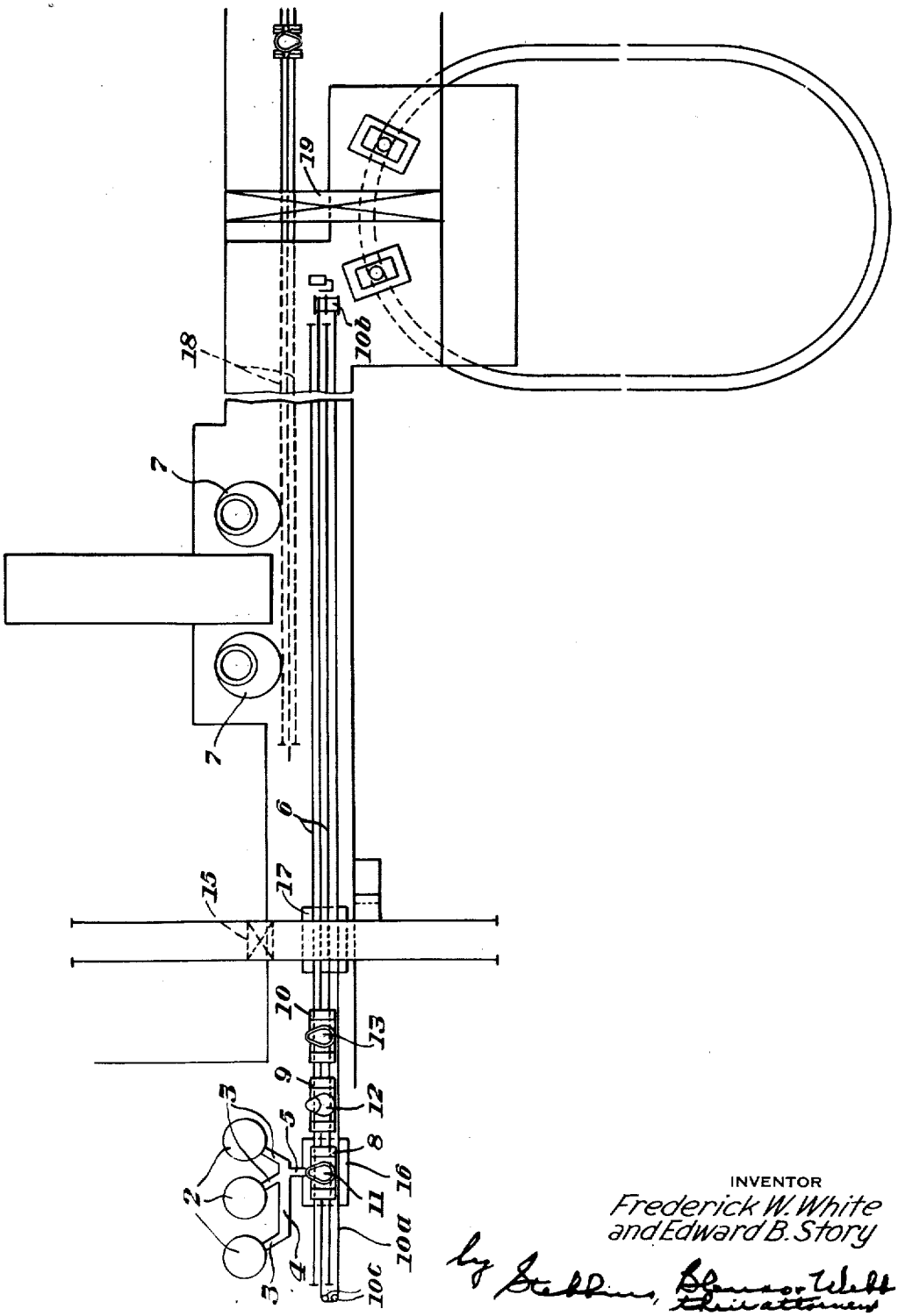
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DESULFURIZING MOLTEN FERROUS METAL

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DESULFURIZING MOLTEN FERROUS METAL

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This invention relates to desulphurizing molten ferrous metal. It relates particularly to the desulphurizing of molten ferrous metal when it is desired that the desulphurized metal shall be uniform as to sulphur content and that the sulphur content shall be relatively low.

