combustion engine comprising a body portion of alloy steel according to claim **1**.

5. Exhaust valve for an internal combustion engine comprising a body portion of alloy steel according to claim **2**.

6. Process of heat treating austenitic, hardening steel alloy suitable for exhaust valves consisting essentially of:

	Percent
Carbon	0.30 to 0.50
Silicon	0.20 to 0.35
Manganese	7 to 15
Chromium	23 to 26
Nickel	1 to 2
Cobalt	1.5 to 5
Copper	0.5 to 3
Nitrogen	0.25 to 0.35
Iron	Balance

which comprises solution annealing at about 1,150–1,250° C. for, respectively, about 30–3 minutes, and precipitation hardening at about 900–1,000° C. for 60–30 minutes.

7. Exhaust valve for an internal combustion engine comprising a body portion of austenitic alloy steel of the composition and heat treated according to claim **6**.

8. Process according to claim **3**, wherein the alloy has the composition according to claim **2**.

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CHARLES N. LOVELL, *Primary Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,431,100 March 4, 1969

Franc Pecnik

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 37, "Extension" should read -- Extensive --; line 39, "Min" should read -- Mn --.

Signed and sealed this 31st day of March 1970.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents