Jan. 26, 1960 W. H. MOORE 2,922,713

MAGNESIUM BEARING CAST IRON

Filed Oct. 31, 1957 2 Sheets-Sheet 1

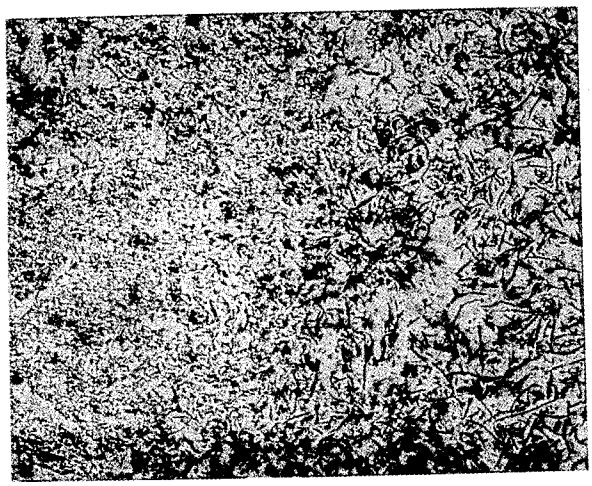


Fig. 1

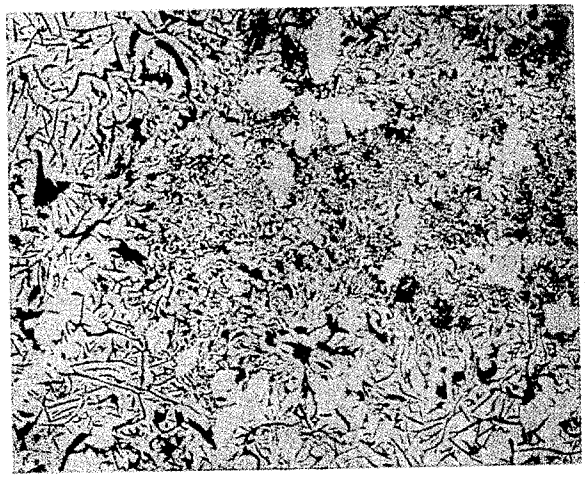


Fig. 2

INVENTOR.

BY William H. Moore

Woodling and Kroot, attys

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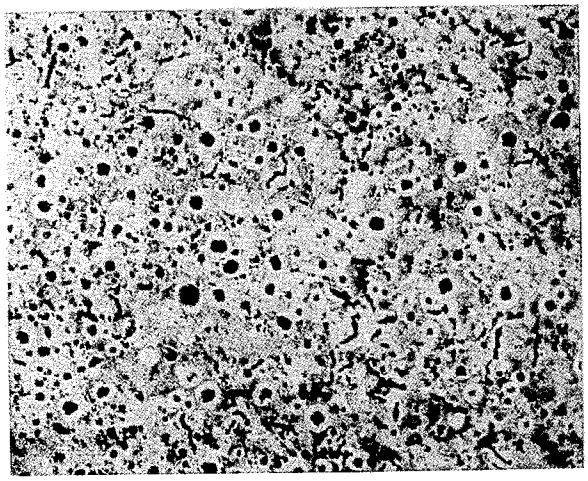


Fig. 3

INVENTOR.

BY William H. Moore

Woodling and Kroot, attys.

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MAGNESIUM BEARING CAST IRON

William H. Moore, Larchmont, N.Y.

Application October 31, 1957, Serial No. 693,653
4 Claims. (Cl. 75—130)

This invention relates to cast iron practice in general and specifically to a superior method of improving the graphite structure and physical properties of a cast iron.

The cast iron to be treated may be hypo or hyper eutectic, but one in which the uncombined carbon appears in normal flake form when cast in conventional molds. Such cast iron is characterized as having low strength and uncertain engineering properties. These poor mechanical properties of common gray cast iron are attributed to the presence of attenuated flakes of graphite which cut up the matrix in the same way as elongated cracks or fissures would do.

The present invention is directed to an improved process of making cast iron with magnesium or magnesium alloys. The process incorporates the use of calcium silicide and calcium fluoride along with magnesium alloys.

