Dec. 16, 1930. L. W. SPRING 1,785,503

APPARATUS FOR DESULPHURIZING CAST IRON

Original Filed June 16, 1928 2 Sheets-Sheet 1

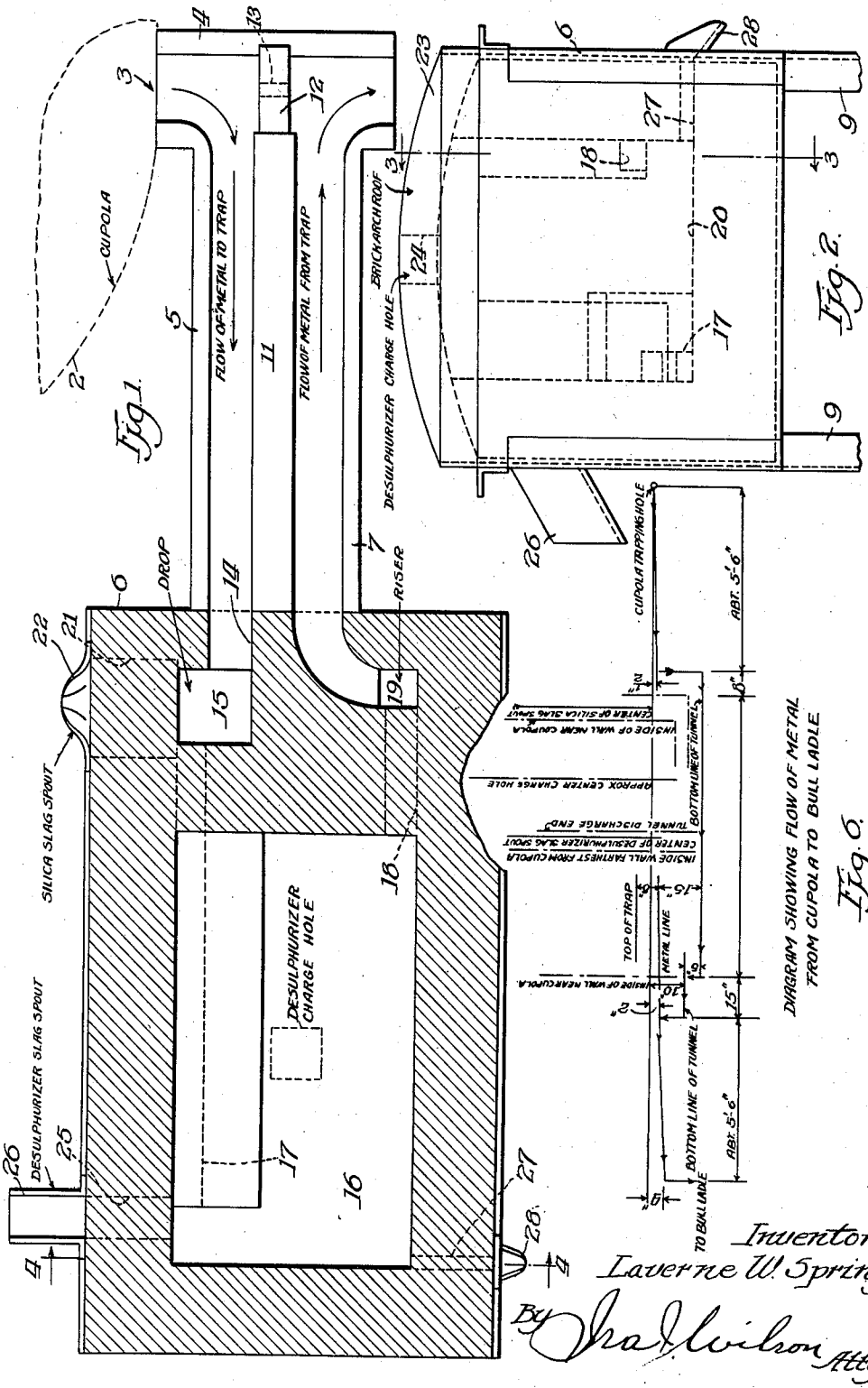


Fig. 1.

Fig. 2.

