

May 3, 1955

M. TAMA
ELECTROMAGNETIC VALVE

2,707,720

Filed April 9, 1952

4 Sheets-Sheet 1

Fig 1

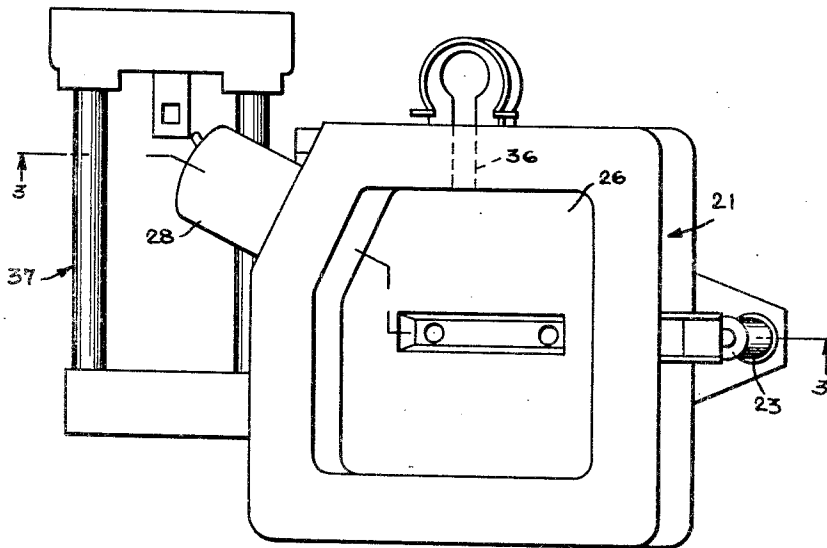
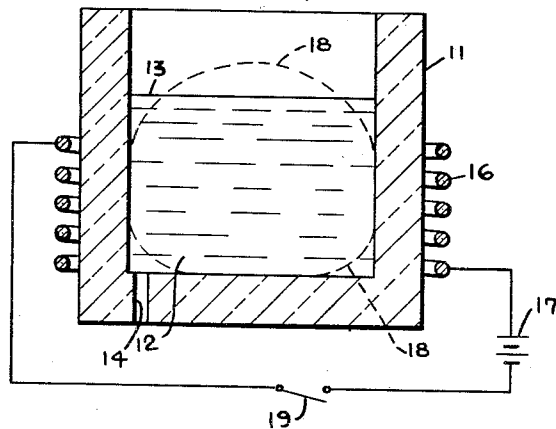


