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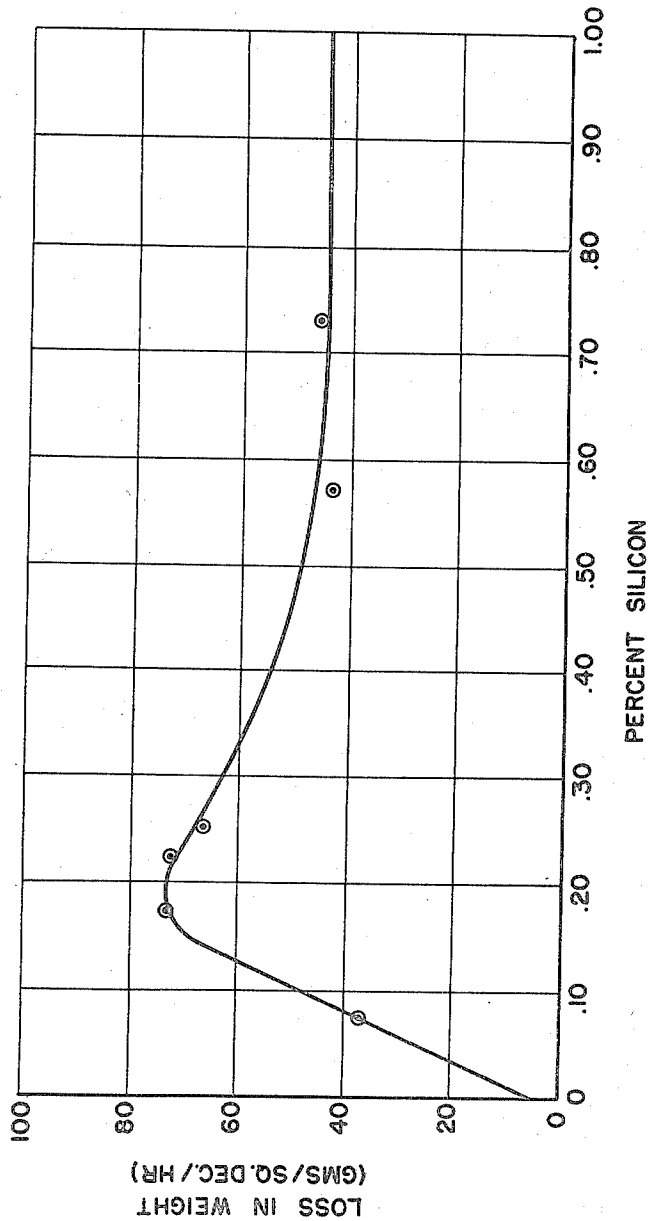
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INTERNAL-COMBUSTION ENGINE VALVE

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INFLUENCE OF SILICON ON
CORROSION RESISTANCE OF
CR-NI-MO VALVE STEEL IN
MOLTEN LEAD OXIDE.



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INTERNAL-COMBUSTION ENGINE VALVE

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This application is a continuation-in-part of my copending application Serial No. 19,293, filed April 6, 1948, and the invention relates to high temperature stainless steel and more particularly to stainless steel valves and valve components which are especially useful at high temperatures and in corrosive atmospheres.

An object of my invention is the provision of strong, tough and durable austenitic stainless steel valves and other internal combustion engine components, which in view of the excellent properties of the particular steel employed, function in a highly satisfactory manner in such fields as passenger car, truck, bus, aircraft, Diesel and marine vessel engine use.

A further object of my invention is the provision of stainless steel products and articles of the character indicated which have substantial resistance to creep in the heated condition, and which are highly hot-hard at the elevated temperatures encountered.

A still further object of my invention is the provision of products and articles of the character indicated which in the heated condition are highly resistant to hot corrosive atmospheres such as those containing the combustion products of anti-knock leaded fuels illustratively of the tetraethyl lead gasoline variety.

Other objects of my invention in part will be obvious and in part pointed out more fully hereinafter.

The invention accordingly consists in the combination of elements, composition of materials and features of products, and in the relation of each of the same to one or more of the others as described herein, the scope of the application of which is indicated in the following claims.

In the accompanying drawing, the single figure represents the effect of silicon content or corrosion-resistance in molten lead oxide of chromium-nickel-molybdenum stainless steel.

As conducive to a clearer understanding of certain features of my invention, it may be noted at this point that a great number of low-alloy steel valves, which formerly operated to some degree of satisfaction at comparatively low temperatures, are now found in many instances to be unacceptable. With increased engine speeds and greater power demands in recent years, as of aeroplanes, trucks, pleasure cars, and the like, and the concurrent use of fuels of the so-called anti-knock leaded varieties, the engine valves meet a severe combination of heat, corrosive and mechanical effects. In ordinary pleasure cars, the temperatures to which the valves are exposed,

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frequently go as high as 700° F. or more on the fuel intake side of the engine, and reach anywhere from about 1100° F. to 1450° F. or more on the exhaust side. These temperatures usually are even more severe in bus, truck and aeroplane engines, especially in the vicinity of the exhaust valves.