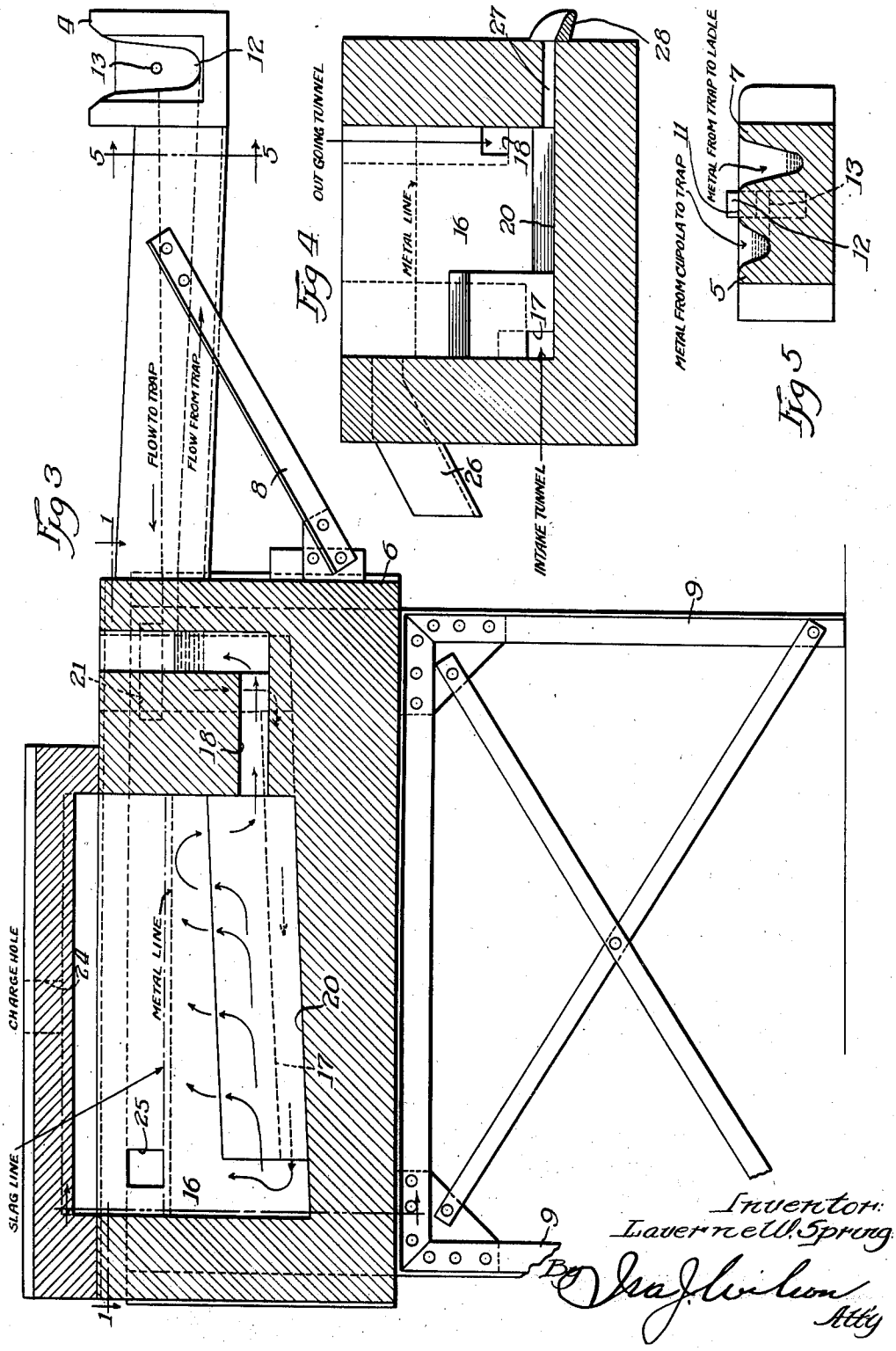
Fig. 6.

