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PRODUCTION OF CAST IRON ARTICLES

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Fig. 1

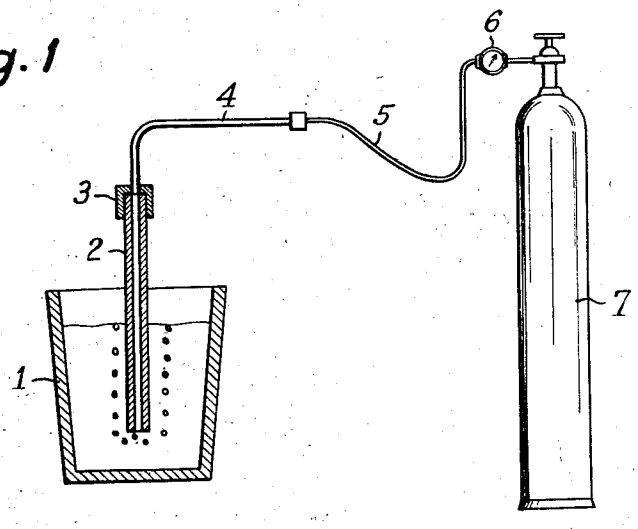
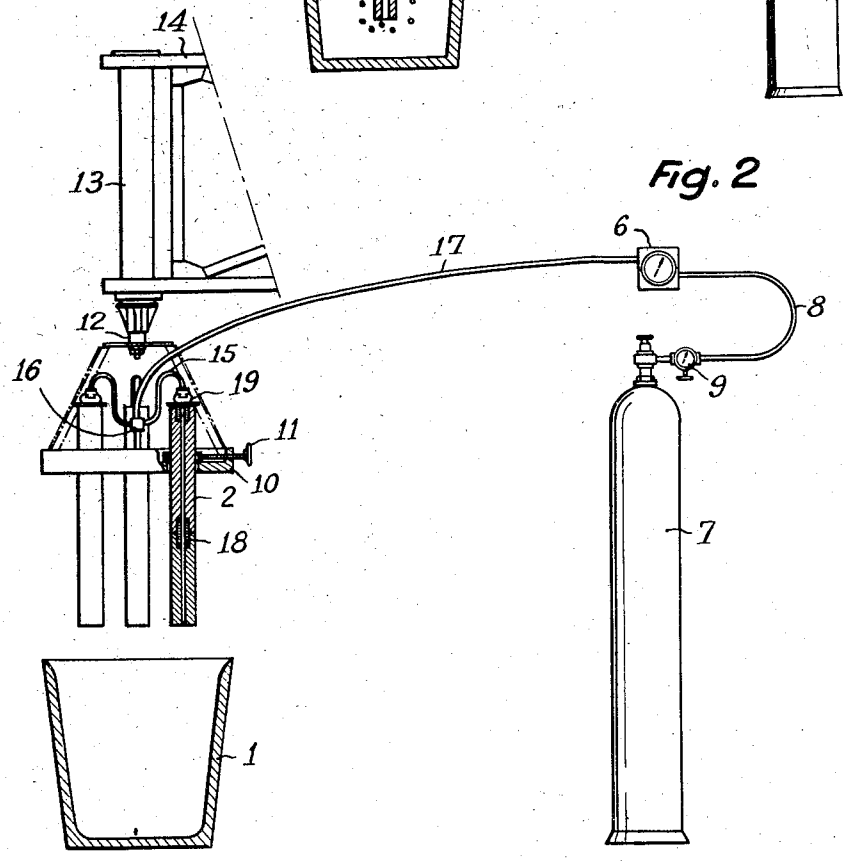



Fig. 2



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# PRODUCTION OF CAST IRON ARTICLES

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6 Claims. (Cl. 75—48)

This invention relates to the production of cast iron articles, and its objects include: the provision of a method of controlling the solidification of cast iron; controlling the tendency of molten iron to solidify as white or grey iron; controlling the depth of the cementite phase in an iron casting; the provision of a method of treating an iron melt to impart improved mechanical characteristics to the castings produced therefrom; to control the mechanical characteristics of iron castings; to provide iron castings having improved, uniform and predictable mechanical characteristics, including any or all of the following: improved machinability, reduced hardness, reduced fragility, increased tensile strength, increased wear resistance; and the provision of iron castings which will be free of hard points or areas and will be readily and uniformly machinable with cutting tools. Further objects will appear as the disclosure proceeds.

