United States Patent

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[54] **METHODS AND APPARATUS FOR TREATMENT OF METALS**
8 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **266/36,** 75/13, 75/61
[51] **Int. Cl.** **F27b 7/14**
[50] **Field of Search** ..... 266/34, 34 (A), 36 (R); 75/13, (Inquired), 46, 61, 93

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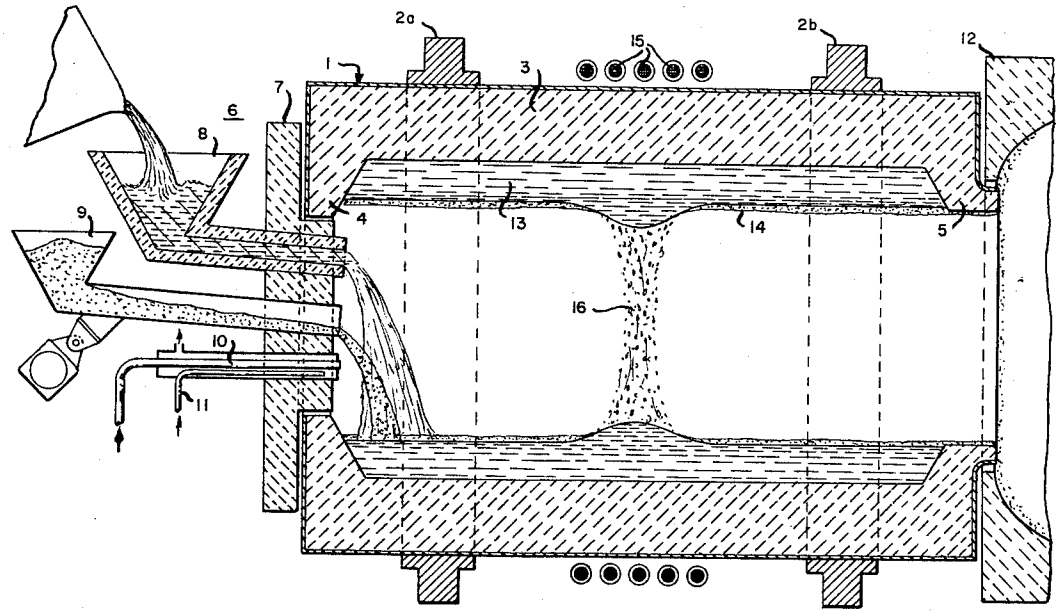
ABSTRACT: A method and apparatus are provided for treatment of molten metal with reactive materials by the steps of adding a molten metal and reactive materials to a rotating drum, passing the mixture from one end of the drum to the other while subjecting the same to centrifugal force sufficient to overcome gravity and maintain it in contact with the drum, subjecting said mixture to a radially directed magnetic force intermediate the ends of the drum sufficient to overcome centrifugal force and cause the mixture to fall radially from the drum top and removing the mixture at the said other end of the drum. The apparatus provides a rotating drum, means for rotating the drum at a speed sufficient to hold the contents therein by centrifugal force on the walls of the drum, feed means for delivering metal and reactive material to the drum interior at one end, and a magnetic field intermediate the end of the drum creating a radial force on the metal sufficient to overcome centrifugal force.