I am aware of United States Patent No. 2,485,760 relating to the production of substantially all spheroidal graphite having a radiating and polycrystalline appearance by retaining 0.04% and above magnesium in the iron. I am also aware of United States Patent No. 2,485,761 relating to compacting the graphite flake of a cast iron by retaining therein at least 0.02% and up to 0.04% magnesium. United States Patent No. 2,485,760 specifically teaches the retention of over 0.04% magnesium for the production of spheroidal graphite.

When the graphite is substantially all spheroidal, as in United States Patent No. 2,485,760, and the residual magnesium content is above 0.04%, the tensile strength of the cast iron is usually of the order of 85,000 to 120,000 pounds per square inch, although strengths as low as 63,100 pounds per square inch are also quoted in the specification.

When the graphite is compacted as in United States Patent No. 2,485,761 and the residual magnesium content is between 0.02% and 0.04%, the tensile strengths range from 23,680 pounds per square inch to 76,000 pounds per square inch.

Whereas these patents teach specifically that the presence of retained magnesium resulted in improved graphite form, it is also well known that magnesium is a carbide stabilizer and when present in the cast iron in amounts in excess of that required to produce the nodular form of graphite, detracts from the ductility of the as-cast material by the formation of excessive quantities of carbides. Most commercial castings containing more than 0.04% magnesium have to be annealed, in order to provide complete freedom from carbides.

In the product of my invention a portion of the graphite, usually 25% or more, is in the nodular form and over 30% of this is spherulitic. The tensile strength is usually above 65,000 pounds per square inch and the product of my invention contains under 0.04% magnesium and usually under 0.02% magnesium.

The product of my invention is, therefore, essentially different from that claimed in either United States Patent No. 2,485,760 or in United States Patent No. 2,485,761.

It is an object of this invention to provide a cast iron in which at least part of the graphite exists in the combined nodular and spherulitic form in the as-cast condition.

It is a further object to provide a cast iron having a tensile strength above 65,000 pounds per square inch in the as-cast condition.

It is a further object to provide a cast iron of improved mechanical properties having a residual magnesium content under 0.04%.

A still further object is to provide a means of incorporating magnesium into the melt so as to provide uniform and dependable results.

Other objects and advantages of the invention become apparent to those skilled in the art from the following description taken from the drawings in which:

Figure 1 is a photomicrograph etched and at a magnification of 100 diameters representing the same cast iron to which an 0.08% addition of magnesium in the form of magnesium ferro-silicon and 1.0% of calcium fluoride has been made.

Figure 2 is a photomicrograph etched and at a magnification of 100 diameters representing the same cast iron to which an 0.08% addition of magnesium in the form of magnesium ferro-silicon and 1.0% of calcium silicide has been made; and

Figure 3 is a photomicrograph etched and at a magnification of 100 diameters representing the same cast iron to which an 0.08% addition of magnesium in the form of magnesium ferro-silicon with 1.0% of calcium silicide and 1.0% of calcium fluoride has been made.

This present invention differs from the well known method of producing cast irons having nodular and spherulitic forms of graphite with magnesium in the manner used to modify the action of the magnesium and ensure a noticeably combined nodular and spherulitic structure with under 0.04% residual magnesium.

It is known by those skilled in the art that nodular graphite may on occasions be produced with a residual magnesium content under 0.04% when very low sulphur contents are obtained in the iron prior to the magnesium addition and even when relatively large magnesium additions are made. Contrasted to this, I am able to produce combined nodular and spherulitic graphic with retained magnesium under 0.04% by my process, without regard to the sulphur content of the iron that is to be treated.

It has not previously been disclosed that calcium fluoride together with calcium silicide and a magnesium bearing alloy, such as magnesium ferro-silicon, may be used to produce a combined nodular and spherulitic graphite with a residual magnesium content of under 0.04%.

In the process described by this invention, calcium silicide, calcium fluoride and an alloy such as magnesium ferro-silicon, are mixed together in suitable proportions and are added to the molten metal by conventional means.

I have found that the presence of calcium silicide and calcium fluoride in the addition agent enable nodular graphite to be formed with a lower magnesium content than when these materials are not used.

The following examples clearly illustrate the process of this invention.