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APPARATUS FOR DESULPHURIZING CAST IRON

Original Filed June 16, 1928 2 Sheets-Sheet 2



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Patented Dec. 16, 1930

1,785,503

UNITED STATES PATENT OFFICE

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APPARATUS FOR DESULPHURIZING CAST IRON

Original application filed June 16, 1928, Serial No. 285,898. Divided and this application filed June 22, 1929. Serial No. 372,914.

This invention pertains to the refining of iron, but more particularly to the purification of iron melted in foundry cupolas and the like, although applicable to the purification of iron as it is reduced from its ores in the usual blast furnace as is my co-pending application Serial No. 285,898, filed June 16, 1928, for Method of desulphurizing cast iron, of which this application is a division. The invention is also applicable to the refining of iron melted or provided in other manners. Primarily the process and apparatus hereinafter described is designed to refine the iron by removing sulphur and other undesirable elements or impurities which may be contained in the iron.

Heretofore sulphur and other impurities have been removed through the use of various slagging materials including limestone, fluor spar, or possibly sodium carbonate or soda ash charged into the cupola with the coke or other fuel, or the pig or scrap iron, as by the process disclosed in Evans Patent No. 1,590,731, dated June 29, 1926, or by treating the molten iron flowing from the cupola into the bull ladle with sodium carbonate or soda ash with or without the aforementioned treatment in the cupola as, for instance, disclosed in Evans Patent No. 1,646,728, dated October 25, 1927. Sometimes too, the molten iron is treated with slagging material for purification or refining while it is contained in the bull ladle. The sodium carbonate or soda ash has the property of removing sulphur from the molten iron or of preventing sulphur from the coke from combining with the iron, or both, and to such an extent, is quite valuable in the manufacture of cast iron of lower sulphur content.

The process disclosed in Evans Patent No. 1,590,731 produces excellent results, but the time during which the treatment may be applied in the cupola is of itself usually too limited to permit removal of all the sulphur desired to be removed from the iron for many purposes. Then also, it is difficult, if not impossible, through this process, to obtain the desired and necessary intimate contact between the sodium carbonate or soda ash and molten iron for the proper removal of the sulphur, or removal of sulphur to the extent desired.

The process disclosed in Evans Patent No. 1,646,728 is also of value, but this process likewise does not afford the desirable or necessary time of intimate contact between the molten iron and the sodium carbonate even when it is operated in conjunction with the process of Evans Patent No. 1,590,731, or with bull ladle treatment, although a more intimate contact may perhaps be obtained by the double process than by either alone. Furthermore, since the "forehearth" treatment under Evans Patent No. 1,646,728 requires a large amount of space directly in front of the cupola and since the necessary space is not always available or readily so, particularly in foundries built or established before the introduction of the process, resort cannot always be had to it.

Again, in carrying out these prior processes it has almost inevitably and invariably happened that silica and other slag escaped from the cupola into the "forehearth" or the bull ladle, the "forehearth" into the bull ladle and thence into the crane, trolley or other ladles from which some would get into the casting. This is largely minimized or entirely prevented through the use of my invention, as will be observed hereinafter. If the soda ash or sodium carbonate treatment be given in an ordinary receptacle, such as a bull ladle or even a "teapot" bull ladle, it becomes necessary from time to time to skim the slag therefrom and replenish the bath with fresh soda ash or sodium carbonate. This is not easily done and may be dangerous.

It is, therefore, one of the primary objects of my invention to provide an apparatus so constructed and arranged that the process may be so carried out that the molten iron or other more or less impure metal or alloy flowing from the cupola or other source of supply may be intimately, thoroughly and completely treated continuously and exposed to the action of the sodium carbonate or soda ash, or other agent, for the removal of impurities, particularly sulphur, without material loss of heat.

Another important object is to provide an apparatus for carrying out the process whereby the slag and impurities gathering and floating on the molten iron at different points in its passage may be prevented from being carried from place to place and particularly to the ladles in any or in any material amount and whereby such slag and impurities may be removed easily and continuously, or from time to time, as desired, or as may be dictated by experience.