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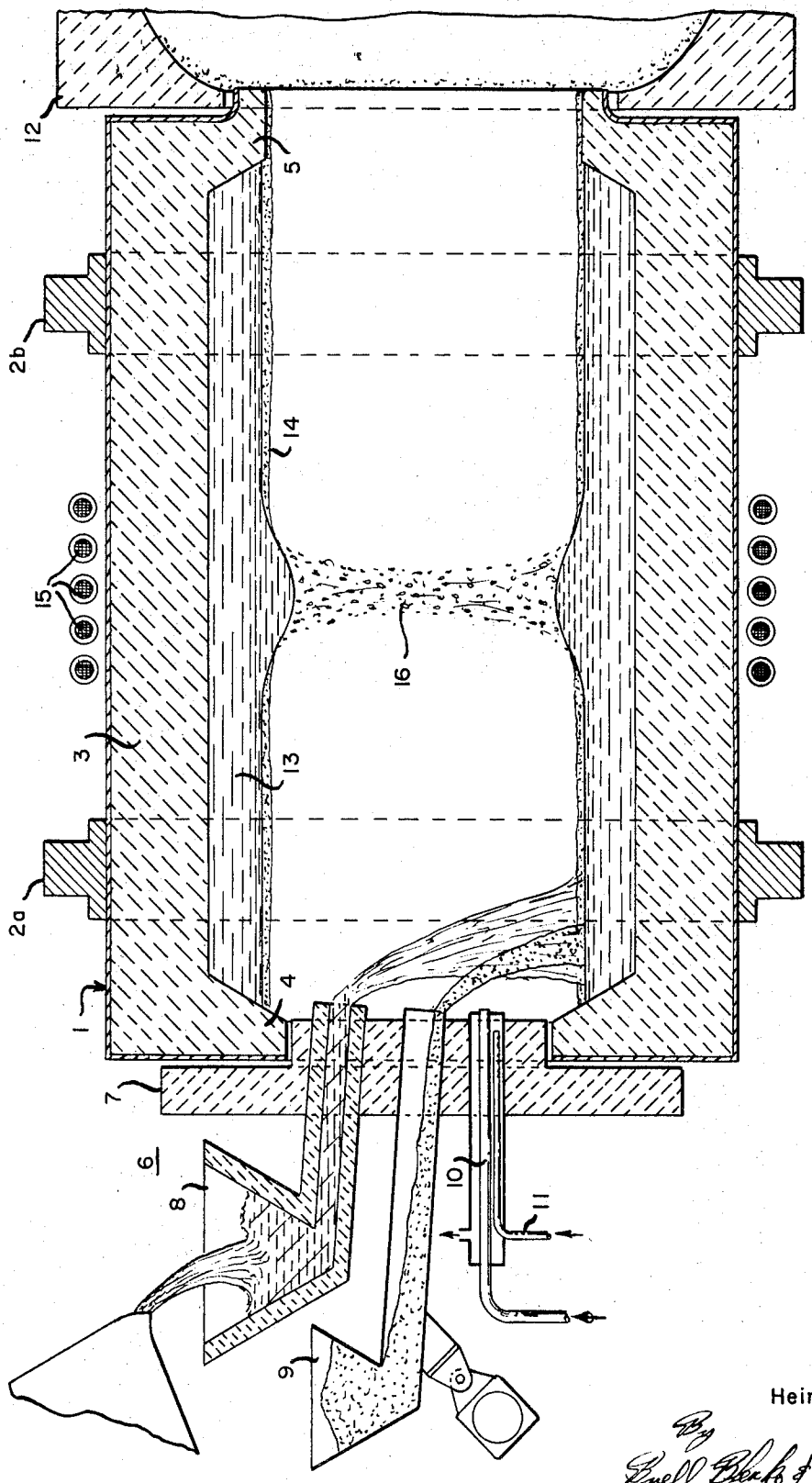

