United States Patent Office 2,762,705 Patented Sept. 11, 1956

2,762,705

ADDITION AGENT AND PROCESS FOR PRODUCING MAGNESIUM-CONTAINING CAST IRON

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No Drawing. Application January 23, 1953, Serial No. 332,998

14 Claims. (Cl. 75—130)

The present invention relates to magnesium-containing addition agents for the treatment of molten cast iron and to a process for treating molten cast iron with said addition agents to incorporate magnesium in said cast iron and to produce cast iron having graphite in a compacted form, particularly a spheroidal form.

It is well known that magnesium is highly reactive in the presence of molten cast iron. It was disclosed in the Millis, Gagnebin & Pilling U. S. Patent No. 2,485,760 that cast irons containing small but effective amounts of magnesium possessed remarkable new properties and were characterized by graphite in a spheroidal form. In the aforementioned patent, it was pointed out that it is possible to add metallic magnesium per se to molten cast iron when the latter is in a "cold" viscous or semi-fluid state. However, it was pointed out in said patent that for the purpose of operating in a commercial foundry it was usually preferable to introduce magnesium into molten cast iron in the form of an alloy of magnesium with a metal such as nickel and/or silicon and/or copper with or without other elements such as iron, manganese, etc. Satisfactory alloys to be used for the purpose of incorporating magnesium into cast iron are described in U. S. Patents Nos. 2,485,760, 2,529,346, 2,563,859, etc. It has been found that agents and alloys made of ferrosilicon and magnesium and substantially devoid of strategic metals, such as copper, nickel, etc., offer promising advantages to the commercial foundrymen because of the low cost and the absence of strategic elements. However, it has been found that when ferrosilicon-magnesium alloys are employed in a commercial foundry for the purpose of introducing magnesium into molten cast iron, these alloys do not have the desired low reactivity, do not produce the desired high magnesium recovery, and have other practical disadvantages.

The foundry art has been faced with the problem of providing an addition agent to be used for incorporating magnesium into cast iron which would have satisfactory addition characteristics when added to molten cast iron, which would provide satisfactory recovery of retained magnesium in the molten cast iron treated therewith, which would not require any substantial amounts of strategic elements and which could be employed under commercial foundry conditions for the production of magnesium-containing cast iron.

Although attempts have been made to overcome the foregoing difficulties encountered in the commercial foundry none, as far as we are aware, was entirely successful when carried into practice commercially on an industrial scale.

It has now been discovered that by the inclusion of a special ingredient and by critically proportioning all ingredients an agent comprised largely of silicon and magnesium will perform satisfactorily in the commercial foundry for the purpose of introducing magnesium into molten cast iron.

It is an object of the present invention to provide an addition agent comprised largely of silicon and magnesium, and having the property on a commercial scale of satisfactorily incorporating magnesium into molten cast iron.

Another object of the invention is to provide an addition agent for treating molten cast iron having a special and critical content of ingredients and a critical proportioning of said ingredients.

Another object of the invention is to provide a magnesium-containing addition agent having an enhanced simultaneous inoculating effect when added to molten cast iron.

The invention also contemplates providing a process for producing magnesium-containing cast iron by means of a special magnesium-containing agent having a special proportioning of ingredients which cooperate with molten cast iron baths to introduce magnesium more quietly and more efficiently into said baths.

It is a further object of the invention to provide a magnesium-containing addition agent satisfactory in a commercial foundry for the purpose of introducing magnesium into molten cast iron but which is substantially devoid of strategic heavy metals.

Other objects and advantages will become apparent from the following description.

Generally speaking, the present invention contemplates an addition agent or alloy adapted for the treatment of molten cast iron baths and comprising about 10% to about 25% magnesium, about 3% to about 14% calcium, up to about 30% iron and the balance essentially silicon with the ratio of magnesium to calcium being between about 1.3:1 and about 5.5:1. The invention also contemplates the treatment of molten cast iron with said agents to incorporate and retain magnesium in said molten cast iron.

