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ALLOY CAST IRON

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Our present invention relates to an improve-
ment in alloy cast iron, in which silicon and chro-
mium are the principal alloying agents, and in
which the silicon, in the various proportions in
which it may be used with reference to the chro-
mium, is always in substantial excess of the
chromium content.

We have found that alloys prepared in accord-
ance with our invention, have high wear and
heat-resisting properties, and exhibit unusual
resistance to scaling, warping and growth at ele-
vated temperatures.

We have further found that such alloy cast
irons are machinable at Brinell hardness far in
excess of that at which cast irons or steels are
considered to be unmachinable.

Further, our alloy cast iron can be produced
from low cost materials, in furnaces of the
cupola type, which are recognized as being the
lowest cost type of furnace in common use to-
day, and by labor which does not require to be
highly skilled.

Cast iron is generally considered to contain the
following materials substantially within the
ranges indicated, namely—

	Per cent
Total carbon-----	2.50 to 3.70
Silicon-----	.80 to 3.00
Manganese-----	.40 to 1.20
Sulphur-----	Under 0.20
Phosphorus-----	Under 1.00

Where any of the elements exceed the maxi-
mum amounts indicated, the excess of the
amount of such element usually required to
produce an iron of normal properties, is consid-
ered an alloying element.

In the alloy cast iron of our invention, we use
silicon in excess of the amount required to pro-
duce a good quality of cast iron, as an alloying
agent to secure properties not found in unalloyed
irons, and we also use chromium as an alloying
agent, but in the compositions of our alloy we
maintain the silicon content always in excess of
the chromium content by a substantial amount.

Despite its hardness, our alloy contains as cast
free carbon in the form of graphite flakes or
nuclei, and is thus definitely not a steel, and
should not be confused with steels containing
silicon and chromium.

With the foregoing explanation in mind, one
of the principal objects of our invention is to
provide an alloy cast iron having high wear and
heat resisting properties and unusual resistance
to scaling, warping and growth at elevated tem-
peratures.

A further object is to provide an alloy cast iron
of great hardness, which is machinable at un-
usually high Brinell hardness, and without the
use of lubricants.

A further object is to provide an alloy cast iron
comprising silicon and chromium as the principal
alloying agents, with the silicon in excess of the
chromium, and having free graphite, the alloy
being characterized by high resistance to wear,
and to scaling, warping and growth at elevated
temperatures, and being machinable at hard-
nesses far beyond those of cast irons.

Still another object of our invention is to pro-
vide an alloy cast iron of the characteristics set
forth above, and having a relatively low melting
point and low shrinkage characteristics, such
that good castings of intricate and thin sections
can be produced with ordinary foundry facili-
ties.

A further object is to provide an alloy cast iron
having the various qualities and characteristics
referred to, which is capable of production in
cupola furnaces at relatively low cost, and with-
out requiring labor of anything more than ordi-
nary skill.

In producing our alloy cast iron, we prefer that
it contain constituents within the following table,
namely—

	Per cent
Silicon-----	3.05-10.00
Chromium-----	0.60- 8.00
Manganese-----	0.20- 3.00
Phosphorus-----	Under 0.30
Sulphur-----	Under 0.20
Carbon-----	1.80- 3.20

While the percentages of the various materials
within the ranges indicated may vary, in all cases
we keep the silicon content in excess of the chro-
mium by a substantial amount. The presence
of the relatively high silicon content with regard
to the chromium in our alloy, we believe, lowers
the solubility of the carbon in the iron at room
temperatures, and hence, as the iron cools from

the molten condition, carbon is precipitated from solution in the form of graphite, which is distributed substantially uniformly throughout the body of the metal in the form of small flakes or nodules.

The alloy can be produced from relatively low cost raw materials and in simple and economical types of melting units, by workmen of no more than ordinary skill. As illustrative, alloy steels require for their production, the use of the electric furnace, the open hearth furnace, or the crucible furnace. All of these types of furnaces are expensive to build, maintain and operate. Our alloy, on the other hand, can be produced in the cupola type furnace which, as recognized in the industry, is the type of furnace which is the cheapest per unit of capacity, in common use. It is not only less expensive in initial cost, than the other types of furnaces referred to, but is also cheaper to maintain and operate.

Examples of a number of compositions of our alloy are given in the tables which follow, in which tables various specimens have been tested against other cast irons.

We give below some results of wear tests, as well as tests of other physical properties, and a few compositions of the alloy of our invention. The wear tests were made by holding the specimen under a weight of 1380 grams on the table of a Dorry machine, a constant stream of washed silica sand being fed to the table during the test. At the end of 6000 revolutions, the specimen was moved and weighed, and the weight loss due to wear was noted. The physical properties were determined by standard A. F. A. methods.

