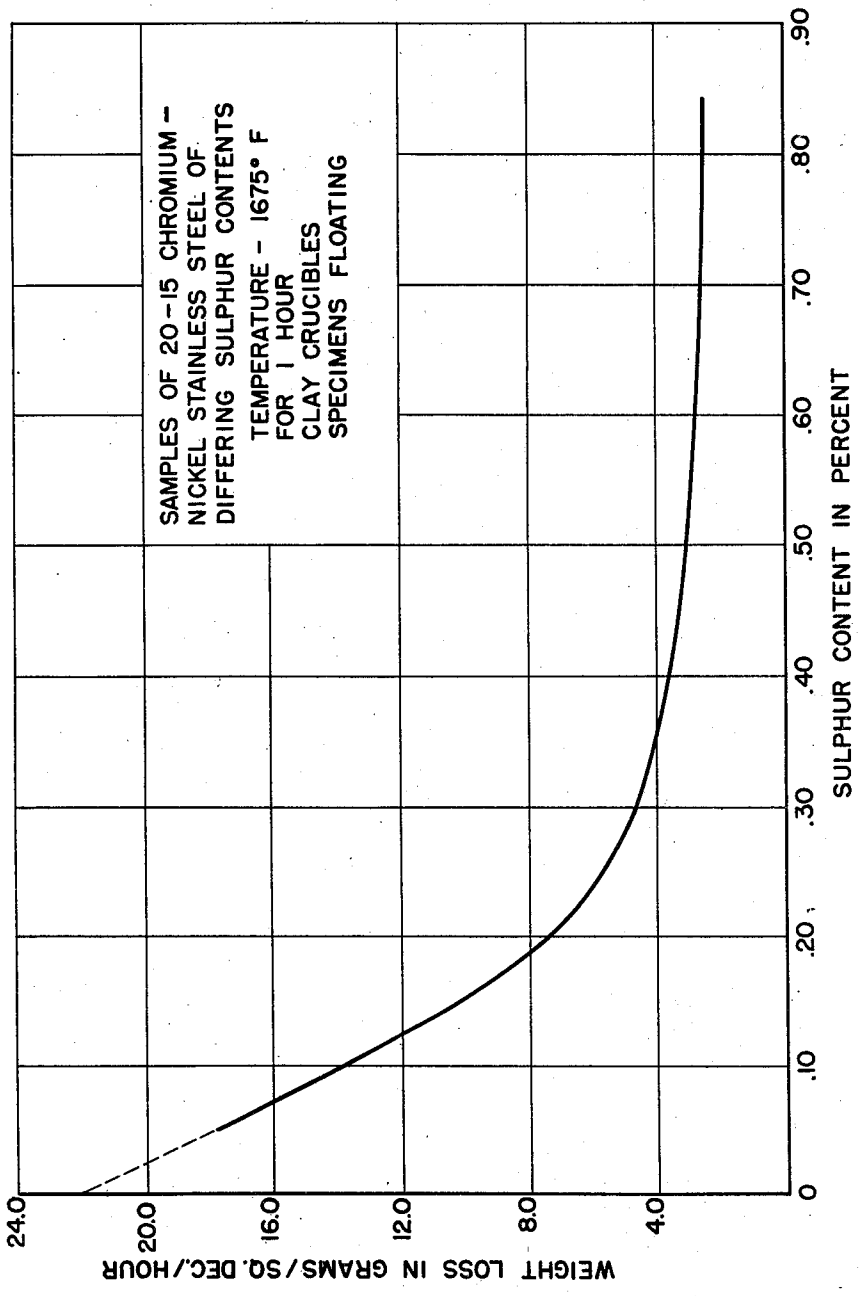
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INTERNAL-COMBUSTION ENGINE VALVE

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INFLUENCE OF SULPHUR CONTENT OF CHROMIUM-NICKEL STEEL ON CORROSION RESISTANCE IN MOLTEN LEAD OXIDE



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INTERNAL-COMBUSTION ENGINE VALVE

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1 Claim. (Cl. 75—128)

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This invention relates in general to stainless steel, and more especially to stainless steel articles having resistance to leaded fuels and their combustion products.