Another equally important object is to provide an apparatus of the character specified that will require a minimum of room or space for thorough and complete treatment of a continuously flowing mass or stream of molten iron and will not require substantial space directly in front of the cupola, nor even an extra length of cupola spout. In this connection a slow but steady and substantially continuous flow of refining slag or treating material or materials, such as soda ash or sodium carbonate, caustic soda, lime and lime compounds, potassium compounds, lithium, and other alkalies or alkaline earths, is maintained in a direction contrary, in the present embodiment substantially opposite, to the general direction of flow of the molten iron stream, and the stream of iron by reason of its travel through the apparatus has all or substantially all of its portions at one time or another brought into intimate and perhaps repeated contact with the treating material or materials. The molten iron stream is caused to flow in a peculiar manner through the arrangement of the apparatus which greatly aids in obtaining the desired effect. The opposite flow of desulphurizing slag in order to arrive at its discharge spout results in greater efficiency of desulphurization and in less loss of such refining slag because it remains longer on the bath of molten metal. Furthermore, the newest and least used and, therefore, the strongest flux is in this way in the latest contact with the partially purified molten iron, thus bringing about the best purification.

Usually there is one temperature, i. e. a proper heat desired for the metal and it is consequently a further object to provide an apparatus for carrying out the process whereby the temperature of the metal delivered to the foundry at the beginning of the run and at other times may be controlled more satisfactorily than has heretofore been done. In accordance with the preferred form illustrated, iron may be taken at any time directly from the cupola or indirectly into and through the desulphurizing bath, or from both, and iron may be taken direct from the cupola until the ladles are fully heated and thereafter partially from the desulphurizer and partially direct from the cupola until the full stream from the desulphurizer is as hot as iron taken direct from the cupola, whereupon the flow direct from the cupola to the ladle may be cut off merely by stopping up a hole in a partition.

A still further object is to provide an apparatus capable of substitution for the apparatus involved when following the disclosure of either Evans patent or capable of use in conjunction with either of Evans' processes, and further, to provide an apparatus whereby the cost of production of cast iron of low sulphur content may be materially reduced, particularly through the use of lower and cheaper grades of materials such as coke and pig or scrap iron having a relatively high sulphur content, or through the use of altered quantities or proportions of such materials.

Still further objects, the advantages, uses and functions of the invention and the preferred form thereof illustrated, will be or should become readily appreciated and understood after reading the following description and claims, and after viewing the drawings, in which

Fig. 1 is a top plan view of a preferred form of desulphurizing apparatus in connection with a cupola, the cupola being merely diagrammatically indicated,

Fig. 2 is an elevational view of the left-hand end of the apparatus shown in Fig. 1,

Fig. 3 is a side elevational view partly in section of the front side of the apparatus shown in Fig. 1,

Fig. 4 is a sectional view taken substantially along the line 4—4 of Fig. 1.

Fig. 5 is a sectional view through the trough structure taken substantially along the line 5—5 of Fig. 3, and

Fig. 6 is a developed diagram of the apparatus and the line of flow of the molten metal from the cupola to the bull ladle.

A cupola, a fragment of which is shown in dotted lines and designated 2 in Fig. 1, is provided with a tap hole or discharge opening for molten metal at its front end as at the point designated with an arrow and marked 3. A suitable trough 4 having a refractory lining is inclined outwardly and downwardly from the cupola discharge opening and connects at one side with a similarly lined trough 5 which is inclined therefrom to a treating receptacle generally designated 6, while a trough 7 inclines downwardly away

from the receptacle 6 to a lower portion of the trough 4 into which it discharges. While it is preferable to have the troughs 4, 5 and 7 built together as shown, they may be built separately or detachable so that the apparatus can be shut down and the troughs and receptacle 6 removed and relined or repaired while the cupola is in operation. The troughs are in the present instance supported by one or more structural braces 8 from the receptacle 6, which is in turn supported on a suitable framework structure 9, the details of which need not be described. As will be appreciated, any arrangement of troughs and treating chambers or basins embodying the features of this invention may suffice for my purposes.

