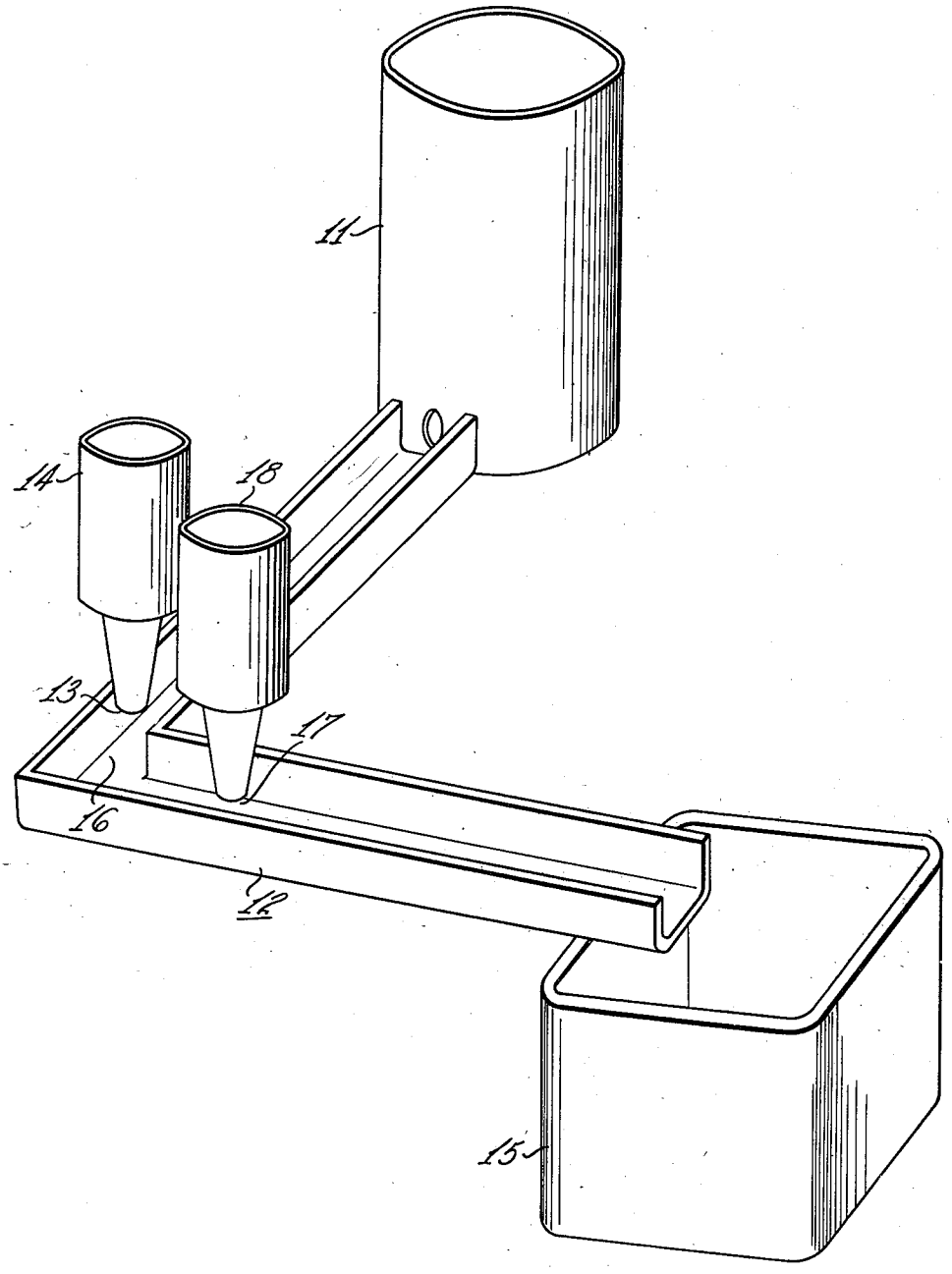
Feb. 4, 1958 W. W. EDENS 2,822,266

METHOD OF PREPARING NODULAR GRAPHITE IRON

Filed Oct. 25, 1956




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United States Patent Office 2,822,266 Patented Feb. 4, 1958



2,822,266

# METHOD OF PREPARING NODULAR GRAPHITE IRON

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Application October 25, 1956, Serial No. 618,286

9 Claims. (Cl. 75—130)

This invention relates generally to ferrous metal alloys and to methods for making them and more particularly to improved methods for making a ferrous alloy which is characterized in its as-cast state by the random dispersion of nodular graphite throughout its matrix and which is known in the art as nodular iron.