An object of my invention is the provision of a durable, corrosion resistant stainless steel which is easily wrought, which is of good impact strength and which is well suited in composition for reliably resisting corrosion by the combustion products of leaded fuels.

A further object of my invention is that of providing high temperature stainless steel articles, as for example internal combustion engine valves and valve parts, turbine parts such as nozzles, and a host of other products which over long periods of use endure the corrosive effects of leaded fuels and their combustion products.

Other objects in part will be obvious and in part pointed out hereinafter.

The invention accordingly consists in the combination of elements and composition of ingredients and in the articles fashioned thereof as described herein, the scope of the application of which is indicated in the following claims.

The single figure of the accompanying drawing is a graph illustrating certain properties of my steel.

As conducive to a clearer understanding of certain features of my invention, it may be noted at this point that stainless steel by general definition contains about 10% to 35% chromium, with or without nickel and with or without additions of other ingredients for special purposes, the remainder being substantially all iron.

There are constantly increasing demands for stainless steels which are capable of withstanding the effects of the combustion products of leaded fuels under conditions of heat. These needs particularly apply to exhaust valves for internal combustion engines, turbine parts, furnace parts and equipment, and the like, where leaded fuels and their combustion products are encountered.

Whether operating conditions are more or less severe, many of the heretofore known stainless steels, despite having a variety of valuable properties, pit and corrode too readily for practical use in the presence of the combustion products of leaded fuels. This occurs even where certain of the steels are of corrosion resistant quality sofar as other corrosive effects are concerned, inclusive of having resistance to acids such as nitric or sulphuric acid, fruit acids, body salts and corrosion in ordinary atmosphere as well as at high temperatures.

In the instance of stainless steel valves, many have appreciable resistance to oxidation even at high temperatures, but the resistance usually is not so favorable where oxidation, pitting and corrosive attack are intensified by the current use

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of leaded fuels. Among the lead compounds so often causing substantial detriment are tetraethyl lead or other leaded fuels and their combustion products containing lead oxide, or the like.

A further intensifying factor in high temperature engines as of the internal combustion type, depends upon whether the particular valve employed is on the intake or exhaust side. In average passenger cars, the temperatures encountered by the valves frequently mounts up to 700° F. on the fuel intake side of the engine and as high as 1100° F. to 1450° F. or more on the exhaust side. These temperatures usually are quite a bit higher in truck or aeroplane engines, especially for the exhaust side of the engine.

Low alloy steel valves and valve parts when considered today for high temperature engine use and the like, are in most instances found to be unacceptable if for no other reason than being vulnerable to scaling and corrosion under the intense heat of operation and general inability to withstand the temperatures. The scaling usually prevents proper seating, and instead permits a leakage of hot gases, which in turn raises the valve head temperatures, a combined action which of course results in quickly burning away the head. Leaded fuels and their combustion gases greatly accentuate this action.

An outstanding object of my invention is the provision of stainless steel articles and products which are highly resistant to the corrosive effects of lead oxide and the like while hot, and which otherwise have good properties for resisting oxidation, corrosion and mechanical effects.

Referring now more particularly to the practice of my invention, I find that in a wide range of chromium-nickel stainless steels, it is the element sulphur which has a marked effect upon the resistance of the steel to corrosion by lead compounds when the element is controlled to proper and critical amounts. The quantity of sulphur considered critical lies between about 0.15% and 0.50%. Higher amounts may occur, but beyond 0.50%, hot working difficulties usually can be expected and the rate of further improvement in resistance to lead-corrosion decreases. The critical amounts of sulphur give a remarkable counteracting effect upon nickel and the like, which otherwise I find tend to diminish resistance of steel to lead-oxide corrosion.