It is well known that depending on the rate at which cast iron is cooled from its initial liquid condition, solidification may proceed according to either of two different processes, one of which will yield white iron and the other grey iron, each of these two classes of iron having widely different properties. This tendency to solidify in one or the other states depends on the composition of the iron as to basic elements and other incidental factors, which are less well known and less regular in occurrence and liable to cause the effect known as anomalous hardening. Various treatments are known for acting in one or the other direction on the tendency of cast iron to solidify in either of the said forms.

Treatments are known for promoting solidification with occurrence of graphite, i. e. in the form of grey iron, which consist of adding to the bath graphitizing materials, that is materials promoting release, in graphite form, of the carbon content in the iron; such materials generally either actually consist of graphite in small amounts, or more usually silicon containing materials, such graphite or such materials generally being added in a more or less highly divided state.

If bars, tubes or solid blocks of graphite or graphitizing materials are immersed in the bath with or without relative motion, they will only exert a substantial effect on the mode of solidification after an excessively long period of time and with too low a yield so that such action cannot be considered as providing an industrial process for treating cast iron.

The present invention has for its object to provide a method of increasing in a few minutes the tendency of a given liquid cast iron to solidify in the form of grey iron, which consists of bubbling a gas through said liquid iron under conditions such that the gas will sweep past a surface of graphite or other graphitizing material. One especially desirable means to this end is to discharge the gas through a hollow body consisting of a graphitizing material, said hollow body being wholly or in part immersed in the bath. By way of example, the discharge



may occur through a graphite tube dipping into the liquid iron at one end.

The gas is discharged into the tube dipping into the metal without the necessity of first loading it with an active substance in the form of powder, cuttings or the like.

Preferably the bubbling step is so conducted that the agitation in the bath will be strong enough to throw up a spray of molten metal above the surface of the bath.

The gas employed may be an inert gas such as argon or nitrogen. Oxygen or air may likewise be used however, providing the bubbling step is short enough, of an order of from one to four minutes for standard grades of cast iron, and is performed at a time when the temperature does not exceed a certain maximum point depending on the nature of the cast iron which maximum in the case of the more usual grades of cast iron is about 1450° C. Beyond such duration and above such temperature, there is a danger of the reverse effect occurring, that is, an increase in the tendency to solidify in the form of white iron, it being noted that this latter effect is known.

The method lends itself to quite a wide range of practical uses.

*(1.) Treatment of ordinary grades of grey iron*

The characteristics generally desired for such grades of cast iron are the highest possible homogeneousness, ready machinability and absence of hard points or areas, even in those sections where thickness is low.

Now, when the invention is applied to cast iron of this type, that is by bubbling therethrough while the iron is liquid gases flowing through a graphite tube, the tendency to solidify as white iron is reduced, in other words, the chill tendency is lowered. Parts are in this way produced having more uniform hardness and enhanced machinability, and generally speaking greater homogeneousness than if the same parts were to be cast without performing such treatment, a fact which may in particular be checked by observing the fracture of test pieces known as chill test blocks.

*Example No. 1.*—An ordinary grey iron having 3.6% carbon, 1.7% silicon, 0.5% manganese, 0.1% sulfur and 0.1% phosphor, produced in a cupola, but not treated according to the invention, may at some points of a casting having a minimum thickness of as little as 5 mm., attain a Brinell hardness value of 255 with 60 Brinell units difference from one point to another in a single casting having variable thickness. A chill test block consisting of a right-angled parallelopiped 20 x 50 x 80 mm. in size, wherein one 20 x 80 mm. face is cast against a block of cast iron and the other faces against a sand mould, has under such conditions a depth of white iron of from 5 to 10 mm.