Fig 2

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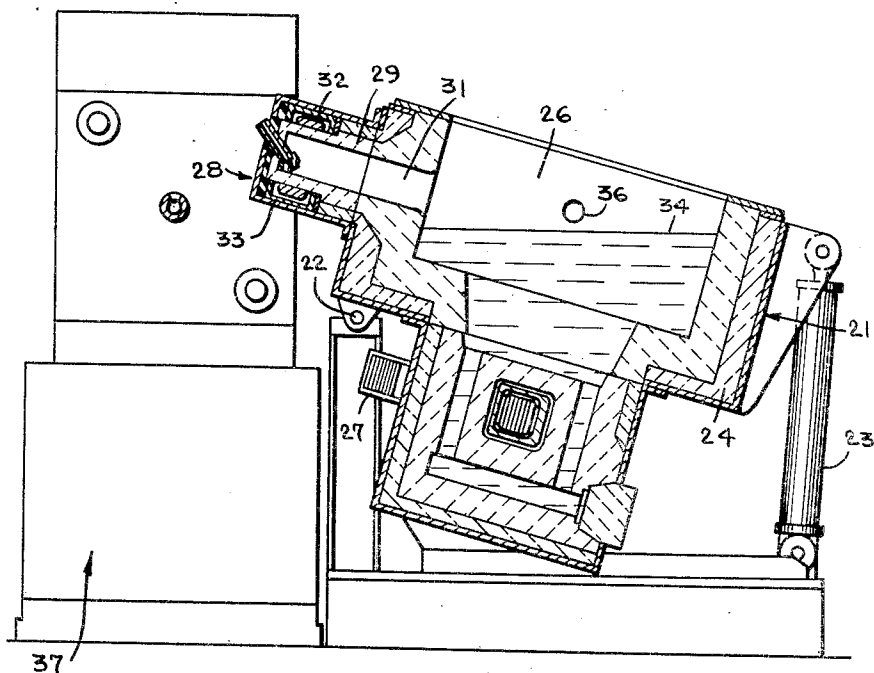
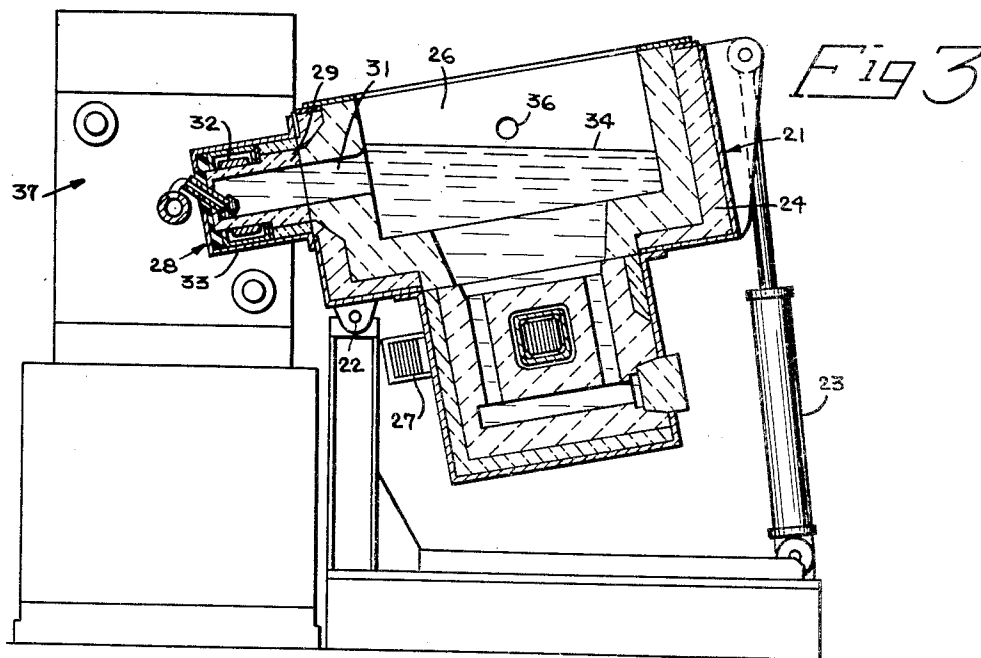


Fig 4

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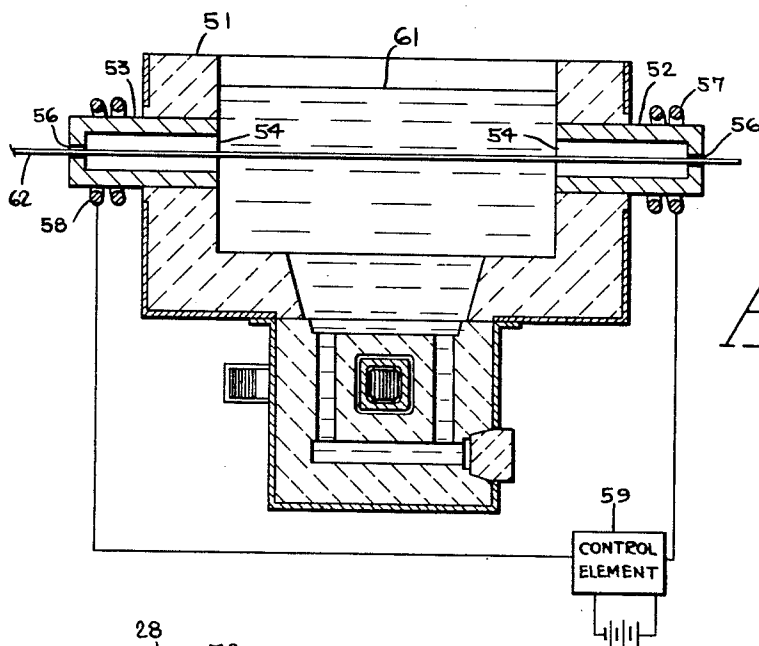