Specimen No.	70	71	2352	2395	2423	2423
Analysis:						Heat treated
T. C.	3.30	3.10	2.52	3.17	2.21	
Si	2.40	1.73	4.23	3.05	5.30	
Mn	.65	.94	.60	.50	.63	
P	.18	.16	.11	.056	.084	
S	.11	.13	.065	.065	.052	
Cr			2.20	.96	2.98	
Brinell hardness No.	179	217	255	255	341	388
Transverse strength						
pounds	2,560	3,230	2,950	3,290	2,120	
inches	.292	.270	.190	.282	.137	
Tensile strength						
lbs. per sq. in.	29,200	43,000	34,700	42,800	32,000	43,000
Wear loss	5.19	3.85	1.931		2.07	1.67

In the foregoing table of tests, specimen No. 70 is a typical medium strength cast iron, while No. 71 is a high strength cast iron. Both were made in regular production in a commercial foundry. The other specimens are alloys of our invention. The heat treated specimen No. 2423, is of the same composition as the specimen of that same number in the table, but not designated as heat-treated. The heat treatment consisted of normalizing at 1800 deg. F. and drawing at 1300 deg. F.

The above data shows that the alloy iron, despite its high hardness, has strength and toughness comparable to a good grade of high test iron.

A remarkable feature of our alloy is that it can be machined at unusually high Brinell hardness. Cast iron is ordinarily considered unmachinable when it has a Brinell hardness of more than 280. All of the given examples of our alloy, however, even though they tested up to 388 Brinell, were readily machinable, and indeed, we have machined specimens of our alloy having a Brinell hardness of 415.

The superior resistance of our alloy to growth

and scaling at elevated temperatures, is indicated in the following table.

The specimens used were heated under identical conditions, in a gas fired furnace for six cycles. Each cycle consisted of bringing the furnace to 1650 deg. F., holding it for five hours, and then allowing to cool over night. The results of the test are given below.

Specimen No.	134-3	219-6	116-1
Analysis:			
T. C.	2.13	2.80	3.44
Si	5.73	2.30	2.25
Mn	.37	.53	.56
P	.05	.27	.43
S	.02	.08	.06
Cr	4.16		
Scale loss	percent. 2.00	8.87	10.70
Growth	percent. .07	1.74	5.82

In this table, specimen 134-3 is an alloy of our invention, while specimen 219-6 is a high strength cast iron, and specimen 116-1 is a soft cast iron. The scale loss and the growth of our alloy are both remarkably low, as indicated in the table.

In addition to the qualities of unusual high hardness, and high wear and heat-resistance, our alloy exhibits the further quality of relatively small shrinkage during solidification of the metal from the molten state, and in addition, has a melting point very much lower than alloy steels. Hence the alloy possesses excellent casting properties, such indeed, that with ordinary foundry facilities, sound castings of intricate and thin sections can be made.

We are aware that steels containing silicon and chromium are known in the art, but our alloy possesses characteristics which distinctly differentiate it from such steels, such for instance, as its low production cost; its machinability; its silicon content in excess of the chromium; and its brittleness as compared to workability of steel; also ease of casting to shape as compared to steel.

On the other hand, the ability of our alloy to be machined at Brinell hardness far greater than that of cast irons, and its unusually high heat resistance and wear resistance, give it qualities unpossessed by cast irons heretofore known in the art with which we are acquainted.

It will be understood that our alloy may be heat-treated subsequent to casting by one of the accepted methods for ferrous alloys; i. e., annealing, either at a temperature above or below the critical; normalizing from a temperature above or below the critical; quenching from a temperature above the critical and drawing at some suitable temperature below the critical.

While the foregoing description sets out a number of specific embodiments of our invention, it will be understood that various changes in proportions of the elements constituting our alloy may be made within the scope of the appended claims. It will further be understood that the foregoing description has been given for purposes of illustration of our invention, and that no undue limitations should be deduced therefrom, but that the claims should be broadly construed within the limitations of the prior art.

Having thus described our invention what we claim as new and desire to secure by United States Letters Patent is:

1. An alloy cast iron, having silicon in proportions greater than chromium, and in which a substantial part of the carbon is in the form of

of free graphite, said alloy containing silicon 4.23% to 10.00%; chromium 0.6% to 8.00%; manganese 0.20% to 3.00%; phosphorus under 0.30%; sulphur under 0.20%; carbon 1.80% to 3.20%, and the balance iron.

5 2. An alloy cast iron containing silicon about 4.23%; manganese about .60%; phosphorus about .11%; sulphur about .065%; chromium about 2.20%, total carbon about 2.50%, and the balance iron, said alloy being characterized by high wear and heat resistance.

10 3. An alloy cast iron containing silicon about 5.30%; manganese about .63%; phosphorus

about .084%; sulphur about .052%; chromium about 2.98%, total carbon about 2.20%, and the balance iron, said alloy being characterized by high wear and heat resistance.

4. An alloy cast iron containing silicon about 5.73%; manganese about .37%; phosphorus about 0.05%; sulphur about .02%; chromium about 4.16%, total carbon about 2.13%, and the balance iron, said alloy being characterized by high wear and heat resistance.

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