FIG. 1

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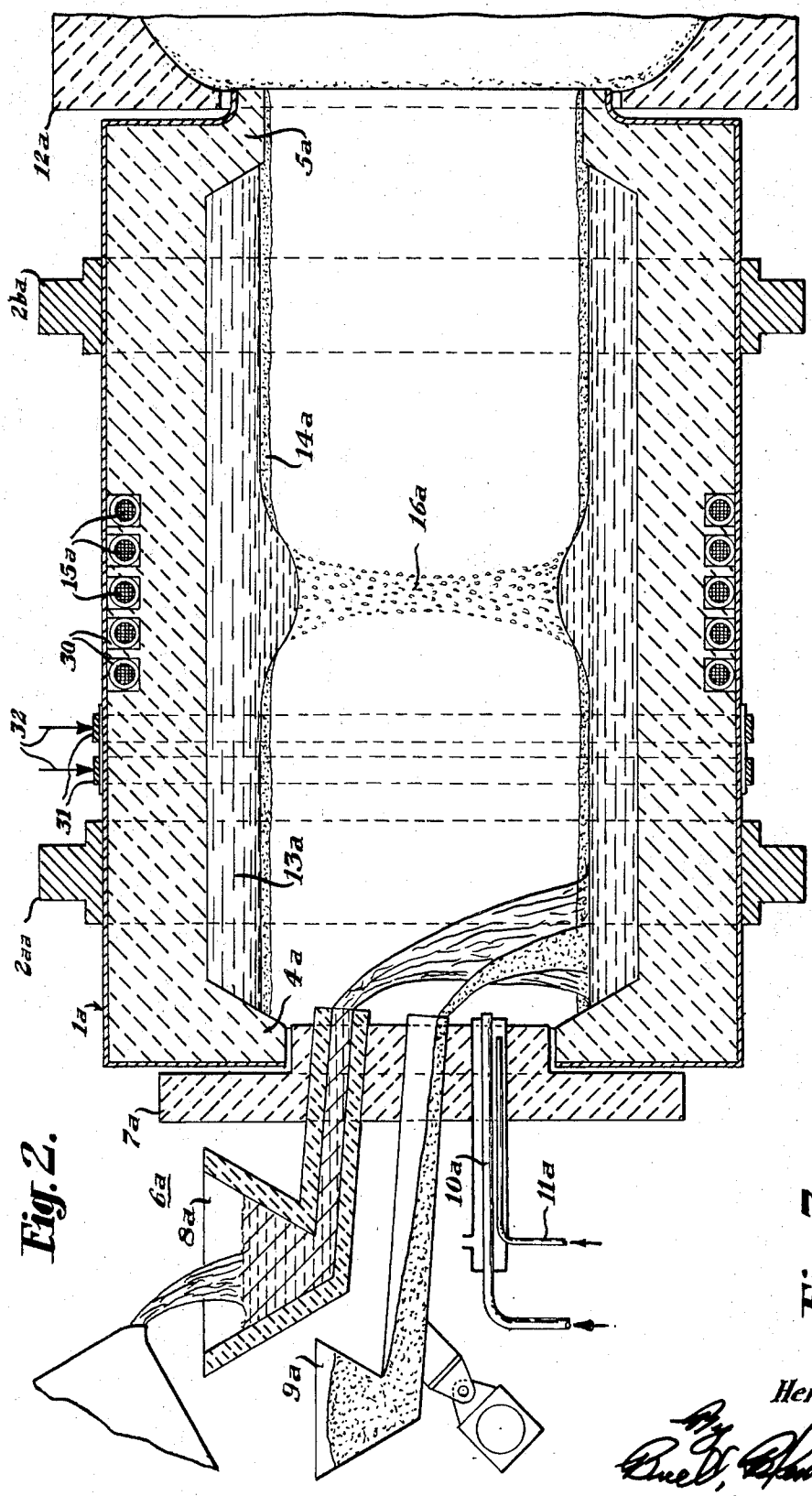

Fig. 2.

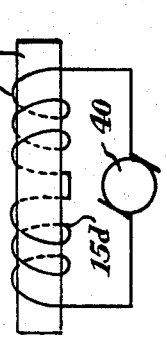

Fig. 5.

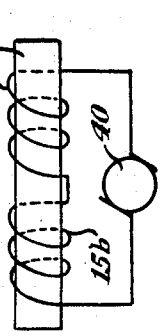

Fig. 4.

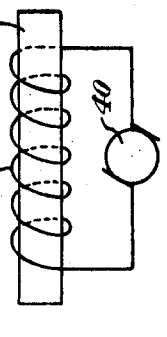

Fig. 3.

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METHODS AND APPARATUS FOR TREATMENT OF METALS

This invention relates to methods and apparatus for treatment of metals and particularly to a method and apparatus for treatment of metals with reactive materials to attain a more rapid reaction or exchange between the metal and the reaction materials.

The desirability of providing a more intimate contact between molten metal to be treated and added reaction materials has long been recognized. In order to accomplish this, various proposals have been made. For example, it has been proposed that gases be blown through a pool of metal with a reactive slag cover so as to cause violent agitation and thereby greater contact between the metal and slag. Similarly, it has been proposed to vibrate the ladle containing the metal and slag, to use ultrasonic probes extending into the molten mass and to use multiple replaced slags to attain a higher degree of efficiency in the reaction between the slag and metal.