Desulphurized molten ferrous metal which is uniform as to sulphur content and in which the sulphur content is quite low is in demand for various uses. One such use is the admixture of the desulphurized molten ferrous metal with molten iron silicate slag to form by the Aston process wrought iron sponge balls which are ultimately worked into wrought iron products. If the metal is not uniform as to sulphur content the resultant wrought iron is non-uniform and in particular cases may not meet specifications or may be unsuited for the use for which it is intended. If the sulphur content is not uniformly desirably low in metal for use in the manufacture of wrought iron by the Aston process which is to be used for certain purposes, as, for example, stay bolts, the wrought iron may not meet specifications and may be otherwise unsatisfactory.

The sulphur content of the metal also constitutes a limiting factor with respect to the temperature at which wrought iron made by use of the metal may be rolled. For reasons well known to those skilled in the art it is desirable to effect at least part of the rolling at relatively low temperature. If the rolling procedure is established for a certain desirably low finishing temperature and particular billets of wrought iron have a sulphur content higher than the sulphur content compatible with the particular finishing temperature being employed defective rolling may and probably will result.

Heretofore it has not always been possible to produce molten ferrous metal for use in the manufacture of wrought iron by the Aston process which had desirably low sulphur content. Very low sulphur ferrous metal could not be obtained when the sulphur content of the metal prior to desulphurizing and refining was higher than usual. It is customary in producing molten ferrous metal for the manufacture of wrought iron by the Aston process to melt the metal in cupolas. When the sulphur content of the molten metal as tapped from the cupolas was unusually high this relatively high sulphur content carried through the desulphurization step and the refining (e. g., Bessemerizing) step, the result being wrought iron of undesirably high sulphur content which might not meet specifications or be suited to particular intended uses or which might not

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roll satisfactorily at particular rolling temperatures being employed.

It is common to desulphurize molten ferrous metal by admixing the molten ferrous metal with a molten desulphurizer, such, for example, as caustic soda or soda ash. The admixing is customarily effected by pouring the molten metal into the molten desulphurizer which is maintained in a receptacle. The sulphur in the metal and the desulphurizer react in known manner so that the sulphur content of the metal is reduced, the desulphurizer, being of relatively low specific gravity as compared with the metal, forming as a slag on top of the metal and carrying with it the sulphur extracted from the metal. The metal and the slag are separated either by decanting off the slag or by withdrawing the metal from beneath the slag.

It has heretofore been proposed to maintain a quantity of molten desulphurizer or desulphurizing slag and successively pour batches of molten ferrous metal to be desulphurized into the slag, replenishing the slag from time to time with new desulphurizer in solid form. The introduction into the ladle containing the molten desulphurizer of replenishing desulphurizer in solid form results in foaming of the slag. Sometimes the slag effervesces so that it overflows the receptacle. It has not been possible by the procedure mentioned to obtain uniformly desirably low sulphur content in batches of molten ferrous metal.

We have discovered that efficient desulphurization is interfered with by foam in the desulphurizing ladle. When the metal is poured into and through a foamy desulphurizing slag the slag apparently does not have sufficient body to cause the metal as it strikes and passes through the slag to break up into relatively small particles which can effectively react with the slag. The desulphurizing reaction is an interface reaction and its efficiency is dependent upon intimate contact of small particles of metal with the slag. We have found that desirably intimate contact does not take place when the desulphurizing slag is foamy.

The principal cause of foam in the desulphurizing slag is the driving off of water of crystallization in the replenishing desulphurizer which is introduced in solid form. The water of crystallization forms steam which creates an ebullience in the slag resulting in the undesirable foamy condition above described.

We have discovered that if the addition of solid replenishing desulphurizer to the molten desulphurizer in the desulphurizing ladle is avoided the undesirable foamy condition of the molten desul-

phurizing slag is likewise avoided. By avoiding adding solid replenishing desulphurizer to the molten desulphurizer in the desulphurizing ladle we can maintain a relatively thick homogeneous slag of relatively high specific gravity which very effectively and uniformly desulphurizes the metal, bringing about results not previously obtainable.

We obviate undesirable foaming of the desulphurizing slag by melting the replenishing desulphurizer before it is introduced into the desulphurizing ladle. If the water of crystallization has been driven off by melting of the replenishing desulphurizer before it meets the main body of molten desulphurizer in the desulphurizing ladle there is very little ebullience or foaming and the slag possesses the desirable characteristics above mentioned.