Low-alloy steel valves usually warp or burn very quickly at modern-day engine temperatures, thus impairing efficiency and requiring frequent replacement. In the exhaust valve position, the steel products suffer all the more and soon fail to seat properly, this then allowing the hot-engine gases to blow by, adding to the destruction of the metal and its functions.

Quite some few stainless steel valves, and valves made of other high-alloy metal have been introduced on the market to better serve present day needs. Among these are high-chromium, high-silicon products. These essentially are ferritic, and possess many desirable properties including high resistance to scaling by heat. They are usually not so strong, however, at high temperatures.

Apart from the ferritic stainless steel valves, there are valves in the prior art made of certain grades of austenitic stainless steel. The austenitic steels have the characteristic of being substantially free of phase transformation and thus, in this respect, are free of volume changes, warping, sticking or cracking during heating and cooling cycles brought about by the motor. It may also be said that valves made of the austenitic stainless steels, as a general class have a more favorable lattice structure for resisting stress-rupture at elevated temperatures than do ferritic or martensitic products. Despite this, however, many of the heretofore known austenitic stainless steel valves leave much to be desired of resistance to heat and corrosive attack, especially where the metal is subjected to the combustion products of leaded fuels. Certain of the heretofore known austenitic products also lack resistance to deformation, or fail too readily by creep and stress-rupture while heated and in operation. It is further true that certain of the austenitic stainless steel internal combustion engine valves or like products too readily suffer stretch as where, for example, in the form of poppet valves. In this connection, any substantial stretch of the metal at the operating temperature of the valve material usually is fatal to proper seating.

An outstanding object of my invention, accordingly, is the provision of strong, hot-hard and

3 durable austenitic stainless steel high temperature valves, valve parts, and any of a variety of other high temperature heat and corrosion-resistant components, as for internal combustion engines, which components are resistant to creep and stress-rupture, reliably resist heat scaling, and which are capable of withstanding attack by combustion products of leaded fuels.

Referring now more particularly to the practice of my invention, I provide high temperature stainless steel components for engines such as internal combustion engine poppet valves and valve components, illustratively casings, heads, stems, claddings, linings, or surfacings which are importantly austenitic and contain chromium, nickel and molybdenum and have a critically low-silicon content. In composition, my high temperature products include about 0.08% to 1.0% carbon, from 15% to 30% chromium, 4.5% to 20% nickel, molybdenum in amounts from about 1% to 4.5%, silicon not exceeding 0.15% (silicon preferably not exceeding 0.09%), and the remainder substantially all iron. The carbon and molybdenum contents increase the metal hot-hardness. By keeping the silicon content at a value not exceeding 0.15% and preferably not exceeding about 0.09%, or even better at amounts ranging from 0.09% down to substantially zero, I find sharp improvement in resistance of the steel products to corrosion and attack by products of combustion resulting from the burning of leaded fuel.

A comparison of one of my steels, which is substantially austenitic, is illustrated in the accompanying drawing where the weight loss in molten lead oxide is plotted against the silicon values. This comparison is given for a number of 23% chromium-5% nickel-2% molybdenum stainless steels (Steels A, B, C, D, E and F in the following table):

Influence of silicon on corrosion-resistance of Cr-Ni-Mo valve steel in molten lead oxide

Steel	C	Mn	P	S	Cr	Ni	Mo	Si	Weight Loss in Lead Oxide
A.....	.362	.50	.007	.022	23.38	4.70	2.80	.07	37.01
B.....	.412	.63	.008	.015	23.25	4.83	2.72	.17	72.10
C.....	.450	.70	low	low	23.75	4.75	2.75	.22	69.48
D.....	.450	.70	low	low	23.75	4.75	2.75	.25	68.51
E.....	.386	.74	-----	.011	22.94	4.87	2.92	.57	43.72
F.....	.522	1.02	1.02	.009	20.11	4.69	2.61	.73	45.70

All of the steels appearing in the table were exposed to molten lead oxide for 1 hour at 1675° F. The resulting weight loss as given in the table and plotted in the drawing, is in grams per square decimeter per hour. This weight loss decreases with a decrease in the silicon content, beginning with about 0.15% silicon. Thus, Steel A clearly is one of the low-silicon steels from which I make high temperature engine components.

A preferred example of my low-silicon steel is principally austenitic, containing about 0.50% carbon, about 21% chromium, 6.5% nickel, about 2% molybdenum, silicon not exceeding 0.15% and preferably not exceeding about 0.09%, and the remainder substantially all iron.