Magnesium-containing agents within the invention represent practical compositions useful for the purpose of introducing magnesium into cast iron and perform this function satisfactorily in spite of the fact that no content of heavy, strategic metal such as copper, nickel, etc., is required. The accomplishment of this result is believed due to the cooperative effect of the ingredients specified in the agents defined hereinbefore, which effect is obtained when said agents are introduced into molten cast iron. Thus, when the magnesium content exceeds about 30%, the increased flare, heat and smoke resulting from the addition of the agent to molten iron make the agent objectionable from a practical viewpoint. When the magnesium content is decreased below about 10%, the efficiency at which magnesium is introduced into molten iron is undesirably decreased. The calcium content of the agent, in conjunction with the magnesium content, is likewise critical and the calcium content of the agent should not exceed about 14% as above this level of calcium, the efficiency at which magnesium is introduced into molten iron is again undesirably decreased and other practical difficulties are encountered, including excessive slag formation, etc. On the other hand, the calcium content should not be lower than about 3% as otherwise it is not possible to obtain the new results contemplated by the present invention, including more rapid, quieter solution of the agent in molten cast iron with higher recovery of magnesium in the cast iron. The iron content of the agents contemplated in accordance with the present invention should not substantially exceed about 30%, since the efficiency of the magnesium introduction into molten cast iron from said agents is undesirably decreased at higher iron levels and other difficulties are encountered. For example, the manu-

facture of alloys having higher iron contents is attended by increasingly violent reactions. The balance of the agents and alloys contemplated by the invention is essentially silicon, including minor amounts of impurities and ingredients which do not change the basic and novel characteristics of the composition. The silicon content of the agents is about 45% to about 75% to cooperate with the other constituents of the agents, notably magnesium and calcium, to more efficiently introduce magnesium contained in said agents into molten iron when said agents are added thereto.

It is very important that the agents contemplated by the present invention contain magnesium and calcium in the ratios set forth herein. When these ratios of magnesium and calcium are maintained, greatly improved results are obtained upon adding the agents to molten cast iron, including more rapid, quieter and smoother addition of the agent and higher recovery of magnesium in the cast iron.

The present invention also contemplates the treatment of molten cast iron baths with the agents provided by the invention for the purpose of introducing magnesium in small but effective amounts into said baths. It has been found that a cooperative effect takes place between the agents contemplated by the invention and molten cast iron baths which provides in the molten baths a higher recovery of magnesium contained in said agents. This effect is associated with the present process for treating molten cast iron employing the aforedescribed agents and is not encountered when agents having compositions outside the ranges of ingredients set forth hereinbefore are employed in treating molten cast iron in accordance with the process contemplated by the present invention.

The agents contemplated by the present invention preferably contain about 12% to about 20% magnesium, about 5% to about 10% calcium, about 8% to about 20% iron, with the balance essentially silicon, and have a ratio between the magnesium and calcium contents of the agents within the limits of about 1.5:1 and about 3.5:1. It is further preferred that the ratio between the magnesium and silicon contents of the agent be maintained between about 1:3 and about 1:6. These preferred agents enable maximum recovery of contained magnesium when added to molten cast iron. In addition, when such agents are employed in the production of gray or graphitic cast iron, consistent production of spheroidal graphite structures and of high mechanical properties are achieved. Furthermore, preferred addition characteristics are obtained.

The agents contemplated by the present invention and falling within the ranges set forth herein advantageously can contain small amounts of cerium, e. g., about 0.25% to about 5% cerium, preferably about 0.5% to about 2% cerium, and these small mounts of cerium contribute to quiet addition behavior of the agents and promote recovery of magnesium in molten cast iron treated therewith.

Besides the essential ingredients magnesium, calcium, iron and silicon, the agents also may contain small amounts of incidental impurities, including phosphorus, etc., introduced from the raw materials employed in producing the agents, etc. In addition to impurities, the alloy may also contain up to about 1% nickel, e. g., about 0.05% to about 1% nickel, up to about 1% cobalt, e. g., about 0.01% to about 0.25% cobalt, up to about 0.5% manganese, e. g., about 0.05% to about 0.5% manganese, less than about 1% aluminum, less than about 1% copper, etc.

The agents preferably are devoid of the elements arsenic, antimony, tin, bismuth, selenium, zirconium, titanium, etc., in amounts which are subversive in the cast iron to the desired effects of magnesium. When cerium is present in the agents aforedescribed, the effects of these subversive elements are minimized.