In the production of magnesium bearing nodular iron according to the salt process, the retained magnesium content of the alloy has a tendency to "drift" from about 0.018 percent by weight to as high on occasions as 0.032 percent by weight. This in turn creates a fluctuation in the amount of sulfur and oxygen present in the as-cast alloy in the form of magnesium sulfide and magnesium oxide respectively. Both magnesium sulfide and magnesium oxide adversely affect the physical properties of the as-cast alloy and it is therefore desirable to avoid them.

Further, when utilizing magnesium as a spherular graphite inducing substance, it is desirable to maintain the retained magnesium content at a consistently low level and to reduce its "drift" so as to eliminate the problems the drift creates with respect to the ease with which castings produced from the melt can be machined. The ultimate machinability of the magnesium bearing casting is believed directly related to the magnesium retained in the casting. A low magnesium content eliminates or otherwise reduces the occurrence of those carbides, sulfides and oxides of magnesium which decrease ease of machinability when they are present.

The aforementioned drift of retained magnesium content from 0.018 percent to as high on occasions as 0.032 percent represents a fluctuation of 77 percent from the approximate low of 0.018 percent. It is herewith proposed that the machinability of the castings produced can be significantly enhanced by providing a way for substantially reducing the drift range of the magnesium content between succeeding heats while maintaining a maximum value of retained magnesium at about 0.020 percent or less. The present invention provides such a way.

Generally, the present invention provides a reproducible and consistent nodular iron product of easily controlled magnesium and extremely low sulfur and oxygen content by the inoculation of molten iron successivley with two salt mixtures and casting the inoculated melt during the period in which the synergistic coaction of the mixtures with the iron is effective in providing an as-cast alloy characterized by randomly dispersed graphitic spheroids throughout its matrix.

Accordingly, one of the prime purposes and objects of this invention is to provide an improved method utilizing the salt concept of making nodular iron which results in a product which is easily reproduced and consistently has less than 0.030 percent retained magnesium in the castings produced therefrom.

Another object of the present invention is to provide an improved method for making nodular iron utilizing the salt concept which results in a product consistently



having a residual sulfur content of the magnitude of about 0.002 to about 0.007 percent.

A further object of the present invention is to provide an improved method for making nodular iron utilizing the salt concept which results in a product having a consistently low residual oxygen content of the magnitude of about 0.01 percent or less.

A still further object of the present invention is to provide an improved method for making nodular iron utilizing the salt concept which results in a more uniform product capable of being more easily reproduced.

These and still further objects are fulfilled in a manner which shall become apparent from a consideration of the following detailed descriptive matter in conjunction with the accompanying drawing which illustrates one embodiment of the present invention. The method of the present invention involves broadly the introduction of first and second salt mixtures into a melt of a molten ferrous metal containing graphite-yielding carbon to provide a low-sulfur low-oxygen nodular iron having a retained magnesium content which is easily reproduced between successive heats.

Specifically, one embodiment of the present invention comprises heating a ferrous metal containing graphite-yielding carbon until it is molten, which in normal foundry practice is between 2500° and 2900° F. When the iron reaches this heat it is inoculated with the first salt mixture which contains by weight from about 30 to about 50 percent sodium chloride and from about 50 to about 70 percent calcium silicon.

When the mixture is introduced into the melt, a reduction reaction takes place between the sodium chloride and calcium silicon which frees the sodium from combination with the halogen and enables it to act upon the molten iron as free sodium. It is believed that the affinity of sodium for the sulfur and oxygen contained in the molten iron results in entrapment or impounding of the sulfur and oxygen by the sodium. The sulfur and oxygen are thus significantly reduced from the molten iron.

After the first mixture has been introduced into the molten iron and while the sulfur and oxygen are effectively entrapped, a second salt mixture containing from about 30 to about 50 percent magnesium chloride and from about 50 to about 70 percent calcium silicon is added to the bath. The addition of the second mixture is made a relatively short period after the first inoculation although the precise time interval is limited only as stated above. This mixture also experiences a reduction reaction between the magnesium chloride and calcium silicon during which magnesium is freed to act upon the bath. Shortly thereafter, and while the second salt mixture is synergistically operating with the first salt mixture and the molten iron to induce the formation of spherular graphite, the bath is cast and permitted to cool.