Fig 8

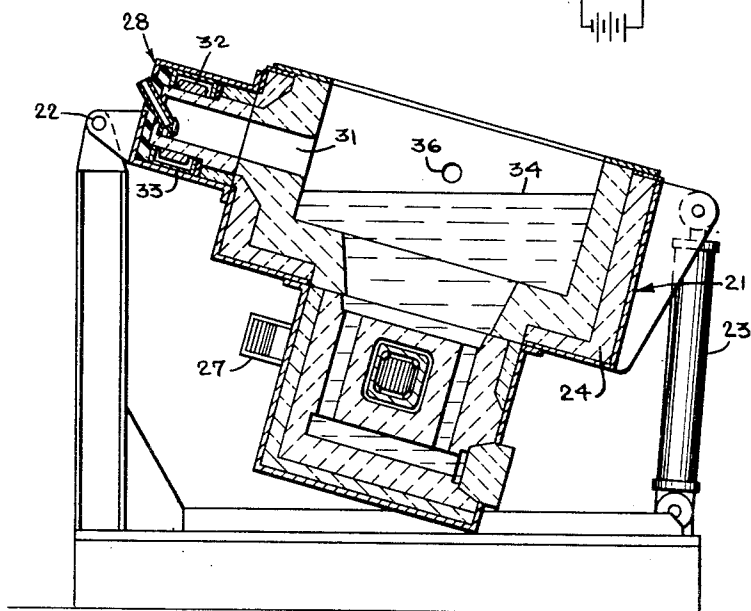


Fig 5

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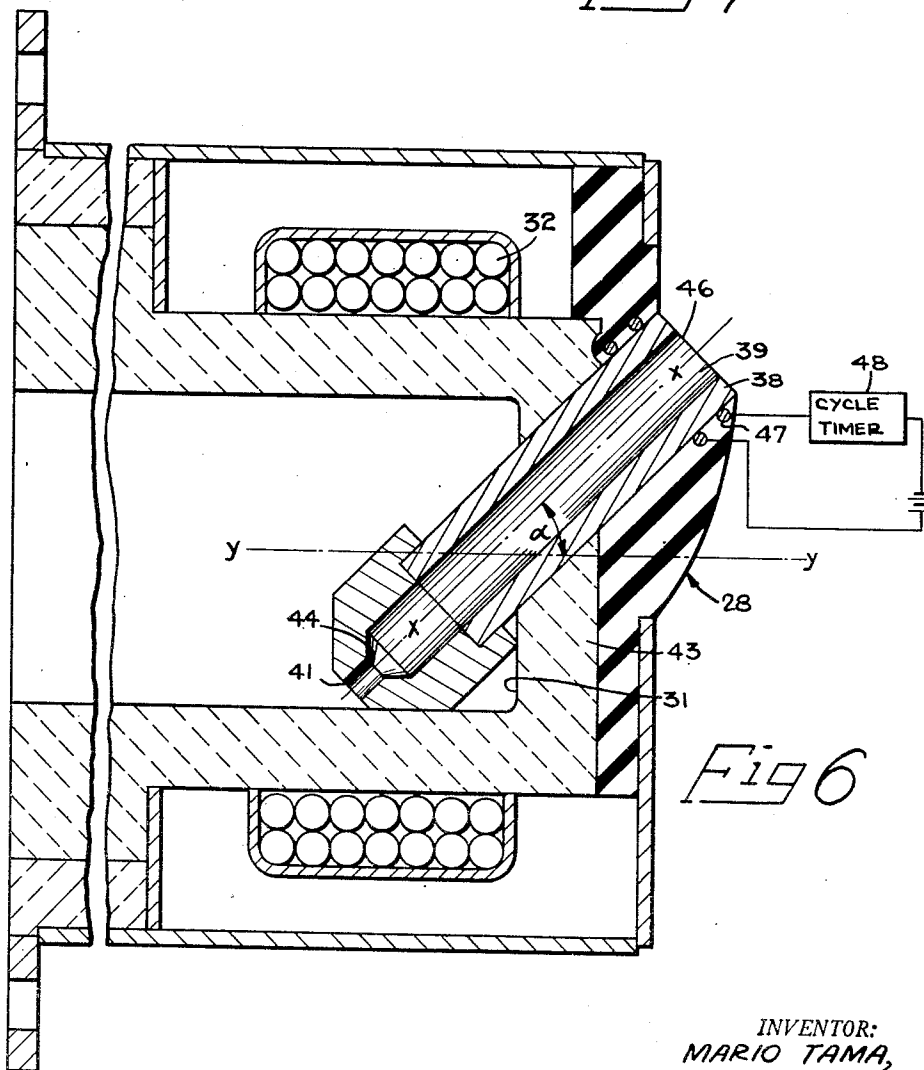
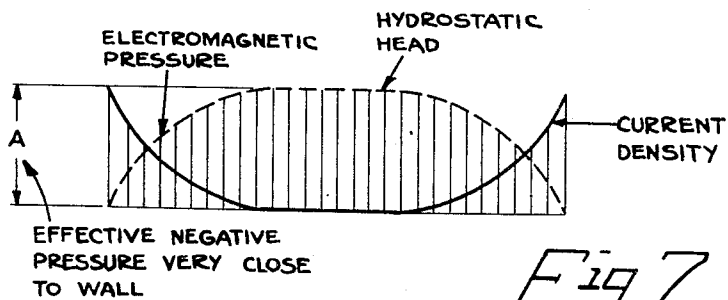
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4 Sheets-Sheet 4