The stainless steels of the general character indicated which I provide, more particularly contain about 0.10% to 1.25 carbon, 12% to 25% chromium, 4% to 35% nickel, sulphur preferably from 0.15% to 0.50%, and the remainder substantially all iron. Such elements as aluminum, silicon, manganese, tungsten and molybdenum may be included in small amounts.

My chromium-nickel stainless steels all are well

suited for resisting attack from hot lead oxide such as in the combustion gases resulting from the burning of leaded fuels, the latter fuels illustratively including tetra-ethyl lead.

Within the composition ranges noted the sulphur and other elements such as carbon, chromium, nickel, and silicon, preferably are so correlated in amount as to achieve properties of hot hardness, resistance to scaling and lead corrosion, also resistance to impact and fatigue, and resistance to wear, all needed in high temperature valve steels and at least for certain types of valves. I accordingly provide these steels, and high temperature articles and products of the steels, by hot working and machining the metal into such products as exhaust valves and valve parts for internal combustion engines, gas turbine nozzles and related turbine parts and supercharger components.

The accompanying drawing illustrates the effects of different amounts of sulphur on corrosion resistance of stainless steel in molten lead oxide. The samples contain about 0.095% carbon, 20.68% chromium, 15.12% nickel, with differing amounts of sulphur, and the remainder substantially all iron. The basic points along the curve in the drawing are derived from a series of steels having the composition just noted and respectively containing 0.047% sulphur, 0.220% sulphur, 0.488% sulphur and 0.822% sulphur. The weight losses of these samples in molten lead oxide at 1675° F. in terms of grams per square decimeter per hour appear below:

TABLE I

Effect of sulphur content of 20–15 chromium-nickel stainless steel on corrosion in molten lead oxide.

Sample	Per Cent S	Weight loss. gms. per sq. dcm. per hr.
A	0.047	17.5
B	0.220	6.0
C	0.488	3.0
D	0.822	2.25

From these valves, particularly the tests on samples B, C, and D, and others determined by interpolation, it is clear that a great improvement in corrosion resistance is had when the sulphur is increased to about 0.15% and on up to about 0.50%. Beyond 0.50% the sulphur still improves the resistance to molten lead oxide, but to a less marked degree and the hot working properties usually suffer.

As a further illustration of my invention, samples of stainless steel containing 0.40% carbon, 22.94% chromium, 4.87% nickel, 2.92% molybdenum, 0.75% manganese, 0.57% silicon, differing amounts of sulphur, and the reminder iron were subjected to corrosion by molten lead oxide at 1675° F. The weight loss for the several samples is given below:

TABLE II

Effect of sulphur content of 24–5–3 chromium-nickel-molybdenum stainless steel on corrosion in molten lead oxide

Sample	Per Cent S	Weight loss, gms. per sq. dcm. per hr.
E	0.010	12.70
F	0.147	6.72
G	0.323	2.51

As another illustration, samples containing 0.212% carbon, 19.96% chromium, 11.44% nickel, 1.40% manganese, 0.85% silicon, with differing amounts of sulphur and the remainder iron were likewise tested in molten lead oxide at 1675° F. with the following results:

TABLE III

Effect of sulphur content of 21–12–2 chromium-nickel-manganese stainless steel on corrosion in molten lead oxide

Sample	Per Cent S	Weight loss, gms. per sq. dcm. per hr.
H	0.013	17.07
I	0.155	14.27
J	0.313	5.75

It is noted that with the high manganese content considerably greater sulphur content is required to achieve the desired resistance to corrosion.

Thus it will be seen that in this invention there are provided a wide variety of stainless steels, and stainless steel articles and products, in which the various objects noted hereinbefore together with many thoroughly practical advantages are successfully achieved. It will be seen that the steels and products are well suited for resisting corrosion by the combustion products of modern fuels.

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

I claim:

Chromium-nickel stainless steel internal combustion engine valves having substantial resistance to corrosion in the presence of the combustion products of leaded fuels, and containing approximately 0.10% to 1.25% carbon, 12% to 25% chromium, 4% to 35% nickel, at least about 0.15% but not over 0.50% sulphur and the remainder substantially all iron.

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