The replenishing desulphurizer may be premelted in various ways, for example, in a separate furnace provided for that purpose or by the heat of the molten ferrous metal which is to be desulphurized. In one manner of procedure the replenishing desulphurizer may be admixed with the molten ferrous metal which is to be desulphurized before that molten ferrous metal has been admixed with the main body of molten desulphurizing slag. A limited amount of foaming occurs when the solid replenishing desulphurizer is admixed with the molten ferrous metal but the foaming is not excessive because the replenishing desulphurizer is of relatively limited mass and is segregated from the main body of molten desulphurizer in the desulphurizing ladle.

We preferably melt ferrous metal in cupolas and tap the cupolas into a tapping ladle. At the beginning of tapping the tapping ladle is preferably empty. During tapping the solid replenishing desulphurizer may be thrown into the tapping ladle where it is melted by the heat of the molten metal. The quantity of replenishing desulphurizer is small compared with the quantity of desulphurizer in the main body of molten desulphurizer in the desulphurizing ladle. For example, for each heat of 27,000 pounds of molten ferrous metal from one hundred to four hundred pounds of solid replenishing desulphurizer may be thrown into the tapping ladle during tapping of the metal from the cupolas.

When the replenishing desulphurizer is all or substantially all melted in the tapping ladle and the tapping for that heat has been concluded the contents of the tapping ladle are poured into the desulphurizing ladle which contains the main body of molten desulphurizing slag which is maintained in the desulphurizing ladle. The contents of the tapping ladle are poured into the desulphurizing ladle slowly and preferably in a stream which has considerable area so that an opportunity for the metal to break up into small particles as it passes into and through the desulphurizing slag is afforded. The desulphurizing slag is desirably of considerable depth, as, for example, 12 to 18 inches. The desulphurizing ladle is preferably a ladle of the hooded type having a pouring orifice below its top.

As each batch of molten metal with the relatively small amount of replenishing desulphurizer admixed with it is poured into the desulphurizing ladle the level of the molten contents of the desulphurizing ladle rises until some of the slag, which because of its lower specific gravity rises to the top, may pass out or be discharged through the pouring orifice of the ladle. Preferably the mass of the thus discharged slag is substantially equal to the mass of the replenishing desulphurizer which is thrown into the tapping ladle as above described. Thus at each heat a predetermined mass, say 300 pounds, of replenishing desulphurizer may be added in the tapping ladle and a substantially equal mass of spent desulphurizing slag discharged through the pouring orifice of the desulphurizing ladle while the contents of the tapping ladle are being poured into the desulphurizing ladle. The discharge of the spent slag in this manner of procedure is automatic and the mass of slag discharged will always be substantially the same as the mass of the replenishing desulphurizer added in the tapping ladle since the mass of molten metal poured out of the desulphurizing ladle after desulphurization therein is substantially equal to the mass of metal poured into that ladle.

As an alternative procedure, instead of causing a portion of the spent desulphurizing slag to be discharged through the pouring orifice of the desulphurizing ladle in each cycle of operation as above described, the surface of the desulphurizing slag may be maintained normally well below the pouring orifice of the desulphurizing ladle so that spent desulphurizing slag will not be automatically discharged through the pouring orifice. At desired intervals spent desulphurizing slag may be discharged from the pouring orifice of the desulphurizing ladle by tilting the desulphurizing ladle to pour out a desired quantity of spent desulphurizing slag. This may be done in each cycle of operation or it may be done less often than in each cycle of operation, as, for example, in each third or fourth cycle.

After the contents of the tapping ladle have been poured into the desulphurizing ladle as above explained the desulphurizing ladle is picked up by an overhead crane, moved to a position above a transfer ladle and tilted to pour out the desulphurized metal into the transfer ladle, the desulphurizing slag being retained in the desulphurizing ladle. This is accomplished by initially rapidly tilting the desulphurizing ladle so that the slag which floats on top of the metal passes quickly past the pouring orifice of the ladle so that a negligible amount of slag passes out through the pouring orifice before pouring of the desulphurized metal begins. Desirably the mass of metal poured into the desulphurizing ladle has previously been ascertained and the transfer ladle is disposed on a scale and the pouring is stopped when the mass of desulphurizing metal poured out of the desulphurizing ladle into the transfer ladle substantially equals the mass of metal poured from the tapping ladle into the desulphurizing ladle. A small amount of metal may be and desirably is left in the desulphurizing ladle to avoid pouring out any substantial amount of slag when the metal is poured into the transfer ladle. If all the metal were poured out it would be difficult to avoid pouring out some slag with it at the end of the pour.

