Feb. 27, 1945. G. CHARLTON 2,370,124

VALVE AND VALVE STEEL ALLOY

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Fig. 1.

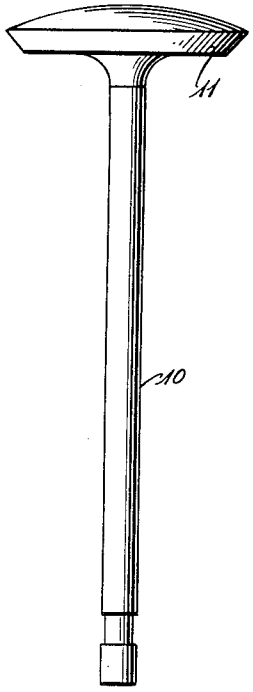


Fig. 2.

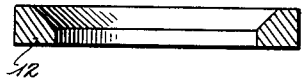
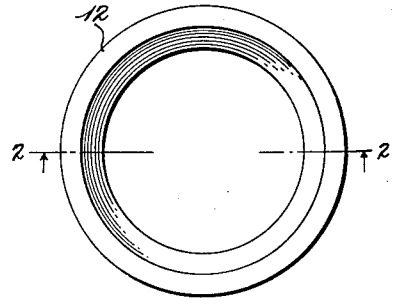


Fig. 3.



COMPOSITION

CARBON	1.20 % -- 1.75 %
MANGANESE	(MAX.) -- 1.00 %
SILICON	2.00 % -- 3.00 %
CHROMIUM	18.00 % -- 21.00 %
MOLYBDENUM	2.00 % -- 4.00 %
COLUMBIUM & TANTALUM	0.50% -- 1.50 % (TOTAL)
IRON	BALANCE

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VALVE AND VALVE STEEL ALLOY

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3 Claims. (Cl. 123—188)

This invention relates to steel alloys in general, and, more particularly resides in the discovery of certain combinations of elements especially resistant to heat and corrosive or erosive effects of internal combustion engine gases to which exhaust valves, valve seat inserts, and other engine parts are continuously subjected, at normal operating temperatures.

Prior to the introduction of anti-knock gasoline, and the attendant corrosive properties of its exhaust gases when combusted, valve steels of a straight chromium-silicon content were considered the best material available for exhaust valves of internal combustion engines. With the development of the high compression type of engine came the use of anti-knock or leaded gasolines which resisted detonation of the fuel in such engines. However, such additions to the gasoline resulted in an exhaust gas including compounds containing lead, oxygen and bromine. Sustained operation of former valve steels in this atmosphere were considerably improved by the addition of nickel, in amounts of 6% or more, to straight chromium-silicon alloys which resulted in a high alloy austenitic type of chromium-nickel-silicon. This last steel, while exhibiting substantial resistance to chemical attack of such exhaust gases, has numerous other drawbacks as, expense, machineability, low Brinell hardness, and a high coefficient of expansion with a low heat conductivity. More recently, it has been proposed to limit the nickel content of the aforementioned alloy to relatively small quantities under 4% with the unexpected result that greater resistance to attack was shown coupled with improved machinability, improved micro grain structure, less cost etc. The high nickel-chrome steels form a group belonging to the austenitic type of steels which are non-hardenable. Steels with low nickel, or no nickel, content belong to the hardenable group which represent martensitic or hardenable steels, the steel proposed by the present invention belonging to the last mentioned group. Both groups have particular peculiar properties, but as compared with present day steels of this latter or hardenable group, then the type in question exhibits superior properties such as, retention of hardness under prolonged heating, wear resistance, etc.

The present invention proposes to advance the state of the art further by omission of the nickel content entirely, also with rather unexpected results in that the alloy, when subjected to the known lead oxy bromide test, at elevated normal operating temperatures of above 1100° F., showed improved resistance to attack over the aforementioned alloys. That is to say while the nickel content is omitted and not relied upon, no substitute such as cobalt or manganese, which are generally considered the equivalent of nickel, is used to impart resistance to lead oxy bromide in the composition. However, a generally higher carbon content than heretofore employed is used, which is coupled with molybdenum and columbium or tantalum, in the hereinafter stated proportions, has produced unexpected excellent results. The results obtained are believed derived from the fact that the carbides formed are difficult to break down, or very stable, which provides a retention of hardness and hot wear resistance and this in turn aids in providing resistance to lead oxides.

Accordingly, the primary object of the present invention is the provision of a steel alloy for internal combustion engine parts such as exhaust valves, valve seat ring inserts, and the like which is superior in resistance to attack from leaded gasoline at elevated temperatures, to which the alloyed part is normally subjected in use; which is less in cost; has better machinability; greater hot strength and hot and cold wear-resistance. A steel such as described has the properties mentioned in greatly improved measure as compared to other known steels in the hardenable group heretofore mentioned.