The present invention provides a method and apparatus for overcoming these problems of the prior art and for providing a greater degree of efficiency in bringing the molten metal and reactive materials into intimate reactive contact.

Preferably I provide a method of treating molten metals and reactive materials to provide more intimate contact comprising the steps of adding the metal and reactive materials to a rotating drum, passing the mixture from one end to the other of said drum, subjecting said mixture to a radially directed magnetic force intermediate the ends of the drum sufficient to overcome centrifugal force and cause the mixture to fall radially from the drum top onto the mixture in the bottom of the drum and removing the mixture at the said other end of said drum. Preferably I provide a rotating drum, means for rotating the drum at a speed sufficient to hold the contents therein by centrifugal force on the walls of the drum, feed means for delivering molten metal and reactive material to one end of said drum, a magnetic field intermediate the ends of said drum creating a radial force on the molten metal in said drum sufficient to overcome the centrifugal force of the rotating drum on the contents thereof to cause the contents to fall radially from the top of the drum rotation. Preferably the drum is provided with a dam or thickened portion at each end which retains the molten material in the drum in a layer of substantial thickness. The drum is preferably provided on its outer circumference with spaced supporting rings which rest on and are rotated by rollers driven by a power source. The magnetic field may be a single stationary field or a plurality of spaced fields adjacent the midpoint of the drum and surrounding the drum or alternatively they may be mounted in the body of the drum and be energized through collected rings on the drum.

In the absence of the magnetic field the rotating drum forms fixed layers of molten metal and reactive materials which do not react or exchange except by diffusion. This is so slow that it is impractical. If the rotation of the drum be slowed to such a degree that gravity overcomes the centrifugal force at the top or zenith of the drum so that the molten mixture rains down in the drum, the falling metallic rain extends over the entire length of the drum which complicates the charging and continuous operation of the drum, requiring removal of the charging device and closing the ends of the drum to prevent throwing material from the drum. The use of a magnetic field intermediate the ends as described above remedies these problems.

The magnetic field generated by the coil and the resulting inductive currents in the melt produce a radial pressure on the melt in that drum section where the coils are located. In the zenith of the drum in which the centrifugal force and gravity act in opposite directions, a metallic rain falls down which is subject to an intensive treatment with the reactioning material. At the baseline where gravity and centrifugal force act in the same direction, the effect of the electromagnetic field, if it is apparent at all, is of much less intensity. Throughout the length of the drum the falling of the metallic rain is limited to the section of the coil windings or an even somewhat smaller section, so that the charging devices do not require a special protection, and the openings at the ends do not need covers.

For practical purposes, it is suggested to operate the coil windings with alternating current line frequency.

Since the zone influenced by the electromagnetic field is only of small width, it is possible to arrange over the length of the centrifugal drum several coil systems one after the other, and thereby achieving several mixing zones each independent from the other. The coils have varying directions of winding when operated with uniform-phase current. They may also be fed by multiple-phase line current.

In the forgoing general description of my invention I have set out certain objects, purposes, and advantages of my invention. Other objects, purposes and advantages will be apparent from a consideration of the following description and the accompanying drawings in which:

FIG. 1 is a longitudinal schematic cross section of one form of apparatus for practicing my invention;

FIG. 2 is a longitudinal schematic cross section of second embodiment of apparatus according to my invention;

FIG. 3 is a schematic side elevation of the furnace and coil arrangement of FIG. 1;

FIG. 4 is a schematic side elevation of a furnace and plurality of successive coils of like direction; and

FIG. 5 is a schematic side elevation of a furnace and plurality of coils of opposite direction.

Referring to the drawing I have illustrated an elongated horizontally arranged drum 1 provided with spaced supporting rings 2*a* and 2*b* surrounding the drum adjacent the two ends thereof.

The horizontally arranged drum 1 with the supporting rings 2*a* and 2*b* is held and driven by several supporting rollers arranged on the circumference, but not shown on the drawing. The inside of the drum 1 is provided with a refractory lining 3. At the faces of the drum the refractory lining 3 forms walls 4 and 5 which narrow the drum openings. Wall 4 is higher on the charging side 6 than at the opposite side of the drum. At the charging side 6 the opening is closed by a cover 7 through which the charging devices 8 for molten metal and 9 for solid additives extend for supplying liquid materials and solid materials respectively. In addition, a device 10 has been provided for the supply of gas-type reaction materials or heating media and incorporates a coolant recirculation system 11. At the opposite end of the drum a collecting furnace 12 is located into which the centrifugal drum extends.