For the purpose of giving those skilled in the art a better understanding of the invention, the compositions of some magnesium-containing agents within the scope of the invention are set forth in the following table:

No.	Percent Mg	Percent Ca	Percent Fe	Percent Si	Percent Others
1	12.5	5.2	12	70	
2	13.5	5	26.8	54.5	
3	13.6	4.6	12	69.5	
4	14	5	12	Bal.	
5	14.7	5	20.6	Bal.	
6	15	5	12	68	
7	15	10	11	64	
8	15	8	20	Bal.	
9	18.3	5	11	65	
10	22.8	5	11	61	
11	27.6	5	10	57	
12	15	7	Bal.	60	0.6 Mischmetal.
13	12	5	Bal.	55	0.8 Mischmetal.
14	17	8	Bal.	65	2 Mischmetal.

For the purpose of giving those skilled in the art a better understanding of the invention, the following illustrative examples are given:

Example 1

As an illustration of the critical effect of the calcium-magnesium ratio in the addition agent upon the recovery of magnesium in cast irons, a series of alloys was prepared having the following compositions:

Alloy	Percent Mg	Percent Ca	Percent Fe	Percent Si	Mg:Ca Ratio
A	15	5	10	Bal.	3:1
B	15	10	8	Bal.	1.5:1
C	15	15	6	Bal.	1:1

Separate portions of molten gray cast iron containing about 0.12% sulfur, about 3.5% carbon and about 1.1% silicon were treated with 2% additions of the foregoing alloys, were inoculated with 0.5% silicon as ferrosilicon and cast in a similar manner. It was noted that Alloys A and B reacted quietly and rapidly with the melt but that Alloy C produced an excessive amount of a fluffy, drossy slag. The resulting castings were analyzed for magnesium with the following results:

Mg:Ca Ratio	Percent Retained Mg	Percent Mg Recovery [1]
3:1	0.058	30
1.5:1	0.053	27
1:1	0.019	10

[1] As calculated from the formula given hereinafter.

Example 2

The marked difference in magnesium recovery between Alloy B having a Mg:Ca ratio of 1.5:1 and Alloy C having a Mg:Ca ratio of 1:1 was confirmed when the experiments outlined in Example 1 were again repeated using 3% additions of Alloys B and C to treat portions of molten cast iron having the same composition as given in Example 1. The resulting castings were analyzed for magnesium with the following results:

Mg:Ca Ratio	Percent Retained Mg	Percent Mg Recovery [1]
1.5:1	0.12	35
1:1	0.023	9.5

[1] As calculated from the formula given hereinafter.

Example 3

About 300 pounds of cupola-melted gray cast iron containing about 0.07% sulfur were ladled onto a 2% addition of an addition alloy containing about 15% magnesium, about 5% calcium, about 10% iron and the

balance essentially silicon. The addition alloy reacted more quietly with, and dissolved more rapidly in, the molten cast iron than a comparable calcium-free addition alloy. The thus-treated metal was then cast without further treatment into a number of castings. The resulting castings were gray cast iron which contained graphite in a spheroidal form and contained about 0.06% magnesium, about 3.2% carbon, about 1% silicon, about 0.2% manganese and about 0.03% phosphorus. The retained magnesium content of 0.06% represents a magnesium recovery, calculated in the manner set forth hereinafter, of about 26% for this addition alloy. A comparable calcium-free addition alloy would have provided a magnesium recovery of less than 15%. A 1.2-inch diameter sand-cast arbitration bar casting made from said metal when tested transversely over 12-inch centers broke at a load of about 9100 pounds with a deflection of about 0.26 inch while 1-inch keel block castings made of said metal had a hardness of about 240 Brinell and exhibited a yield strength of about 51,000 pounds and a tensile strength of about 70,000 pounds.

Example 4

About 200 pounds of gray cast iron melted in an indirect arc furnace and containing about 0.12% sulfur, about 3.4% carbon and about 1% silicon were ladled upon a 2.5% addition of an alloy similar to that used in Example 1. This addition alloy reacted quietly and dissolved rapidly in the melt whereas a comparable calcium-free alloy was considerably more reactive and took a much longer time to dissolve in the melt. The thus-treated metal was then cast without further treatment into a number of castings which had a steely fracture and had a microstructure containing spheroidal graphite with substantially no free carbides. The castings contained about 0.074% retained magnesium, about 3.4% carbon and about 2.6% silicon. The retained magnesium content of about 0.074% represents a magnesium recovery, calculated in the manner set forth hereinafter, of about 29% for this alloy whereas a comparable calcium-free alloy provided a magnesium recovery of only 9% under similar conditions. A 1.2-inch diameter sand-cast arbitration bar casting made in this manner when tested transversely over 12-inch centers broke at a load of about 9700 pounds with a deflection of about 0.28 inch. One-inch keel bar castings made from said metal had a hardness of about 195 Brinell and exhibited a yield strength of about 59,000 pounds per square inch, a tensile strength of about 81,500 pounds per square inch and an elongation of about 13.5%.