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2,707,720

ELECTROMAGNETIC VALVE

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Application April 9, 1952, Serial No. 281,333

8 Claims. (Cl. 13—33)

The invention relates to the flow control of molten metal and relates more particularly to the controlled discharge of molten metal from holding vessels therefor.

The invention has among its objects to provide for improved methods and means to control the discharge of molten metal, for the purpose of ladling accurately predetermined amounts of molten metal from a vessel.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

This is a continuation-in-part of my copending application, Ser. No. 29,263, filed May 26, 1948, for Induction Pump for Casting Molten Metals now Patent No. 2,707,718 issued May 3, 1955.

With the above and other objects of the invention in view, the invention consists in the novel methods, construction, arrangement and combination of various devices, elements and parts, as set forth in the claims hereof, certain embodiments of the same being illustrated in the accompanying drawings and described in the specification.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description, taken in connection with the accompanying drawings, in which:

Fig. 1 is a vertical sectional view showing an apparatus in accordance with the broad aspects of the invention;

Fig. 2 is a plan view of an apparatus embodying the invention;

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2, showing the apparatus at discharge;

Fig. 4 is a sectional view similar to Fig. 3 but showing the apparatus in non-discharge position;

Fig. 5 is a sectional view similar to Fig. 3, but embodying a modification;

Fig. 6 is a fragmentary sectional view showing a detail illustrated in Fig. 3, at an enlarged scale compared thereto;

Fig. 7 is a schematic view showing a graph; and

Fig. 8 is a vertical sectional view, illustrating a modification.

In carrying the invention into effect in the embodiments which have been selected for illustration in the accompanying drawings and for description in this specification and referring now particularly to Fig. 1, there is provided a vessel reservoir, or container 11, designed to hold molten metal. The container 11 is made of suitable material, such as a refractory material capable of making without being damaged contact with hot molten metal such as, for instance, molten aluminum. The container 11 is shown filled with metal 12 to a level (illustrated by a solid line) and indicated at 13. The container 11 has in the bottom wall a bore 14 that connects the interior thereof with the outside of the container. The bore 14 is located far below the level 13 of the metal 12, and in normal position of the molten metal provides a passage for discharge of the metal from the container.