With all the production conditions remaining the same, with the exception that air is bubbled for a duration of 90 seconds through a graphite tube at a rate of 13 liters per minute prior to moulding, in a ladle containing about sixty kilograms liquid cast iron.

The maximum hardness of castings identical with those defined above is reduced to 219 and the maximum difference is only 42 Brinell units.

If nitrogen is substituted for the air, the figures observed are respectively 202 and 41 Brinell units. A chill test block cast as stated above only has a white depth of from about 1 to 3 mm. after treatment.

*Example No. 2.*—A cast iron containing 3.3% carbon, 1.9% silicon, 0.6% manganese, 0.09% sulfur and 0.6% phosphor, produced by standard methods had a case hardened depth of 4 mm.

When nitrogen was discharged into a ladle of 1200 kg. of liquid iron through four graphite tubes 110 x 10 mm. dia. and 760 mm. length, the treatment being continued

two minutes at a rate of 180 liters nitrogen per minute. The resulting depth of chill was 2 mm.

(2.) *Production of high-tensile cast iron machinable with a cutting tool*

The invention may equally be applied to certain grades of low-carbon and low-silicon cast iron, for producing high-tensile iron machinable with a cutting tool. When using known methods such cast iron on solidification shows a white structure throughout its depth, is hard, is not machinable with a cutting tool and is liable to brittle fracture under impact.

By applying the process of the invention to such grades of iron a grey structure is imparted to them, the graphite being present in the form of flakes that usually are short and thick. Cast iron thus treated has remarkable mechanical characteristics, while still being readily machinable with a cutting tool.

*Example No. 3.*—A cast iron produced by known methods having a carbon content of 2.6 to 2.8% and silicon content of 1.4 to 1.6% is not machinable and is brittle, its hardness exceeds 400 Brinell, and the above specified chill test blocks have a fracture white throughout.

According to the invention, nitrogen or argon is bubbled through the liquid bath through a graphite tube, the bubbling being initiated as the bath is at 1480° C. and continued for two minutes.

The resulting cast irons then showed tensile strengths (as measured on a cylindrical test piece machined from a 22 mm. casting or bar) in a range of from 37 to 42 kg./sq. mm. They were perfectly machinable with cutting tools, even down to a thickness of 5 mm., with a hardness of from 220 to 260 Brinell and the fracture of a chill test block was white down to a depth of only 10 to 15 mm. from the chilling surface.

*Example No. 4.*—A cast iron was produced by known methods containing 3.3% carbon, 1.1% silicon, 0.8% manganese, 0.08% sulfur, 0.15% phosphor. This was tested with a test piece 100 x 40 x 140 mm. in size one 100 x 400 face of which was cast against a block of cast iron. The depth of chill was 45 mm. The cast iron would therefore have been found difficult to machine at points where the walls did not exceed 4 cm. in thickness; it moreover would have been brittle.

According to the invention nitrogen was bubbled for two minutes at a rate of 160 liters per minute into a 1700 kg. capacity ladle through four graphite tubes 110 x 10 mm. diameter and 760 mm. length immersed in the bath. The depth of chill was reduced to 12 mm., the iron was easily machinable at all points of the pieces where the thickness was not less than 15 mm. and had an ultimate tensile strength of 34 kg./sq. mm.

(3.) *Production of cast iron having high wear resistance*

The invention may also be applied to low-carbon and low-silicon cast irons as above, under conditions such that there will remain in the iron a proportion of cementite great enough to impart high wear resistance, such proportion of cementite however being maintained low enough so that machinability will not be impaired.

Such result is attained for example by performing the treatment with a bubbling step of two minutes duration on a cast iron having 2.4% carbon and 1.3% silicon, which after treatment will have a tensile strength of 28 to 32 kg., lower therefore than in the foregoing example, but wherein a micrographic examination will reveal a network of cementite adapted to impart to this material a very substantial wear resistance under given conditions of friction.