The stainless steel in my valves, valve parts and other components preferably has a low sulphur and a low phosphorus content, for such reasons as avoiding the presence of substantial quantities of molybdenum compounds of these elements and thus contributing to ease of working and forming the metal to desired shape. Usually, I limit the sulphur and phosphorus in the alloy steel each

to an amount not exceeding about 0.04%. Manganese, where present at all, seldom exceeds 1%, this element normally appearing in some small quantity as an incident to production of the steel. 5
Incidental or purposeful additions of nitrogen usually are present in the alloy metal of my products, and this preferably in amounts ranging up to about 0.01 times the amount of the chromium employed in the alloy composition. There are 10 occasions too where my stainless steel valves and other products include as for special purposes, one or more such elements as titanium, columbium, tungsten, vanadium, cobalt, copper, tantalum, aluminum, zirconium, or the like, ranging 15 from quite small to substantial amounts not inconsistent with the properties desired.

By virtue of the substantially austenitic quality of the steel my valve products and other components are not susceptible to phase transformation during heating and cooling cycles and, accordingly, are free of change of phase. The valves, even where in the form of internal combustion engine exhaust poppet valves, are hard, strong and tough at the high temperatures encountered 20 and are highly resistant to scour and the corrosive effects of the combustion products of leaded fuels. They reliably resist scaling, warping and cracking at full engine temperatures and upon being cooled and re-heated.

Thus it will be seen that in this invention there are provided low-silicon austenitic chromium-nickel-molybdenum stainless steel articles and products, in which the various objects noted hereinbefore together with many thoroughly practical advantages are successfully achieved. It 25 will be seen that the products are well suited for resisting corrosion in the presence of combustion products of leaded fuels.

While certain of the articles which I provide

take the form of internal combustion engine valves, valve parts and other internal combustion engine components, it will be understood that 55 certain advantages of the invention are had from other products of the low-silicon steel, among which are high temperature gas turbine nozzles, turbine parts adjacent to the nozzle, and any of a variety of supercharger components.

As many possible embodiments may be made of my invention, and as many changes may be made in the embodiment hereinbefore set forth, it will be understood that all matter described herein is 60 to be interpreted as illustrative and not as a limitation.

I claim:

1. Stainless steel having substantial hardness at high temperatures and substantial resistance 65 to corrosion in the presence of leaded fuel combustion products, and containing about 0.35% to 1.0% carbon, about 15% to 30% chromium, about 4.5% to 20% nickel, about 1% to 4.5% molybdenum, all in such proportions as to assure a substantially fully austenitic structure, sil- 70

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icon not exceeding about 0.15%, and the remainder substantially all iron.

2. Austenitic stainless steel having substantial hardness at high temperatures and substantial resistance to corrosion in the presence of leaded fuel combustion products, and containing about 0.08% to 1.0% carbon, approximately 15% to 30% chromium, about 4.5% to 20% nickel, about 1% to 4.5% molybdenum, nitrogen ranging from extremely small amounts up to about 0.01 times the chromium, silicon not exceeding about 0.09%, and the remainder substantially all iron.

3. Austenitic stainless steel having substantial hardness at high temperatures and substantial resistance to corrosion in the presence of leaded fuel combustion products, and containing about 0.35% to 1.0% carbon, about 23% chromium, approximately 5.0% nickel, about 3% molybdenum, silicon not exceeding about 0.09%, not more than about 1% manganese, sulphur and phosphorus each not exceeding about 0.04%, and the remainder substantially all iron.

4. An austenitic stainless steel having substantial hardness at high temperatures and substantial resistance to corrosion in the presence of leaded fuel combustion products, and containing about 0.08% to 1.0% carbon, about 15% to 30% chromium, about 4.5% to 20% nickel, about 1% to 4.5% molybdenum, silicon not exceeding about 0.09%, manganese below about 1%, sulphur and phosphorus each not exceeding about 0.04%, and the remainder substantially all iron.

5. An austenitic stainless steel internal combustion engine valve having substantial hardness at high temperatures and substantial resistance

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to corrosion in the presence of leaded fuel combustion products, and containing about 0.08% to 1.0% carbon, approximately 15% to 30% chromium, about 4.5% to 20% nickel, about 1% to 4.5% molybdenum, silicon not exceeding about 0.15%, and the remainder substantially all iron.

6. An austenitic stainless steel internal combustion engine exhaust valve having substantial hardness at high temperatures and substantial resistance to corrosion in the presence of leaded fuel combustion products, and containing about 0.35% to 1.0% carbon, about 23% chromium, approximately 5.0% nickel, about 3% molybdenum, silicon not exceeding about 0.09%, sulphur and phosphorus each not exceeding about 0.04%, and the remainder substantially all iron.

7. An austenitic stainless steel internal combustion engine exhaust valve having substantial hardness at high temperatures and substantial resistance to corrosion in the presence of leaded fuel combustion products, and containing about 0.35% to 1.0% carbon, about 21% chromium, approximately 6.5% nickel, about 2% molybdenum, silicon not exceeding about 0.09%, and the remainder substantially all iron.

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The following references are of record in the file of this patent:

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