The container 11 is surrounded by a coil 16 that is disengageably interconnected by a circuit 17 to a source of alternating electric current. A switch 19 of the circuit 17 permits connection and disconnection of the coil

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to the source. Upon energization of the coil 16, by closing of the switch 19, there will be produced within the metal mass 12 of the container 11 a certain tension or pressure that results in an arching of the upper surface of the metal 12, as well as of the lower surface near the container bottom as indicated in broken lines in Fig. 1 at 18.

The extent of this spherical arching depends on the power of the current fed through the coil 16. As shown in Fig. 1, the power of the current is so selected that the tension induced in the molten metal mass 12 forces the surface to arch sufficiently so that it moves away from the bottom corner in which there is located the bore 14. Thus, while the coil 16 is energized by closing of the switch 19, the metal, owing to the induced tension, is being moved away from the bore 14. Accordingly, during energization there will be no discharge through the bore 14. Conversely, when the switch 19 is opened, the coil 16 will be de-energized and the metal will be discharged flowing through the bore 14.

Thus there is provided by this construction a device for electrically controlling, at will, the discharge of metal from the container 11, which I have termed an "electromagnetic valve."

I cannot assert that I fully understand the reason for this phenomenon, but certain features thereof have become known to me during protracted experiments that I have carried out. For instance, I have found that the electromagnetic tension or pressure within the metal mass is not uniformly distributed throughout the same.

The probable distribution of the induced tension or pressure over the width of the container has been plotted in the graph shown in Fig. 7, together with the variation of current density over the same area. According to the conclusion that I have arrived at, I believe that the sum of all electromagnetic pressures builds up towards the center. The total electromagnetic pressure opposes the hydrostatic pressure balancing the same. Therefore, near the outer regions there exist less action pressures or tensions that may even assume negative values.

The hydrostatic pressure mentioned in the foregoing normally is the pressure produced by the height of the actual level of the molten fluid; however, the theoretical level may considerably be increased over the actual level, for instance by trapping above the fluid level compressed air, which would correspondingly increase the "effection" level and accordingly the effection hydrostatic pressure. Accordingly, the hydrostatic pressure level mentioned herein below, will be understood to mean either the actual or the theoretical level, which is higher, as explained in the foregoing.

The power induced in the container 11 by the coil 16 will also maintain the temperature of the molten metal disposed therein.

A more perfected embodiment of the instant invention is shown in Figs. 2-4 and 6, and a modification thereof in Fig. 5. As illustrated in these views, there is provided a metal melting furnace generally indicated at 21 that is suspended tiltably about a tilting pivot 22. An hydraulic mechanism 23 is provided to tilt the furnace 21 from a discharge position shown in Fig. 9 to a metal retaining position such as shown in Fig. 10. An intermediate normal position, wherein the metal level is at a normal height or parallel to the bottom of the furnace 21 is provided for, but has not been illustrated.

For the purpose of illustration only, I have chosen a furnace of the induction type, including side walls 24 that surround with the bottom walls a melting chamber 26 which surmounts an inductor heating unit 27.

An electromagnetic valve or discharge device 28 is connected to the furnace 21, either permanently as shown in Fig. 3, or removably as shown in Fig. 6. The electro-

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magnetic valve 28 comprises a wall 29 that surrounds a valve chamber 31, and said valve chamber 31 intercommunicates interiorly with the melting chamber 26 of the furnace 21. The electromagnetic valve 28 is connected to one side of the furnace, preferably below the normal level thereof. The wall 29 carries encircling induction coils 32 that are surrounded, in turn, by a magnetic shield 33.

In actual experiments, it was shown that a six inch head could be contained with the following power. Primary winding 480 volts, 27 amperes, 10 kilowatts, and secondary winding 34 volts, 1570 amperes.