A heat of cast iron was melted and when a portion of this heat was cast and examined, it had all of the graphite in the conventional flake form and exhibited a tensile strength of 20,500 pounds per square inch. The analysis of this test was:

T.C.	3.42
Si	1.87

Mn	0.51
S	0.06

Another portion of this melt was treated with 1.0% of a magnesium ferro-silicon alloy containing 8.0% of magnesium. This corresponds to a magnesium addition of 0.08%. This treated portion was cast and examined. It showed the graphite in the flake form with some compacted flake graphite, but with no nodular or spherulitic graphite. The tensile strength was 35,200 pounds per square inch and the analysis was:

T.C.	3.38
Si	2.32
Mn	0.52
S	0.02

Another portion of this melt was treated with 2.0% of a mixture consisting of one part of magnesium ferro-silicon and one part of powdered calcium fluoride. This corresponds to a 0.08% addition of magnesium. This portion was cast and examined. It was essentially similar to the test made with 1.0% of magnesium ferro-silicon in that the graphite was in flake form with some compacted flake, but with no nodular or spherulitic graphite (Figure 1). The tensile strength of this test piece was 36,000 pounds per square inch and the analysis was:

T.C.	3.39
Si	2.33
Mn	0.51
S	0.02

Still another portion of this melt was treated with 3.0% of a mixture consisting of one part of magnesium ferro-silicon, one part of calcium silicide and one part of calcium fluoride. This corresponds to a 0.08% addition of magnesium. This portion was cast and examined. The test piece showed the major proportion of the graphite in the combined nodular and spherulitic form together with a small proportion of compacted flake graphite (Figure 3). The tensile strength was 76,800 pounds per square inch and the analysis was:

T.C.	3.40
Si	2.52
Mn	0.50
S	0.02

A still further portion of the melt was treated with 2.0% of a mixture of one part of calcium silicide and one part of magnesium ferro-silicon. This corresponds to an 0.08% addition of magnesium. This portion was cast and examined. The test piece showed flake graphite with a very small proportion of mixed flake nodular and eutectiform graphite (Figure 2). The tensile strength was 35,000 pounds per square inch and the analysis was:

T.C.	3.37
Si	2.48
Mn	0.51
S	0.02

In another series of experiments an iron was melted having an analysis of total carbon 3.35%, silicon 1.60%, manganese 0.41% and sulphur 0.04%. A portion of this melt, when cast without any treatment, showed flake graphite. To a portion of this melt a mixture consisting of 1% magnesium ferro-silicon, 1% of calcium silicide and 1% of calcium fluoride, making a total addition of 3%, was added. The portion thus treated, was examined and found to contain a magnesium content of .012% and the graphite was found to be in the nodular and spheroidal form. A second portion of this bath was treated with an increased amount of the same mixture corresponding to 1½% of magnesium ferro-silicon, 1½ of calcium silicide and 1½% of calcium fluoride, making a total addition of 4½%. A portion cast from the thus treated melt was found to contain nodular and spheroidal graphite and had a retained magnesium content of .022%. A third portion of this melt was treated with a still further increased amount of this mixture corresponding to 2% of magnesium ferro-silicon, 2% of calcium silicide and 2% of calcium fluoride, making a total addition of 6%. A piece cast from this, so treated portion, was examined and found to contain a .031% retained magnesium and the graphite was found to be in the nodular and spheroidal form. A fourth portion of this same bath was treated with a single addition agent consisting of 2% of magnesium ferro-silicon. This so-treated portion was cast and the casting was examined and found to contain a retained magnesium content of .055% with the graphite in the nodular and spheroidal form.

These experiments clearly indicate that calcium silicide in conjunction with calcium fluoride to improve or modify the action of magnesium ferro-silicon as to produce a large proportion of nodular graphite in the iron treated and marked improvement in mechanical properties thereof. In the absence of calcium silicide and calcium fluoride the same addition of magnesium ferro-silicon does not materially affect the graphite from or the mechanical properties of the cast iron to which it has been added, unless the amount of retained magnesium is found to be above .04% as has been previously disclosed in the art.

I have varied the proportions of the agents added, viz., magnesium ferro-silicon, calcium silicide and calcium fluoride, and in each case I have found that the presence of calcium silicide and calcium fluoride is essential to the production of the nodular and spherulitic form of graphite where the amount of magnesium alloy added by itself is unable to promote this form of graphite unless the amount of retained magnesium is above .04%.