The desulphurized metal in the transfer ladle may be poured into a Bessemer converter and refined by Bessemerizing. The molten Bessemerized metal may then be admixed with molten iron silicate slag to make a wrought iron sponge ball by the Aston process. This is preferably done by pouring the molten metal into and through the iron silicate slag as is now well known.

Our desulphurizing process may be employed in desulphurizing molten ferrous metal tapped from a blast furnace or melted in a cupola, air furnace or other melting furnace.

Other details, objects and advantages of the

invention will become apparent as the following description of a present preferred method of practicing the same and present preferred apparatus for the practice thereof proceeds.

In the accompanying drawing we have illustrated a present preferred method of practicing the invention and have shown present preferred apparatus for use in the practice thereof, in which the figure is a plan view, largely diagrammatic, of a portion of a plant for the manufacture of wrought iron by the Aston process.

Referring now more particularly to the drawing, there is provided a battery of cupolas, three being shown and being designated by reference numeral 2. The cupolas have runners 3 connected by a trough 4 having a delivery portion 5 disposed at a tapping station. By the arrangement shown any one or more of the cupolas may be tapped at one time and the molten metal tapped therefrom is delivered at the tapping station. There is provided a straight track 6 which extends past the cupolas and also past a battery of Bessemer converters 7, two converters being shown. Disposed on the track 6 are three cars 8, 9 and 10. The cars 8, 9 and 10 are releasably coupled together. Any suitable source of motive power is provided for moving the cars 8, 9 and 10 along the track. For example, a cable 10a may have its ends connected with the car 10 and may pass about a winding drum 10b and a sheave 10c. As the cars are releasably coupled together the car 10 may be moved alone or the cars 9 and 10 may be moved without the car 8, or all three cars may be moved together.

A tapping ladle 11 is mounted on the car 8. A desulphurizing ladle 12 is mounted on the car 9. A transfer ladle 13 is mounted on the car 10. The ladles 11 and 13 are of the open top lip pour type. The ladle 12 is of the hooded type having a pouring orifice below the top thereof. A hooded type ladle is shown in Patent No. 2,241,434. All three ladles are removably mounted upon their respective cars so that they can be picked up by an overhead crane 15, moved from one position to another and tilted to pour out their contents.

Two scales are provided, one being designated 16 and being disposed at the tapping station and the other being desginated 17 and being disposed generally beneath the runway for the crane 15.

A preferred method of operation will now be described. At the beginning of operation all three ladles 11, 12 and 13 will be empty, but after a few heats have been tapped from the cupolas a substantial volume of molten desulphurizer or desulphurizing slag will be maintained in the desulphurizing ladle 12. We shall describe the treatment of a heat of molten ferrous metal during operation and when the desulphurizing ladle 12 contains its normal quantity of desulphurizing slag. The desulphurizer used is preferably caustic soda although soda ash or other suitable desulphurizer may be employed. Caustic soda is supplied in solid crystalline form and has to be rendered molten for the desulphurizing of molten ferrous metal. During normal operation after the starting period the desulphurizing ladle 12 will contain a substantial depth of molten desulphurizing slag, perhaps 12 to 18 inches.

With a quantity of molten desulphurizer or desulphurizing slag being maintained in the desulphurizing ladle 12 and with the tapping ladle 11 and the transfer ladle 13 empty, one or more of the cupolas 2 is or are tapped into the tapping

ladle 11, which is disposed at the tapping station on the scale 16. The weight of molten ferrous metal tapped from the cupola or cupolas into the tapping ladle 11 is determined by the scale 16. In the normal operation at the Ambridge plant of A. M. Byers Company about 27,000 pounds of molten ferrous metal is tapped from the cupolas at each heat. During the time when the molten ferrous metal being tapped from the cupolas is flowing into the tapping ladle 11 there is introduced into the tapping ladle 11 a replenishing quantity of caustic soda which may have a mass of the order of 300 pounds for a 27,000 pound heat of molten ferrous metal. Preferably a small amount of molten metal is first allowed to run into the tapping ladle whereupon the solid caustic soda is thrown into the ladle. The solid caustic soda may be thrown in in portions at spaced intervals.

The heat of the molten metal melts the caustic soda and drives off the water of cyrstallization which forms steam and causes some amount of foaming in the tapping ladle. While a foamy desulphurizing slag in the desulphurizing ladle is undesirable for reasons above explained, the presence of some foam in the tapping ladle is not serious inasmuch as the desulphurizing action of the desulphurizer in the tapping ladle is only partly relied on. The purpose of introducing the replenishing quantity of desulphurizer in the tapping ladle is to melt that desulphurizer before introducing it into the desulphurizing ladle. The premelting of the replenishing desulphurizer before it is introduced into the desulphurizing ladle obviates objectionable foaming in the desulphurizing ladle.