One embodiment of the present invention is shown in the drawing and comprises preparing a molten bath of a ferrous alloy containing graphite-yielding carbon by heating the alloy in a basic cupola 11 to about 2700° F. The molten bath is then fed down a runner 12 or spout where it is inoculated, as at 13, with a charge of about 20 lbs. per ton of iron of a salt mixture containing 40 percent sodium chloride and 60 percent calcium silicon by weight. This first salt mixture drops by gravity feed from hopper 14. After the introduction of the first salt mixture into the molten bath, the inoculated bath, still in the runner 12 passing toward a pouring ladle 15, passes through an elbow 16 provided in runner 12 to impart turbulence into the molten stream to insure mixing between the molten iron and the first salt mixture. Upon leaving the elbow 16, the bath is inoculated again, as at 17, with

a charge of about 40 lbs. per ton of iron of a second salt mixture containing 40 percent magnesium chloride and 60 percent calcium silicon by weight. This second salt mixture is fed by gravity feed from hopper 13. The turbulence imparted to the stream by the elbow 16 in the runner continues and assures a thorough mixing of the stream and the second salt mixture.

The stream is caught in a pouring ladle 15 and poured into molds (not shown) in a normal manner to provide an as-cast ferrous alloy having spherular graphite inclusions randomly dispersed throughout its metallic matrix having a retained magnesium content of approximately 0.020 percent, a retained sulfur content of about 0.002 to about 0.007 percent and a retained oxygen content of up to about 0.01 percent.

In the foregoing example, 20 lbs. of the first salt mixture per ton of iron treated were introduced. It has been found that a charge of the first salt mixture weighing approximately one percent the weight of the initial iron charge will effectively remove from the iron bath about 50 percent of the sulfur it initially contained. A charge of the first salt mixture weighing about three percent by weight of the initial iron charge will remove about 70 percent of the initial sulfur. No appreciable gain is achieved by increasing the amount of the first salt mixture beyond three percent by weight of the iron to be treated. A desirable amount of the first salt mixture is approximately two percent by weight of the iron being treated.

The foregoing example further described the introduction of 40 lbs. of the second salt mixture per ton of iron treated, which is approximately 2 percent by weight of the iron treated. It has been found that less than 2 percent may be used to provide satisfactory results but that when 2 percent is exceeded, the results are less desirable and machinability, impact strength and ductility are adversely affected.

As previously mentioned, the second salt mixture is added to the molten bath a short period after the bath has been inoculated with the first salt mixture. Though the precise time interval does not appear to be critical beyond the limits herein defined, the method is found to be most effective when the time lag between introductions does not exceed several minutes and excellent results were obtained when, as in the described example, the introductions were made into a flowing stream on opposed sides of an elbow in such a manner as to impart considerable turbulence to the stream. The time interval practiced under given circumstances will readily occur to one skilled in the art and will be determined by the total weight, the composition of the melt initially charged into the cupola, and the apparatus available. The prime limitation, if it be one, is that the first mixture be given sufficient time to react and yet not sufficient time to be spent. In laboratory operations using a fourteen pound heat, it is found that when the introduction of the second mixture is made two to three seconds after the introduction of the first mixture, the results are desirable. It further is apparent that a basic cupola, having a capacity of thousands of pounds in contrast to the electric induction furnace of the laboratory having a capacity of fourteen pounds, will tolerate a greater time lag although the ratio of the time lag to the quantity of material being treated should remain fairly constant.

The synergistic action of the two mixtures upon the molten iron bath provides results which are wholly unpredictable and to a certain extent unexplainable. Thus when molten iron is treated with magnesium chloride and calcium silicon without first being treated with the mixture of sodium chloride and calcium silicon, residual sulfur content runs from about 0.015 to about 0.018 percent and more magnesium is required to impel the desired nodular graphite structure. It is believed that this result is attributal to a certain amount of the magnesium being captured as magnesium sulfide and magnesium oxide. On the other hand, when the molten iron bath is treated according to the present invention, the sulfur and oxygen, which would otherwise contaminate and capture the magnesium, is effectively dispelled from the bath. The reason why sulfur and oxygen are dispelled is not fully understood. It may be a result of the action of the sodium, the synergistic coaction of the sodium and the magnesium, the synergistic coaction of the two salt mixtures, or a combined effect of any or all of the three.



A further observed result is the ability to hold the melt in the ladle for an exceedingly greater period of time than heretofore possible without losing the nodular effect on the graphite. Again the reasons for this phenomenon are not fully understood.