The troughs are preferably made considerably deeper than they are wide to minimize cooling, as will be understood, and are separated by a suitable refractory wall 11. What is known as a cupola breast brick with one or more holes which may be plugged or opened at will, or even a temporary wall, that is, a wall which may readily be knocked out if desired, is designated 12 and separates the upper and lower portions of the trough or spout 4 to cause the metal to flow down the trough 5. At the beginning of the run it may be desired to flow metal directly from the cupola into the bull ladle and for such purpose or for the purpose of obtaining metal of different heats or of various qualities, the troughs 5 and 7 may be blocked off preferably adjacent to the trough 4 and the opening 13 provided through the wall 12, used, or the wall 12 itself may be knocked out. At any later time the dams or walls which may be placed in troughs 5 and 7 may be knocked out and the tap hole or opening 13 closed or the wall 12 may be replaced. It may also be desirable to permit the metal to flow through the opening or tap hole 13 without cutting off the flow of metal into and from the receptacle 6, for it is but a simple matter to remove a plug from a small opening such as that indicated at 13 and replug the opening whenever desired, this being done commonly in cupola tapping.

The inflow trough 5 connects with an opening 14 in an end wall of the receptacle 6 and discharges the molten stream of iron into a well or drop 15 from whence the metal flows into what may be variously termed a treating chamber basin or trap 16 through a tunnel 17 leading from the well 15 adjacent the bottom thereof and well below the normal level of the molten metal therein and discharging into the treating basin 16 adjacent the far end and at or near the bottom thereof. A tunnel 18 like the tunnel 17 opening into the basin 16 well below the normal level of the molten metal therein conducts the molten metal from the basin to a riser or well 19 from the top of which metal flows into the trough 7 and thence to the bull ladle or other receptacle.

The line of flow of the metal from the cupola to the bull ladle or other receptacle is more or less gently inclined as may the better be observed from the diagram of Fig. 6, but when the metal reaches the well 15 it reaches a level therein consistent with the levels reached in the basin 16 and well 19 so that any slag, particularly ordinary cupola or silica slag, carried with it from the cupola is trapped by the walls of the well 15 and prevented from flowing into the basin 16. In order to remove this cupola or silica slag and other impurities carried with the metal from the cupola, the rear side of the receptacle is provided with an opening 21 the bottom of which is at or slightly above the normal level of the molten metal in the well or drop 15 and the outer end of the opening is provided with a spout 22. Thus slag accumulating in the well or drop 15 may flow out through the spout 22 to a suitable place of disposal or, if desired, a rake or other implement may be used to draw it off from time to time.

The receptacle 6 and particularly the basin 16 is provided with a refractory lined cap, roof or cover 23, which may be removed and replaced through a suitable hoisting apparatus. The top of the cover at or about a portion directly over the center of the treating basin 16 in the present instance, is provided with an opening 24 through which the desulphurizing chemical, that is, the soda ash or sodium carbonate or other chemical or material in brick, lump or pulverized form, is supplied to the bath. This material is supplied from time to time and in such quantities as may be dictated by experience, but I have found it desirable to supply sufficient to maintain substantially a half inch of the fused desulphurizing chemical over the entire surface of the molten metal within the basin 16.

The molten metal as it enters the chamber 16 from the tunnel 17 flows much after the manner indicated by the full line arrows shown in Fig. 3, that is, it eddies and swirls as it flows generally toward its entrance into the tunnel 18, and through its turbulent action practically every portion is brought into contact with the desulphurizing chemical at least once. This action is aided through the construction of the bottom refractory wall 20 of the basin 16 of the receptacle which inclines upwardly from its far end wall adjacent the discharge end of the tunnel 17 to the other end of the basin. Preferably above the discharge end of the tunnel 17 where the metal enters the basin 16, a desulphurizing slag discharge orifice and spout 25 and 26, respectively, are provided, the bottom of the opening 25 at its inner end being substantially at the normal level of the molten metal within the basin 16 and together with the spout declining outwardly and downwardly to provide a grav-

ity flow for the spent desulphurizing slag. With this arrangement the desulphurizing slag opening and spout are disposed at a place remote and relatively down stream with respect to the place of supply of the desulphurier and the receiving end of the tunnel 18. The arrangement is such that slag forming on the metal in the basin 16, that is, the used soda ash or sodium carbonate and impurities, flow across the surface of the molten pool toward the desulphurizing slag spout 26 and through gravity and the action of the molten metal is caused to flow through the opening 25 and down the spout. Regardless of the theory of the operation, the arrangement illustrated and described has been found to operate as described and with the utmost satisfaction.