When about 27,000 pounds of molten metal have been tapped into the tapping ladle 11 as determined by the scale 16 the tapping is stopped and the tapping ladle 11 is picked up by the overhead crane and its contents are poured into the desulphurizing ladle 12. Preferably the tapping ladle 11 is provided with a wide shallow pouring lip so that the stream issuing therefrom may easily break up into small particles as it enters and passes through the molten desulphurizing slag in the desulphurizing ladle 12. As explained above this promotes effective desulphurization.

During pouring of the contents of the tapping ladle 11 into the desulphurizing ladle 12 slag will issue from the pouring orifice of the desulphurizing ladle. This is because the volume of metal and slag which would be contained in the desulphurizing ladle 12 if the pouring orifice were plugged is such that it would extend above the level of the pouring orifice sufficiently that about 300 pounds of slag would be above that level, i. e., a mass of slag equal to the replenishing mass of desulphurizer introduced into the tapping ladle 11 as above explained. Consequently upon each heat there is a discharge through the pouring orifice of the desulphurizing ladle 12 of a mass of spent desulphurizing slag substantially equal to the mass of replenishing desulphurizer added during that heat. In this way a constant volume of desulphurizing slag is maintained and continually revivified.

After the contents of the tapping ladle 11 have been poured into the desulphurizing ladle 12 as above explained the desulphurizing ladle is picked up by the overhead crane and the train of cars is moved to the right, viewing the drawing, to position the car 10 on the scale 17. The desulphurizing ladle 12 is positioned over the transfer ladle 13 and is tilted to pour out a portion of its con-

tents through the pouring orifice. The desulphurizing ladle is initially tilted very rapidly so that the slag therein which because of its lower specific gravity floats upon the metal will rise above the level of the pouring orifice without a substantial portion of the slag passing through the pouring orifice. The desulphurized metal is poured out of the desulphurizing ladle 12 into the transfer ladle 13 until 27,000 pounds of molten metal, i. e., the same mass as was tapped from the cupolas in the same heat, is in the transfer ladle 13. Then the desulphurizing ladle 12 is quickly tilted back to upright position.

After the operation just described the desulphurizing ladle 12 will contain the same mass of desulphurizing slag and metal as at the beginning of the heat because 27,000 pounds of metal and 300 pounds of desulphurizer were introduced into the ladle 12 from the ladle 11, 27,000 pounds of metal were poured from the ladle 12 into the ladle 13 and 300 pounds of slag issued from the pouring orifice of the ladle 12. A small amount of metal remains in the ladle 12 with the slag to obviate pouring out of slag near the end of the pour when metal is poured from the ladle 12 into the ladle 13, which would be likely to occur if an effort were made to pour out all of the metal.

There will be some slag on top of the metal in the transfer ladle 13. That slag is raked off, whereupon the car 10 is moved to a position opposite one of the Bessemer converters 7 where the desulphurized metal is poured from the transfer ladle 13 into the converter. That metal is refined in the converter in the usual way after which it is delivered from the converter in a ladle mounted on a car movable on a track 18 below the level of the track 6 to a processing station 19 where it is poured into a bath of molten iron silicate slag maintained in a ladle to form a wrought iron sponge ball by the Aston process as known in the art.

When the plant is being started up there will be no molten desulphurizing slag in the desulphurizing ladle 12. In other words, as mentioned above, all three of the ladles 11, 12 and 13 will be empty. The cupolas are tapped into the ladle 11 but in the first heat instead of tapping only 27,000 pounds, which is a normal heat, a somewhat greater mass of metal will be tapped into the ladle 11, for example, 29,000 to 30,000 pounds. About 300 or possibly about 400 pounds of caustic soda is thrown into the ladle 11. The contents of the ladle 11 are poured into the ladle 12. The 300 or 400 pounds of fresh caustic soda is sufficient to desulphurize the 29,000 to 30,000 pounds of metal in the desulphurizing ladle but since there was no substantial quantity of slag in that ladle at the time the contents of the ladle 11 were poured in no slag will issue from the pouring orifice during that heat. After desulphurizing 27,000 pounds of metal will be poured from the ladle 12 into the ladle 13, leaving in the ladle 12 2,000 to 3,000 pounds of metal and 300 or 400 pounds of slag. Thereafter 27,000 pounds of metal is tapped at each heat and 300 pounds of caustic soda is introduced into the ladle 11 at each heat and the normal procedure as first explained above is followed. No substantial amount of slag will issue from the pouring orifice of the ladle 12 until after several heats when the volume of slag in the ladle 12 has been built up to the point where the slag will rise above the pouring orifice upon introduction into the ladle 12 of the contents of the ladle 11.