The valve chamber 31 is so arranged that it will be filled with metal when the furnace 21 is tilted into discharge position (Fig. 3) even at a minimum level, indicated at 34. In the melting chamber 26, above the metal level 34, there is provided a charge aperture 36 which is only a short distance above the level 34, regardless of the angle of tilting thereof, since it is located centrally of the melting chamber 26. By this arrangement, the melting chamber may continuously be charged during intermittent discharge operation of the electromagnetic valve 28.

As best shown in Figs. 2, 3 and 4, the furnace 21 may be applied to a die casting machine 37 of conventional construction, and the furnace 21 is arranged so close to it that the molten metal is required to travel only a few inches from its point of discharge from the valve 28 to the cold chamber of the die casting machine 37.

The tilting of the furnace 21, in connection with the exemplifications shown in Figs. 3 and 4, provides on one hand, for keeping the valve 28 always filled, in the discharge position, and, on the other hand, for emptying the valve in the metal retaining or valve drying position. This tilting arrangement enhances the safety of the furnace and valve, since it permits the withdrawal of all the metal from the valve at any time that this should be necessary or desirable.

These embodiments can either work on the principle of constant charging through the orature 36 during discharging of the valve 28, or of intermittent charging during interruption periods of the discharge.

In the embodiment shown in Fig. 5, the valve spout is aligned approximately with the tilting bearings. The valve is then controlled, for instance by moving slightly during each discharge jet, to compensate for the change in metal level. The effective molten metal head and the resultant hydraulic pressure over the valve are thus kept approximately constant, and the rate of metal flow will be substantially constant even though several hundred pounds are eventually discharged without refilling.

The electromagnetic valve 28 is best illustrated in Fig. 6. A tube or nozzle 38 is provided that is made of refractory material, such as graphite, or of other suitable material. The tube 38, which surrounds a discharge passage 39 is inserted into the valve chamber 31 at an inclined angle, so that the bottom of the tube which has an inlet 41, will be near the bottom 42 of the chamber 31 and be spaced for a certain distance from the end wall 43 thereof. The end wall 43 is disposed oppositely relative to the side wall of the furnace 21 to which the valve 28 is attached.

I have found that the distance between the inlet 41 of the nozzle 38 and the wall 43 is critical, since the tensions induced within the molten metal are so that at a certain predetermined distance of the inlet 41 from the end wall 31 a smaller amount of electric power is required to prevent discharge than at most other positions. As best shown in Fig. 6, in the preferred position, the axis of the tube 39 intersects the axis yy centrally of the chamber 31 at an angle (α) of approximately 45° near the inner surface of the end wall 43.

The passage 39 has a restriction 44 of the ratio of area of about 1 to 2 as compared to the remainder of

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the passage to provide for a continuous rate of flow during discharge.

The coil 32 surrounds only the surface part of the valve 28 that is near the tube inlet 41, as I found that a greater distribution of the surface encircled by the coil is probably not necessary.

The tube 38 is inclined upwardly and outwardly, relative to the chamber 31, so that metal during discharge will pass through the tube in an upward and outward direction, and the metal will be discharged from the upper outlet opening 46 of the tube 38 and will flow therefrom downwardly in a free parabolic stream.

In order to prevent freezing of the metal near the inlet 46, I provide a resistor 47 for heating the outer end of the tube 38. The power for the resistor 47 may be provided by suitable means, such as for instance by an electric cycle timer 48. A cycle timer of this type that I have used had an actual power requirement of less than 450 watts. This was found sufficient to maintain the temperature of the nozzle 38 while controlling the flow of molten aluminum.

A different embodiment is shown in Fig. 8. A vessel 51 for holding molten metal is shown that is provided with two nozzles or tubes 52 and 53. These nozzles are in axial registry and disposed oppositely to each other relative to the vessel 51. Each of the nozzles 52-53 is provided with an induction coil 57 and 58, respectively, and these coils are interconnected, by means of a control element 59, to an electric source. The control element 59 provides for synchronous switching off and on of the coils 57 and 58.