Further and other objects and advantages of the present invention reside in the novel combination and range of elements about to be described in this specification and which are pointed out with particularity in the appended claims.

Valve parts which may be of the alloy disclosed herein are shown by way of example in the attached drawing, in which:

Figure 1 is a side elevation of a valve for an internal combustion engine;

Figure 2 is a vertical section through a valve seat insert taken on the line 2—2 of Figure 3; and

Figure 3 is a plan view of the valve insert of Figure 2.

The valve 10 of Figure 1 or at least the head portion 11 thereof as well as the valve insert 12 of Figures 2 and 3 can advantageously be constructed of the alloy practically described below.

Illustrative of one example of a typical analysis which has shown excellent results is the following approximate percentage of elements.

Carbon	Manganese	Silicon	Chromium	Molybdenum	Columbium
Per cent 1.46	*Per cent* .52	*Per cent* 2.65	*Per cent* 19.22	*Per cent* 2.66	*Per cent* 1.00

In the above analysis the remainder is balanced by iron, including the usual small quantities of sulphur and phosphorus which are common adul-

terants in commercial steel specifications. Also for commercial reasons columbium and tantalum including small quantities of aluminum are usually employed together or singly in an amount not exceeding 1.50% without altering the special properties attributed to this alloy. These elements columbium and tantalum are alike in their action, in that they serve to refine the grain size of alloy steels normally maintained at elevated operating temperatures. The essential elements in such alloy are believed attributed to the relatively high carbon content coupled with the chromium and silicon elements.

While the foregoing analysis sets forth a particular percentage of elements in producing one heat of the alloy it is obvious that a range in variation of these percentages may be made between certain close limits, so that different grades of the alloy are not produced without departing from the broad properties disclosed for the alloy of this invention. A narrow range of the various elements in the analysis disclosed is to be distinguished from a broad range of elements in the analysis which would have different properties at opposite ends thereof. Satisfactory results may be obtained by use of the following workable range of the elements between the limiting percentages.

Carbon	Manganese max.	Silicon	Chromium	Molybdenum	Columbium and tantalum
Per cent 1.20-1.75	*Per cent* 1.00	*Per cent* 2.00-3.00	*Per cent* 18.00-21.00	*Per cent* 2.00-4.00	*Per cent* .50-1.50 total

In this range of elements the balance is comprised of iron from 75% to 58%, together with the usual amounts of sulphur and phosphorus ordinarily present in commercial steels. The principal elements and the constituents combined therewith endow the composition with its characteristic properties, as aforementioned.

This alloy has been found to have, among other things, the following properties:

It is an excellent oxidation resistor. Tested for resistance to the erosive effect of exhaust gases of combustion containing tetra ethyl lead compounds it exhibited values comparable to Stellite, which is frequently used as a criteria, but as distinguished therefrom the present alloy is readily forged and machinable.

The hardness value of the alloy first mentioned, as unhardened, is approximately 35 Rockwell, C scale, this being high for a material which can be machined and fabricated. This hardness was retained when the sample was subjected to sustained periods at elevated temperatures above 1000° F. to which the alloy would normally be subject in use; such retention of hardness under elevated operating temperatures evidences excellent resistance to wear.

It is also an excellent oxidation resistor. A sample exposed for eight hours to a temperature of approximately 1750° F. remained bright in appearance and free from oxidation.

From the foregoing disclosures it will now be apparent that the alloy disclosed embodies, among other things, the objects and advantages of the invention first enumerated. It is to be sharply distinguished from other steel alloys devised for the purposes stated, especially in view of the aforementioned shortcomings thereof. Formal changes may be made in the elements, which come within the range of equivalents, without departing from the workable range of elements as previously stated and to which the characteristic properties of the alloy is believed confined as covered in the following claims.

What I claim is:

1. An internal combustion engine valve part, normally subject to elevated operating temperatures above 1000° F. for sustained periods, formed from an alloy comprised of the following: carbon 1.20% to 1.75%, manganese 1.00% maximum, silicon 2.00% to 3.00%, chromium 18.00% to 21.00%, molybdenum 2.00% to 4.00%, columbium and tantalum singly or together .50% to 1.50% total, and the remainder iron, and said alloy engine part characterized by ready machinability and forgeability.

2. A valve part for an internal combustion engine formed from a steel alloy characterized by high resistance when subjected to attacks of lead oxy bromide at valve operating temperatures consisting of the following: carbon 1.46%, manganese .52%, silicon 2.65%, chromium 19.22%, molybdenum 2.66%, columbium and tantalum 1.00% total, and the remainder iron.

3. An exhaust valve for an internal combustion engine comprising the alloy set forth in claim 2.

GEORGE CHARLTON.