The opening to the tunnel 18 being well below the normal surface level of the molten metal within the basin 16, the desulphurizing chemical and slag on the surface of the metal within the basin is trapped therein and prevented from flowing with the metal through the riser or well 19 and down the trough 7. Whenever it is desired to drain the pool of metal within the basin 16, this is done through a drain opening 27 and drain spout 28 leading through the refractory walls of the receptacle 6 from the interior of the basin 16 and adjacent to the lower end of the sloping floor thereof. The opening 27 will ordinarily be plugged with refractory clay, but the plug may be broken out when desired. Metal, of course, may be taken from the opening 27 if at any time it should be desired to do so.

Apparatus constructed after the manner of my invention requires no change in the cupola, for the desulphurizing apparatus, that is, the troughs, are attached directly to the side of the usual cupola spout. Since the apparatus is disposed to one side of the cupola comparatively little or no room or space required for foundry operations directly in front of the cupola is necessitated, and where there are cupolas with trolley or ladle tracks already laid they need not be changed. At any time iron may be taken directly from the cupola, or directly from the desulphurizing bath from the spout 28 or from the troughs 7 and 4, inwardly through the desulphurizing bath or from the cupola and from the desulphurizing bath simultaneously. Ordinarily the only time that the metal will be taken from the spout 28 is when it is desired to drain the basin, but of course it may be otherwise used.

It will be appreciated that the arrangement is of decided advantage in governing the temperature of the metal delivered to the foundry, since at the beginning of the run iron may be taken directly from the cupola until the ladles are fully heated, then diverted into and through the preheated desulphurizer and a mixture of iron part directly from the cupola and part from the desulphurizer used until the full stream from the desulphurizer is as hot as the iron taken direct from the cupola. An apparatus of this type has another advantage over the forehearth in that should any difficulty occur with the use of the desulphurizer, molten iron may be taken directly from the cupola with practically no loss of time or inconvenience to the foundry. Should a forehearth burn through or become clogged or otherwise become unusable, time would be lost and the foundry seriously incapacitated.

Treatment of the iron by the apparatus disclosed herein permits iron, pig or scrap, having a high sulphur content, or cupola charges of metal containing a larger percentage of scrap with a lesser percentage or even none of the higher priced pig iron, to be used. Likewise, high sulphur coke, ordinarily useless for the manufacture of cast iron, could be used and a much cheaper but satisfactory cast iron product produced. In a desulphurizing apparatus constructed after the manner of the invention iron having a content of considerably more than 0.1% of sulphur has been used, and through the treatment described has resulted in the production of iron containing less than 0.07% of sulphur, and greater desulphurization can be obtained. These are but an illustrative few of the results, advantages and uses of the invention, but many others will be or should become apparent to those skilled in the art.

While I have disclosed a type of apparatus for carrying out my invention, it will be appreciated that many modifications and changes may be made therein without departing from the spirit of the invention or the scope of the appended claims and that the same apparatus is applicable to some other metals and alloys. For example the tunnel 17 and slag drip 22 may be omitted although the addition of these elements lessens the effect of personal operation upon the results of the operation of the apparatus described.

I claim:

1. In combination with a cupola having a metal discharge opening, a treating receptacle disposed adjacent to said opening and substantially tangentially of said cupola at said opening, a trough leading from said opening substantially radially of said cupola and inclined downwardly and outwardly, a second gravity trough leading from the first said trough adjacent said cupola opening to said receptacle, and a third gravity trough leading from said receptacle to the first said trough outwardly of the connection of the latter to the second said trough.

2. In combination with a cupola having a metal discharge opening, a treating receptacle disposed adjacent to said opening and

substantially tangentially of said cupola at said opening, a trough leading from said opening substantially radially of said cupola and inclined downwardly and outwardly, a second gravity trough leading from the first said trough adjacent said cupola opening to said receptacle, a third gravity trough leading from said receptacle to the first said trough outwardly of the connection of the latter to the second said trough, and a perforable wall disposed across the first said trough and between the connections of the second and third said troughs thereto.

In witness of the foregoing I affix my signature.

LAVERNE W. SPRING.