Example 5

About 200 pounds of indirect arc furnace melted cast iron similar to that described in Example 2 was ladled upon a 2.5% addition of an agent containing about 15% magnesium, about 10% calcium, about 8% iron, with the balance essentially silicon. This addition alloy reacted quietly and dissolved rapidly in the melt whereas a comparable calcium-free alloy was considerably more reactive and required a much longer time to dissolve in the melt. The thus-treated metal was cast without further treatment into a number of castings which had a steely fracture and had a microstructure containing spheroidal graphite with substantially no free carbides. The castings contained about 0.064% retained magnesium, about 3.3% carbon and about 2.6% silicon. This retained magnesium content represents a magnesium recovery of about 25%, as calculated in the manner set forth hereinafter, whereas a comparable calcium-free alloy provided a magnesium recovery of only 9% under similar conditions. A 1.2-inch diameter sand-cast arbitration bar casting made in this manner when tested over 12-inch centers broke at a load of about 9200 pounds with a deflection of about 0.2 inch, and 1-inch keel bar castings made in this manner exhibited a yield strength of about 57,000 pounds, a tensile strength of about 84,500 pounds, an elongation of about 5% and a hardness of about 207 Brinell.

Further to illustrate the influence of the ratio of magnesium to calcium upon the addition characteristics of magnesium-containing agents such as contemplated by the present invention, the following alloys were prepared having a varying magnesium-calcium ratio:

Percent Mg	Percent Ca	Percent Fe	Percent Si	Mg-Ca Ratio
15	15	6	Bal.	1:1
15	10	8	Bal.	1.5:1
18	5	10	Bal.	3.6:1
23	5	9	Bal.	4.5:1

Sufficient of these alloys was added to separate portions of cast iron melts containing about 0.12% sulfur, about 3.5% carbon and about 1% silicon to comprise a magnesium addition of about 0.45% in each case, and the magnesium recovery which was obtained in each case is as follows:

Ratio Mg:Ca	Mg Recovery [1]
1:1	8
1.5:1	35
3.6:1	21
4.5:1	17

[1] Percent Mg Recovery = $\frac{\text{Percent Retained Mg}}{(\text{Percent Mg Added}) - (\text{Percent S in Original Iron})} \times 100$

Those skilled in the art will appreciate that a number of practical operating factors will influence the recovery of magnesium in cast iron when said cast iron is treated with the agents contemplated in accordance with the present invention. Thus, the temperature of the molten iron treated is a factor; the sulfur content is a factor since the sulfur content of the bath must be reduced to a low value, e. g., less than about 0.02%, before retained magnesium becomes effective in controlling graphite in cast iron to the spheroidal form; the manner in which the agent is added to the molten cast iron is a factor; the particle size of the addition agent is a factor; the time the molten bath is held before casting after the addition of the agent to the iron is a factor; etc. However, for most practical purposes, additions of 3% or less of the agent provided in accordance with the present invention will produce cast iron castings containing magnesium in an amount sufficient to control the occurrence of graphite in said castings in the spheroidal form. For example, additions of 3% or less will generally be sufficient in treating baths ranging in temperature from about 2500° F. to about 2750° F. and containing sulfur up to about 0.15%. It has been found that, in treating amounts of molten iron up to about 300 pounds, the agents and alloys contemplated in accordance with the present invention preferably are sized in the particle size range of about 1/16 inch to about 1/4 inch, since this particle size range provides improved magnesium recoveries in the iron castings resulting from the addition of said agents to molten cast iron. In treating larger quantities of iron, a larger particle size can satisfactorily be employed.

