

UNITED STATES PATENT OFFICE.

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INGOT MOLD.

No Drawing.

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My invention relates to ingot molds.

It is one object of this invention to produce ingot molds which will, barring accidents and rough usage, give an unexceptional number of ingots or heats during its life.

Some ingot mold makers pour the ingot molds from molten iron as it comes from the blast furnace without remelting. This direct metal method has some limiting factors. The temperature of the molten iron from the time it leaves the furnace until it is poured into the mold becomes lower, which reduces its ability to hold carbon in solution. This carbon or "kish," as it is called, comes to the surface and makes it necessary to pour the metal with a "bottom-pour" ladle. The temperature of the iron being comparatively low reduces its fluidity, and unless the mold wall is fairly thick, as four inches or more, the metal tends to "cold shut" or solidify in layers, making a scrap mold. It is therefore almost impossible to make good ingot molds by direct metal method, having a small wall thickness. The chemical analysis of direct metal has very great variations and can not make molds of uniform composition. Its total carbon content is not controllable and depends upon the saturation point of the iron for carbon, this point depending on the temperature and the percentages of silicon, sulphur, phosphorous, manganese and probably oxides. Accordingly direct metal molds are very likely to be ununiform.

Cupola metal for molds is made by melting in a cupola pig iron plus possibly returned scrap and purchased cast iron scrap. Cupola metal as compared with direct metal has better fluidity due to the higher temperature generally obtaining; better control of the temperature owing to the ease of manipulating the coke ratio in a shorter period of time; better control of the composition, as to the silicon, phosphorous, sulphur, and manganese, and as to the carbon by the introduction of steel scrap to lower the total carbon content.

Molds are scrapped among other reasons because of their fire-cracking, which begins as fine, hair-like cracks on the inside surface of the molds, these cracks developing into larger cracks whose edges are raised above the original surface of the mold. These

cracks tend to hold the ingots while solidifying thus tending to break the molds or prevent the ingots from being extracted. Another cause of scrapping molds is cracking due to sudden changes of temperature which require the molds to expand and contract rapidly. This is due to mold metal not being strong enough or the mold wall being thin. Another cause of scrapping is due to the warping of the mold walls.

I have made a study of the factors affecting mold failures, the most important being those due to mold growth or dilatation and mold cracking. Cast iron subjected to alternate heating and cooling shows a resultant increase in volume, which may be as high as 10% during the life of an ingot mold. It is believed that this growth is partly caused by the difference in coefficients of expansion between the graphite flake and the matrix of iron. This allows oxygen to penetrate between the flake and the matrix which oxidizes at first the iron and its metalloids and later the graphite itself. As the oxides require more room than the original iron did, a permanent growth is made. Also constitutional changes occur which produce internal stresses eventually forming internal cracks which help make passages for oxygen penetration. The cracks themselves increase the volume of the mold wall. Graphitization or precipitation of temper carbon from the cementite (Fe_3C) which occupies more room helps the mold growth.

It is an object of this invention to produce ingot molds in which the said growth may be retarded or reduced. This may be accomplished by reducing the size and number of the graphite flakes, thus minimizing the effects of the said differences in coefficients of expansion; by more uniform distribution of the graphite; by changing the form of the graphite from a flat flake to very fine curved lamellæ or to round nodules.

In the preferable practice of my invention, I employ a cupola in which I add to the metal charge, pig iron, for example, form 40% to 60% steel scrap, giving, for example, a total carbon content of 3.10% or less. I prefer the silicon range to be from .90% to 1.30%, depending on the total carbon. Test bars made of this metal cast in green or dry sand molds and poured at atmospheric temperature showed a white or

mottled fracture up to about a two inch section. If the green or dry sand molds up to about two-inch section are heated, the fracture of the test bar becomes grey, and
5 a definite ratio exists between the size of the section and the temperature to which the molds must be heated. If the test bars cast in green or dry sand molds are about two inches or more thick and cast at atmos-
10 pheric temperature, the fracture is completely grey although a light grey. Increasing the section of the test bar from about two inches up to six inches or over, the fracture remains practically the same, and
15 uniform from the outside surface to the center of the bar. As ingot molds generally have a wall section of two inches or more, it is not necessary with my method that the molds in which my ingot molds are made
20 shall be heated.

The size of the graphite flakes is somewhat dependent upon the temperature at which the metal is melted. It is believed that, if the iron is melted at a temperature
25 exceeding 2730° F., all the graphite is dissolved and in cooling no graphite nuclei appear to aid the precipitation. Consequently when precipitation takes place at about 2000° F., the graphite which forms is in a finely
30 divided state, which enhances the value of the steel scrap addition.

The metal just described when poured into molds shrinks considerably more than ordinary grey iron. This shrinkage is not
35 serious as an allowance for finish can be made or risers can be used which can be later removed.

Photomicrographic tests of the said metal show great differences from regular cast
40 iron. In my metal the graphite is almost nodular and almost evenly distributed, while in regular cast iron it is in flat flakes irregularly distributed. Under high magnification the matrix of my mold metal is
45 largely pearlitic, while in regular cast iron there is considerable free ferrite with a larger percentage of graphite which breaks up the continuity of the matrix. To have a true pearlitic matrix the combined carbon
50 must be at the eutectoid amount of .89%.

However, for practical purposes, the combined carbon in my mold metal may range approximately from .70% to 1.10% without affecting the same very much. The low limit shows some free ferrite plus pearlite in the
55 matrix and the high limit shows some free cementite plus pearlite in the matrix.

A test of my mold metal showed a tensile strength of 40,000 pounds per square inch; a transverse strength of 4700 pounds on 12-
60 inch centers; a deflection of .17 of an inch in 12 inches; and a Brinell hardness of 228. Thus, the strength and elasticity of my metal is about twice those of ordinary cast
65 iron.

Ingot molds made from my metal and according to the method described have a much longer service than the ordinary cast iron molds. Fire checking, cracking and
70 warping of the molds are very much reduced. The growth of the metal in the molds is decidedly reduced. The cost of steel made in my molds will be reduced owing to increased service of the molds and
75 to the improved surface of the ingots which reduces the cost of chipping and grinding.

I do not limit my invention to the use of a cupola, as an air furnace, or an electric furnace or equivalent may be used. Possibly
80 direct metal may be used with the addition of molten steel.

With my method it is not necessary that the molds in which my ingot molds are made
85 shall be heated.

I claim:

1. An ingot mold having low dilatation under repeated heating and cooling and consisting of a ferrous alloy whose composition is ferrite plus carbon and other metalloids in such proportions as to produce a
90 combined carbon of .70% to 1.10%.

2. An ingot mold having high resistance to heat and consisting of a ferrous alloy whose composition is ferrite plus carbon and other metalloids in such proportion as to
95 produce a pearlitic structure having a combined carbon of .70% to 1.10%.

In testimony whereof I hereunto affix my signature.

EDWARD R. WILLIAMS.