It is not clearly understood why the calcium silicide and calcium fluoride used in this invention in conjunction with magnesium so markedly modifies the action of magnesium, but it is thought that this effect is due to a mechanism of constant boiling, in which a slag is formed containing magnesium and calcium and migration from the metal to the slag or from the slag to the metal occurs until a balance is reached. Any attempt to add further quantities of magnesium to this slag by increasing the addition, would merely cause migration of the magnesium from the melt to the slag and even when relatively large quantities of magnesium are added, it is found that the metal does not absorb this magnesium content in an amount above approximately .035%.

I prefer to use magnesium ferro-silicon because of a definite economic advantage, but I have found that any other magnesium-bearing alloy may be used successfully in carrying out the process of my invention.

I also prefer to mix the agents together before addition although good results have also been obtained when the individual agents were added substantially simultaneously.

On occasions, I have found it necessary to incorporate an additional graphitizer such as ferro-silicon in the addition, although this is rarely required in view of the very strong graphitizing power conferred by the high silicon content of the agents used.

I do not wish to limit myself to any one particular form of graphite in the product of my invention. It is well known by those skilled in the art that more than one form of graphite may exist simultaneously in all gray cast iron. When the nodular graphite clearly predominates in the microstructure, the iron referred to as nodular. The product of my invention will always contain both nodular and spherulitic forms of graphite, and at least 25.0% of this type is graphite. This is accomplished with a residual magnesium content of under 0.04%, a condition which has been reported as impossible of attainment by other inventors in the field.

From the practical standpoint, my process is controlled by means of a fracture test well known ot those skilled in the art. The mixture of magnesium alloy, calcium silicon

and calcium fluoride is added until a fracture test very clearly indicates a profound change in the fracture of the iron. This change is usually accompanied by the appearance of a steely fracture and the occurrence of a ringing sound in the test piece when it is struck.

The melting of a low sulphur iron is desirable in carrying out my process, but is by no means essential. I usually prefer to treat a metal containing from 0.03% to 0.06% sulphur but I have also had good results with sulphur contents as high as 0.12% and as low as 0.01%. A relatively low sulphur iron is desirable from the economic standpoint, as with high sulphurs, large portions of the alloy added are consumed in reducing the sulphur content.

Although this invention has been described in its preferred form with a certain degree of particularly, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in details may be resorted to without departing from the spirit and scope of the invention hereinafter claimed.

This application is a continuation-in-part of application Serial Number 383,884, filed October 2, 1953, now abandoned.

What is claimed is:

1. The method of producing a cast iron casting containing nodular and spheroidal graphite from a cast iron melt, said casting having less than .04% retained magnesium, said method comprising adding to said melt a mixture of calcium silicide, calcium fluoride and a magnesium alloy, the magnesium content of said agent being in an amount in excess of that required to produce above .04% retained magnesium in the cast iron, said calcium silicide and calcium fluoride acting to limit the retained magnesium to under .04%, said magnesium alloy when

added to said melt by itself being unable to produce a casting containing nodular and spheroidal graphite at a retained magnesium level of under .04%, and finally pouring said melt to produce said casting.

2. In the process of adding magnesium to a cast iron melt that improvement consisting of adding to a melt of cast iron a mixture of magnesium ferro-silicon, calcium silicide and calcium fluoride, in amount that the total magnesium added is in excess of 0.04%, said calcium silicide and calcium fluoride in said mixture acting so as to limit the retained magnesium content of the melt to under 0.04%.

3. In the manufacture of nodular cast iron containing magnesium that improvement consisting of adding to a melt of cast iron a mixture of magnesium ferro-silicon, calcium silicide and calcium fluoride, said mixture acting so as to limit the retained magnesium of the melt to a value of less than .04%, but yet sufficient to cause free graphite to be in the nodular form.

4. The process of producing cast iron with free graphite in the nodular form by adding to a melt having a sulphur content above .02%, a mixture of calcium silicide, calcium fluoride and magnesium ferro-silicon in amount that the total magnesium added is in excess of 0.04%, said mixture producing a retained magnesium content in the melt of under .04% without first desulphurizing said melt.

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