As those skilled in the art know, cast iron is essentially an alloy of iron, carbon and silicon in which the carbon is present in excess of the amount which can be retained in solid solution in austenite at the eutectic temperature. Preferably, the cast iron to be treated with the agents contemplated by the present invention contains at least about 87% iron and is characterized by having iron in the alpha form at atmospheric temperatures. The cast iron preferably contains about 2% to 4.5% carbon and about 1.3% to 5% silicon, for example, about 2.5% to 4% carbon and about 1.5% to about 4.5% silicon. Such cast irons may contain small amounts of alloying elements less

than a total af about 8%, e. g., up to about 5% nickel, up to about 1% molybdenum, up to about 1% chromium, etc. Manganese, sulfur and phosphorus normally are not considered alloy additions. Preferably the manganese content of the cast iron is less than about 1%. The bath to be treated may contain up to 0.25% or even 0.5% phosphorus although it is preferred that the phosphorus content be below about 0.15%, e. g., about 0.02% to 0.06%. Similarly, the sulfur content may be as high as 0.2% or more, e. g., 0.005% to 0.2%, although it is preferred that the sulfur content be below 0.15%, e. g., 0.03% to 0.1%.

Although magnesium retained in small amounts effective to control graphite to a compacted form, including a spheroidal form, in cast iron has a very powerful whitening effect therein, the special magnesium-containing agent provided in accordance with the present invention has an enhanced simultaneous inoculating effect which tends to compensate for the whitening effect of the magnesium content on the cast iron treated. Thus, in many instances, no supplemental graphitizing inoculation such as that provided by a late silicon addition is required in employing the agent provided in accordance with the present invention. For example, magnesium-containing iron castings 1 inch or more in section frequently need not be given a supplemental inoculation to insure graphitization. Similarly, when such "as-cast" irons contain about 2.25% silicon, castings ½ inch or more in section may be cast carbide-free without supplemental inoculation, and at a silicon content of about 2.75% or more, ¼-inch cast iron castings may be cast carbide-free without supplemental silicon inoculation. However, even in such cases, supplementary graphitizing inoculation such as a late addition of ferrosilicon will still produce desirable effects, including higher strength, etc., in the magnesium-containing iron.

The special magnesium-containing agents contemplated in accordance with the present invention may be manufactured in alloy form using conventional melting equipment. For example, in induction furnace melting, these special alloys may be prepared by melting together calcium-silicon, ferrosilicon and magnesium to provide the desired composition. Preferably, half the calcium-silicon (a commercial product containing about 30% to about 33% calcium) required to provide the desired calcium content is charged in the bottom of the furnace followed by the ferrosilicon (a commercial product containing about 50% to about 85% silicon) and the remaining calcium-silicon is then charged on top. As soon as the charge is molten, the magnesium should be added. In this manner, the magnesium may be added at a temperature below its boiling point, thereby eliminating magnesium flare and practically eliminating the magnesium smoke. Magnesium lowers the melting point of the melted calcium-silicon-ferrosilicon mixture sufficiently that power may be shut off during the magnesium addition.

The agents may also be prepared in the form of briquettes using powdered ingredients such as magnesium powder, ferrosilicon powder, calcium-silicon powder, etc., to give the required composition and employing a suitable binder to provide solidity in the briquette.

Although the theoretical explanation is not fully understood, it has been established through many tests that calcium in the proper ratio to magnesium has a very beneficial effect in improving the addition characteristics of and in improving the magnesium recovery from the agent of the invention. The effect of calcium in the special amounts and proportions set forth hereinbefore promotes quiet addition behavior and more rapid solution in the molten cast iron, and markedly reduces the violence of the addition reactions when molten cast iron is treated with alloys and agents provided by the present invention.

Although the present invention has been described in conjunction with certain preferred embodiments thereof, those skilled in the art will understand that variations and modifications thereof can be made. Such variations and modifications are to be considered within the purview and scope of the specification and the appended claims.

We claim:

1. As a new article of manufacture, an addition agent adapted to introduce magnesium into cast iron comprising about 12% to about 20% magnesium, about 5% to about 10% calcium, with the ratio of magnesium to calcium being between about 1.5:1 and about 3.5:1, about 8% to about 20% iron, and the balance essentially silicon.

2. As a new article of manufacture, an addition agent adapted to introduce magnesium into cast iron comprising about 12% to about 20% magnesium, about 5% to about 10% calcium, with the ratio of magnesium to calcium being between about 1.5:1 and 3.5:1 and the ratio of magnesium to silicon being between about 1:3 and 1:6, about 8% to about 20% iron, and the balance essentially silicon.