It is understood that the foregoing description describes only an exemplary embodiment of this invention and is not limited strictly thereto inasmuch as the present invention is intended to be limited only in the scope of the appended claims. Such modifications as may readily occur to one skilled in the art who is familiar with the present disclosure are likewise includable within the intended scope of the present invention such as, e. g., using halides other than the chlorides of sodium and magnesium; using known reducing agents other than calcium silicon; or making other equally obvious modifications.

What is claimed is:

1. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; treating said molten bath by successive additions of a first and a second salt mixture to said bath, said first salt mixture containing from about 30 to about 50 percent sodium chloride by weight and the remainder essentially calcium silicon, said second salt mixture containing from about 30 to about 50 percent magnesium chloride by weight and the remainder essentially calcium silicon; and casting said treated bath while said mixtures are effective in inducing the formation of spherular graphite.

2. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; introducing to said molten bath a first salt mixture weighing from about one percent to about three percent of the weight of the molten cast iron and containing from about 30 to about 50 percent sodium chloride by weight and the remainder essentially calcium silicon; introducing a second salt mixture to said molten bath, said second salt mixture containing from about 30 to about 50 percent magnesium chloride by weight and the remainder essentially calcium silicon; and casting said treated bath while said mixtures are effective in inducing the formation of spherular graphite.

3. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; introducing to said molten bath a first salt mixture weighing from about one percent to about three percent of the weight of the molten cast iron and containing from about 30 to about 50 percent by weight sodium chloride and the remainder essentially calcium silicon; introducing to said molten bath a second salt mixture weighing about two percent of the weight of the molten cast iron and containing from about 30 to about 50 percent by weight magnesium chloride and the remainder essentially calcium silicon; and casting said treated bath while said mixtures are effective in inducing the formation of spherular graphite.

4. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; treating said molten bath by adding successively a first and a second salt mixture to said bath, said first salt mixture containing about 40 percent sodium chloride and about 60 percent calcium silicon by weight, said second salt mixture containing about 40 percent magnesium chloride and about 60 percent calcium silicon by weight; and casting said treated bath while said mixtures are effective in inducing the formation of spherular graphite.

5. The method of making a ferrous alloy characterzied in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; treating said molten bath by adding successively a first and a second salt mixture to said bath, said mixtures weighing approximately three percent and two percent respectively of the weight of the molten iron contained in the bath, said first salt mixture containing 40 percent sodium chloride and about 60 percent calcium silicon by weight, said second salt mixture containing about 40 percent magnesium chloride and about 60 percent calcium silicon by weight; and casting said treated bath while said mixtures are effective in inducing the formation of spherular graphite.

6. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; introducing into said bath a first salt mixture containing from about 30 to about 50 percent sodium chloride by weight and the remainder essentially calcium silicon; creating turbulence in said bath to mix said mixture with said bath; introducing into said turbulent bath a second salt mixture containing from about 30 to about 50 percent magnesium chloride by weight and the remainder essentially calcium silicon; and casting said treated bath while said first and second mixtures are effective in inducing the formation of spherular graphite.



7. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; treating said molten bath by adding successively a first and a second salt mixture to said bath, said first salt mixture containing from about 30 to about 50 percent of a sodium halide by weight and the remainder essentially calcium silicon, said second salt mixture containing from about 30 to about 50 percent magnesium halide by weight and the remainder essentially calcium silicon; and casting said treated bath while said mixtures are effective in inducing the formation of spherular graphite.

8. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; inoculating said molten iron with sodium carried by a mixture of a sodium halide and calcium silicon; imparting turbulence into said inoculated iron to distribute said mixture throughout said iron; inoculating said turbulent molten iron with magnesium carried by a mixture of a magnesium halide and calcium silicon; and casting said twice inoculated iron while said mixtures are effective in inducing the formation of spherular graphite.

9. The method of making a ferrous alloy characterized in its as-cast state by a metallic matrix having spherular graphite inclusions randomly dispersed therethrough comprising: providing a bath of molten cast iron containing graphite-yielding carbon; inoculating said molten iron with sodium carried by a mixture of a sodium halide and calcium silicon; imparting turbulence into said inoculated iron to distribute said mixture throughout said iron; inoculating said turbulent molten iron with a magnesium-bearing material; and casting said twice inoculated iron while said mixture and said material are effective in inducing the formation of spherular graphite.

No references cited.