The centrifugal drum is brought into rapid rotation by supporting rings 2*a* and 2*b* so that its contents will cover the refractory lining 3 on its circumference over the entire length of the drum.

The contents consists of the metallic melt 13 which forms the bottom layer on account of its bigger specific weight, and the slag 14 acting as reaction material and floating on the metallic melt.

Around the drum 1 coil windings 15 have been arranged through which alternating current is flowing and the electromagnetic field exerts a radial pressure on the electricity conducting metallic melt 13. During the process a metallic rain 16 falls down from the drum zenith 13 under the influence of magnetic forces whereby the melt is dissolved in drop form and is mixed intensively with the slag, or it is exposed to the reaction material supplied to the inside of the drum.

The device operates, for example, as follows:

The drum 1, rotating at a certain speed and preheated, is supplied through hopper 8 with liquid metal to be treated. This liquid metal immediately spreads and forms a thin metallic cylinder 13. As soon as a sufficient thickness of the metallic cylinder 13 is reached, electric power to coil 15 is switch on. As soon as the metallic rain zone 16 has formed during the course of additional charges of liquid metal, reaction materials are added through hopper 9 and the

operation proceeds continuously. The treated metal and the used-up slag flow over wall **5** and into furnace **12**, where the slag settles.

In FIG. **2** I have illustrated a furnace in which coil windings **15***a* are placed in slots **30** in the outer periphery of the drum **1***a*. Current is delivered to the coil windings **15***a* through collector rings **31** on the drum periphery and sliding shoes or brushes **32** connected to a source of alternating current. All other parts are the same as those of FIG. **1** and bear like numerals with the suffix *a*.

In FIG. **4** I have shown schematically an apparatus having successive coils **15***b* and **15***c* surrounding the drum **1***b*, both coils would in the same direction. In FIG. **5** I have shown schematically an apparatus having successive coils **15***d* and **15***e* wound in opposite directions around the drum **1***c*. These arrangements provide spaced apart radial forces acting on the molten metal in the drum. In each case the source of current is an alternating current generator **40**.

While I have illustrated and described a presently preferred practice and embodiment of my invention in the foregoing specification, it will be understood that the invention may be otherwise embodied within the scope of the following claims.

I claim:

1. A method of treating molten metal with reactive materials to provide intimate contact therebetween comprising the steps of adding the metal and reactive materials to a rotating drum, passing the mixture from one end to the other of said drum while rotating said drum at a speed sufficient to overcome the force of gravity and hold the contents thereof against the walls of the drum, subjecting the mixture to a radially directed magnetic force intermediate the ends of the drum sufficient to overcome the centrifugal force of the rotating drum and cause the mixture to fall from the drum top and removing the mixture at the said other end of the drum.

2. An apparatus for treating molten metal with reactive materials comprising a rotating drum, means for rotating the drum at a speed sufficient to overcome the effect of gravity and hold the contents therein by centrifugal force on the walls of the drum, feed means delivering molten metal and reactive materials to one end of said drum, a magnetic field intermediate the ends of the drum creating a radially directed magnetic force on the molten metal in said drum sufficient to overcome the centrifugal force in the drum to cause the contents to fall from the top of the drum.

3. An apparatus as claimed in claim **2** having a receiving furnace at the other end of said drum.

4. An apparatus as claimed in claim **2** wherein a stationary coil surrounds the drum intermediate its ends to form said magnetic field.

5. An apparatus as claimed in claim **2** wherein coil windings are embedded in the wall of the rotating drum intermediate its ends to form said magnetic field.

6. An apparatus as claimed in claim **2** wherein the magnetic field is created by a plurality of successive coils surrounding the drum intermediate its ends.

7. An apparatus as claimed in claim **6** wherein successive coils have opposite directions of winding.

8. An apparatus as claimed in claim **2** wherein the magnetic field is derived from an alternating current line frequency.