3. As a new article of manufacture, an addition alloy adapted to introduce magnesium into cast iron comprising about 12% to about 20% magnesium, about 5% to about 10% calcium, with the ratio of magnesium to calcium being between about 1.5:1 and about 3.5:1, about 8% to about 20% iron, up to about 2% cerium, and the balance essentially silicon.

4. As a new article of manufacture, an addition agent adapted to introduce magnesium into cast iron comprising about 10% to about 25% magnesium, about 5% to about 10% calcium, up to about 30% iron, with the ratio of magnesium to calcium being between about 1.5 to 1 and about 3.5 to 1, and the balance essentially silicon.

5. As a new article of manufacture, an addition agent adapted to introduce magnesium into cast iron comprising about 10% to about 25% magnesium, about 3% to about 14% calcium, up to about 30% iron, with the ratio of magnesium to calcium being between about 1.5 to 1 and about 3.5 to 1, and the balance essentially silicon.

6. As a new article of manufacture, an addition alloy adapted to introduce magnesium into cast iron comprising about 10% to about 25% magnesium, about 3% to about 14% calcium, up to about 30% iron, with the ratio of magnesium to calcium being between about 1.3:1 and 5.5:1, and the balance essentially silicon.

7. As a new article of manufacture, an addition agent adapted to introduce magnesium into cast iron comprising about 10% to about 25% magnesium, about 3% to about 14% calcium, up to about 5% cerium, up to about 30% iron, with the ratio of magnesium to calcium being between about 1.3:1 and 5.5:1, and the balance essentially silicon.

8. The process for producing magnesium-containing cast iron which comprises establishing a bath of molten cast iron and introducing into said bath an effective amount up to about 3% of an agent comprising about 12% to about 20% magnesium, about 5% to about 10% calcium and about 8% to about 20% iron, with the ratio of magnesium to calcium being between about 1.5:1 and 3.5:1 and the ratio of magnesium to silicon being between about 1:3 and 1:6, and with the balance being essentially silicon.

9. The improved process for introducing magnesium into molten cast iron which comprises establishing a bath of molten cast iron and incorporating magnesium therein by adding an effective amount up to about 3% of an alloy containing 12% to about 20% magnesium, about 5% to about 10% calcium, with the ratio of magnesium to calcium being between about 1.5:1 and 3.5:1, up to about 5% cerium, about 8% to about 20% iron, and the balance essentially silicon, and thereafter casting metal from said bath to produce cast iron castings containing magnesium.

10. The process for producing an improved cast iron which comprises establishing a bath of molten cast iron, introducing into said bath at least a small but effective amount of magnesium as an alloy containing about 10%

to about 25% magnesium, about 3% to about 14% calcium, up to about 30% iron, with the ratio of magnesium to calcium being between about 1.3:1 and 5.5:1, with the balance essentially silicon, and thereafter casting metal from said bath in an inoculated condition to produce castings containing a small but effective amount of magnesium and containing graphite in a compacted form.

11. The process for producing an improved cast iron which comprises establishing a bath of molten cast iron, introducing into said bath at least a small but effective amount of magnesium as an agent containing about 10% to about 25% magnesium, about 3% to about 14% calcium, up to about 30% iron, up to about 5% cerium, with the ratio of magnesium to calcium being between about 1.3:1 and 5.5:1, with the balance essentially silicon, and thereafter casting metal from said bath in an inoculated condition to produce castings containing a small but effective amount of magnesium and containing graphite in a compacted form.

12. As a new article of manufacture, an addition alloy adapted to introduce magnesium into cast iron comprising about 10% to about 30% magnesium, about 3% to about 14% calcium, up to about 30% iron, with the ratio of magnesium to calcium being between about 1.3 to 1 and about 5.5 to 1, and the balance essentially silicon.

13. The process for producing an improved cast iron

which comprises establishing a bath of molten cast iron, introducing into said bath at least a small but effective amount of magnesium as an alloy containing about 10% to about 30% magnesium, about 3% to about 14% calcium, up to about 30% iron, with the ratio of magnesium to calcium being between about 1.3 to 1 and about 5.5 to 1, and the balance essentially silicon, and thereafter casting metal from said bath in an inoculated condition to produce casting containing a small but effective amount of magnesium and containing graphite in a compacted form.

14. An addition agent according to claim 12 wherein cerium is incorporated in an amount up to about 5%.

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