

# UNITED STATES PATENT OFFICE

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## MANUFACTURE OF BLACK-HEART MALLEABLE CAST IRON

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Up to date black-heart malleable cast-iron has been manufactured by various processes, namely:

1. Fusion in reverberatory furnace
2. Fusion in cupola furnace
3. Fusion in crucible furnace
4. Fusion in electric furnace
5. Fusion in Martin open-hearth furnace

and sometimes a combination of cupola, electric furnace and/or converter is used.

The cast-iron thus produced shows the following average composition:

	Per cent
Total carbon in combined form	2.70 to 3.00
Silicon	1.00
Manganese	0.40
Phosphorus less than	0.25
Sulphur less than	0.20

This cast-iron, that gives a white fracture or white heart and is brittle, undergoes a heat treatment that is carried out on the following lines:

From 20° C. to 950° C. and above, quick heating  
At 950° C. and over, 48 to 60 hours rest  
Cooling from 950° C. to 650° C.; 3° C. per hour,  
say about 100 hours

followed by quick cooling.

Total length of time of effective heat treatment,  
148 to 160 hours

Various schemes were initiated with the idea of shortening the time of heat treatment. These schemes are founded on the chemical composition of the untreated cast white pig-iron, without taking into consideration the size of the particles of cementite (iron carbide Fe<sub>3</sub>C).

Now, actual practice proves the impossibility of the applying such schemes.

On the other hand, various metals were added separately to the cast-iron with the object of lowering the duration of the heat treatment, but considerable trouble was encountered in arriving at a final product, consisting wholly of graphite and ferrite, and being the result of the attempts to shorten the period of heat treatment.

My invention has for its object a method that removes the above disadvantages and that allows the obtaining of a black-heart malleable cast-iron of which the composition, heat treatment and the thickness of casting form the main features.

The fusion is carried out by the usual means as

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outlined above; the process according to my invention is then distinguished by the fact that it consists in adding together calcium, aluminium and titanium in association, such combined conditions of these three metals to the cast-iron eliminating the disadvantages accruing from the addition of only one of these metals at a time.

The inclusion of these three metals together at the same time leads to a remarkable reduction of the size of the cementite (Fe<sub>3</sub>C) particles in the cast white pig-iron and this will result at the time of the heat treatment in:

1. Shortening the time of the first graphitization stage.
2. Increasing the cooling rate of the second stage of graphitization, at a rate of 20° C. per hour up to 650° C., without the pearlitic structure appearing.

3. In producing graphite in a very fine state of subdivision and smaller crystals of ferrite, giving better mechanical properties.

The white cast-iron thus produced in the form of pig shows the following composition:

Total combined carbon	Less than 3.00%
Silicon	Less than 1.50%
Manganese	Less than 0.75%
Phosphorus	Less than 0.25%
Sulphur	Less than 0.20%
Aluminium	Less than 0.30%
Titanium	Less than 0.30%
Calcium	Less than 0.30%

Castings obtained from this cast-iron are packed cold in white sand or hammer-scales in line with customary practice.

The length of time of heat treatment, that forms the main characteristic of the present invention, is shortened in proportion to the degree of fineness of the cementite particles that is tantamount to saying that under similar conditions, the length of the period of heat treatment is in direct relation to the thickness or the cooling rate of the castings.

Consequently, in accordance with the present invention, the heat treatment is carried out as follows:

From 20° C. to 900–950° C., quick heating  
At 900–950° C., 0 to 24 hours rest depending on the thickness of castings  
Cooling from 950° C. to 650° C., 20° C. per hour, say 15 hours  
Total length of time of effective heat treatment, 21 to 39 hours.

After completion of cooling, the resulting metal

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shows a black heart and is tempered throughout its entire thickness; it is machined easily, is malleable and ductile when cold.

Cast-iron produced in accordance with the present method will result in considerable savings, as compared with known methods, in handling and maintenance, and further it assures a larger output because of the fact the length of the period of heat treatment is considerably shorter than it is with any of the usual methods.

It is quite obvious that, apart from the essential inclusion of the three metals mentioned above (calcium, aluminium and titanium) with the idea of shortening the duration of the first stage of graphitization, of increasing the cooling rate of the second stage, and of getting finally a graphite-ferrite structure with particles in a very fine state of subdivision, it is also feasible, for other special requirements such as improvement of the physical and/or mechanical properties of cast-iron produced by this quick-tempering method, to embody other metals in such cast-iron, without on that account interfering with the high rate of tempering.

These metals, such as nickel, copper, cobalt, molybdenum, vanadium, etc., depending on the final product aimed at may be added in varying amounts either one by one or associated together.

Thus, for instance, if an improvement is required in the mechanical and machining qualities of the cast-iron, nickel may be embodied to advantage.

To get an increase in the tensile strength copper that blends intimately with iron and forms a solid solution therewith, may be added.

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With regard to cobalt, that can be mixed in any proportion, this metal likewise has the property of increasing the tensile strength.

What I claim is:

5 1. A method for producing black heart malleable cast-iron consisting in incorporating to white iron simultaneously substantial contents that are not higher than 0.30% of each of the following metals: calcium, aluminium and titanium, heating rapidly up to about 900 to 950° C., allowing the metal to remain at the temperature thus reached not above about 24 hours, slowly cooling down to 650° C., said latter cooling lasting altogether about 15 hours, and thereupon immediately allowing the metal to cool naturally to room temperature.

10 2. A black heart malleable cast-iron appearing with very fine cementite grains and containing substantial amounts not above 0.30% of each of the following metals: calcium, aluminium and titanium, the final structure annealed throughout being constituted by very fine graphitic elements and smaller ferrite crystals and appearing as a malleable, easily machinable metal deformable when cold.

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#### REFERENCES CITED

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

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