Not only do we obtain a vastly more satisfactory and uniform desulphurizing of the metal than has heretofore been obtainable but we effect a remarkable economy of desulphurizer, which is expensive. The key to the improvement is in the rendering molten of the replenishing desulphurizer before introducing it into the desulphurizing ladle. While in the preferred method above described the replenishing desulphurizer is melted by the heat of the metal in the ladle 11 it may be melted in a separate furnace provided for that purpose and delivered from that furnace either into the ladle 11 or directly into the ladle 12.

While we have shown and described a present preferred method of practicing the invention it is to be understood that the invention is not limited thereto but may be otherwise variously practiced within the scope of the following claims.

We claim:

1. A method of desulphurizing molten ferrous metal comprising heating to a temperature about that of the molten ferrous metal to be desulphurized a quantity of previously unused desulphurizer which gasifies upon being heated to melt and decompose the desulphurizer to drive off substantially all gaseous matter formed and, after thus preparing the desulphurized, intimately associating the desulphurizer and the molten ferrous metal to effect desulphurization of the molten ferrous metal by pouring the molten ferrous metal and desulphurizer into a single chamber receptacle wherein throughout the pour all molten ferrous metal in the receptacle forms a single pool all portions of which are in mixable contact with the desulphurizer, the desulphurization in said receptacle being characterized by minimization of foaming which would be caused by release of gaseous matter and by enhancement of interface reaction between the desulphurizer and all portions of the metal.

2. A method of desulphurizing molten ferrous metal comprising introducing into molten ferrous metal to be desulphurized desulphurizer in unmelted form which gasifies upon being heated and by the molten ferrous metal heating the desulphurizer to a temperature about that of the molten ferrous metal to melt and decompose the desulphurizer to drive off substantially all gaseous matter formed and, after the desulphurizer has been thus prepared, intimately associating the desulphurizer and the molten ferrous metal to effect desulphurization of the molten ferrous metal by pouring the desulphurizer and molten ferrous metal into a single chamber receptacle wherein throughout the pour all molten ferrous metal in the receptacle forms a single pool all portion of which are in mixable contact with the desulphurizer, the desulphurization in said receptacle being characterized by minimization of foaming which would be caused by release of gaseous matter and by enhancement of interface reaction between the desulphurizer and all portions of the metal.

3. A method of desulphurizing molten ferrous metal comprising forming a bath of molten ferrous metal and previously unused desulphurizer which gasifies upon being heated which has been heated to a temperature about that of the molten ferrous metal to melt and decompose the desulphurizer to drive off substantially all gaseous matter formed and thereafter intimately associating the molten ferrous metal and desulphurizer to effect desulphurization of the molten ferrous metal by pouring the bath into a single chamber receptacle in such manner that at least a sub-

stantial portion of the desulphurizer enters the receptacle at least as early as during the early part of the pour and wherein throughout the pour all molten ferrous metal in the receptacle forms a single pool all portions of which are in mixable contact with the desulphurizer, the desulphurization in said receptacle being characterized by minimization of foaming which would be caused by release of gaseous matter and by enhancement of interface reaction between the desulphurizer and all portions of the metal.

4. A method of desulphurizing molten ferrous metal comprising maintaining in a single chamber receptacle a quantity of molten desulphurizer, simultaneously introducing into the receptacle molten ferrous metal to be desulphurized and additional desulphurizer which gasifies upon being heated which has been heated to a temperature about that of the molten ferrous metal to melt and decompose the desulphurizer to drive off substantially all gaseous matter formed, the molten ferrous metal in the receptacle forming throughout the pour a single pool all portions of which are in mixable contact with the desulphurizer, the desulphurization in said receptacle being characterized by minimization of foaming which would be caused by release of gaseous matter and by enhancement of interface reaction between the desulphurizer and all portions of the metal, the additional desulphurizer replenishing the first mentioned desulphurizer, and separating the desulphurized molten ferrous metal from the molten desulphurizer.

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