It will be seen that the method has great flexibility in that the results obtainable depend on the rate and duration of the gas discharge which may very easily be controlled. In contrast, in conventional processes involving so-called "inoculation" by addition of materials in more or less divided form it is much more difficult to adjust and control the action of such materials.

The process forming the subject of the invention is therefore more reliable while being more economical than the inoculation processes now known.

Regardless of the grade of cast iron being processed, it has been found that the castability increased as a result of the treatment, grain size was finer and structure more homogeneous. The surface of the bath is cleaner and above all the oxide inclusions so difficult to avoid in cast iron treated by conventional inoculation with ferrosilicon or silico-calcium are not observed to be present.

The method is advantageously employed for the production of high-grade mechanical parts: components for machine tools, mill rolls, diesel and other internal combustion engine cylinder liners, ingot-moulds, etc.; these applications being only given by way of example.

It follows from the foregoing that the results of the treatment may differ somewhat with the nature of the gas involved in the bubbling step, but that the essential condition is the presence of a means of gas discharge comprising walls of graphite or graphitizing material.

The accompanying drawings illustrate by way of example, two embodiments of apparatus for performing the invention.

Fig. 1 is a diagrammatic illustration of the principle involved.

Fig. 2 shows an embodiment of more commercial character which more especially relates to the method of Example 2.

In Fig. 1 there is shown at **1** the ladle or crucible in which a bath of molten cast iron is contained. Dipping into this bath is a graphite tube **2** connected by a collar **3** with a bent rigid tube **4** which in turn is connected through a flexible tube **5** and a flowmeter **6**, to a container of compressed gas **7**, such as air or nitrogen. It is immediately clear from the drawing that the gas from the container **7** enters the bath of cast iron while sweeping past the walls of the graphite tube **2**.

In the embodiment of Fig. 2 the ladle or crucible is again shown at **1**, the compressed gas container at **7**, and the flow meter device at **6**. This device itself is connected to the container **7** through an intermediate tube **8** and a pressure reducer valve **9**. Four graphite tubes **2** are here provided and are carried by a common support **10** provided with a clamping arrangement **11**, the support **10** being in turn secured to one end of the piston rod **12** of a ram actuator **13** carried by a fixed bracket **14** above the crucible **1**. The respective tubes **2** are connected through tubes **15** with a feeder head **16** connected by a common flexible pipe **17** with the container and flowmeter **6**. The tubes **15** finally are connected at **19** with the graphite tubes.

Further in Fig. 2 there is shown at **18** a hollow union for assembling two adjacent graphite tube elements **2**. The ram **13** provides the possibility of controlling at will downward and upward movement of the graphite tubes **2** into the ladle or crucible and thereby accurately determining the duration of the process.

It will be understood that the apparatus may admit of a large number of modified embodiments, particularly as concerns the means for raising and lowering the graphite tubes.

What we claim is:

1. Process for treating liquid cast iron in order to diminish the tendency of the latter to solidify in the form of white cast iron; comprising the steps of immersing at least one member of graphitizing material in a bath of the liquid cast iron, and bubbling a gas through the bath of liquid cast iron in contact with a surface of said member, the temperature of said bath of liquid cast iron being low enough, and the period of bubbling of gas through said bath being short enough in consideration of the nature of said gas to avoid any chemical action between said gas and the liquid cast iron.

2. Process as in claim 1; wherein said bubbling of the gas is effected in a manner to cause agitation of the bath that is strong enough to throw up a spray of the liquid cast iron above the surface of the bath.

3. Process as in claim 2; wherein said gas is inert.

4. Process as in claim 2; wherein said gas contains oxygen and said bubbling is continued for a maximum of 4 minutes with the temperature of said bath being a maximum of 1450 degrees centigrade.

5. Process as in claim 1; wherein said graphitizing material consists of graphite.



6. Process as in claim 1; wherein said graphitizing material consists of silicon.

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