This embodiment lends itself for metal coating, such as galvanizing, of articles for instances wires or the like. The vessel 51 is arranged, by means of a suitable heating mechanism (not shown), to maintain a bath of molten metal 61, such as coating material, for an article, for instance a wire 62, to be drawn through the opposite nozzles 52 and 53.

During actual use, the coils 57 and 58 are energized and the resultant tension within the metal disposed in the nozzles, as described hereinbefore, will restrain the metal from flowing out of the vessel through the outlets 56. Each outlet 56 is so dimensioned that the area thereof is only slightly larger than the area of the sectional contour of the article to be drawn through the bath 61.

This embodiment permits the coating of articles by drawing them through the bath while maintaining the same straight, and without requiring any elastic deflection of the article from straight position, eliminating thereby the need for deflecting rollers or similar auxiliary devices heretofore in use for the coating of wire and other articles.

It will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific exemplifications thereof will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims they shall not be limited to the specific exemplifications of the invention described herein.

Having thus described the invention, what I claim as new and desire to be secured by Letters Patent, is as follows:

1. In an electromagnetic valve for molten metal, a container for a molten metal mass, an electric induction coil operable when energized to produce in at least a portion of the molten metal mass within said container a tension inducing said portion to move in a direction away from the side wall of said container, a tube extending through said side wall and having an inlet on the interior of said container immersed in the metal adjacent the bottom and spaced from said side wall for a distance beyond the movement of said metal portion and terminating exteriorly of said container in an outlet disposed below the hydrostatic pressure level of said container and out-

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side of the surface area of said metal portion under tension.

2. An electromagnetic valve, as claimed in claim 1, further characterized in that said tube has between its ends a restricted passage of a fraction of the area of said outlet.

3. An electromagnetic valve, as claimed in claim 1, further characterized in that said tube is inclined upwardly and outwardly of said container, whereby molten metal passes therethrough upwardly for discharge.

4. In a metal melting furnace, a tiltably supported vessel for receiving and melting metal, heating means operably connected to said vessel, and means for tilting said vessel in opposite directions about a normal horizontal position, between an extreme inclined position wherein the mutual pressure level is unevenly concentrated above one side of said vessel, and another extreme position of induction wherein said side is drained of metal, in combination therewith, an electromagnetic valve comprising a container connected to said side of said vessel below the level at normal position thereof whereby said container will be filled with metal at all positions of said vessel between said first inclined position and said normal position, an electrically energizable induction coil surrounding said container and being operable when actuated to produce in at least a portion of the molten metal mass within said container a tension inducing said portion to move in a direction away from the side wall of said container opposite said vessel side, and a discharge passage extending from a point on the interior near said side wall to the exterior of said container and having on the exterior an outlet disposed below the pressure level of said metal, said tension being sufficient to restrain discharge through said outlet upon energization of said coil.

5. A melting furnace as claimed in claim 4, further characterized in that said container is mounted adjacent the tilting axis of said vessel.

6. In a pouring device, walls forming a chamber adapted to contain a bath of electrically conducting material, walls forming a side pouring opening from the chamber beneath the level of the molten material, and

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electric induction means deflecting the bath away from the side pouring opening to prevent pouring.

7. In a pouring device, walls forming a chamber adapted to contain a bath of electric conducting material, a pouring opening communicating with the chamber beneath the level of the molten material at one side thereof, an inductor coil in inductive relation to the pouring opening and deflecting molten material from the pouring opening, means for tilting the chamber to raise the pouring opening above the level of the molten material and means automatically responsive to abnormal reduction in current drawn by the deflecting means for tilting the chamber to raise the pouring opening above the level of the molten material.

8. In a pouring device, walls forming a chamber adapted to contain a bath of electrically conducting molten material, a tubular extension connected to the side of the chamber, separable connections between the tubular extension and the walls of the chamber, a mouth at the outer end of the tubular extension, adapted to communicate with a stream of molten material from the tubular extension, and an electric inductor coil surrounding the tubular extension, the stream passing within the outer half of the depth of penetration.

References Cited in the file of this patent

UNITED STATES PATENTS

329,491	Schulze-Berge	Nov. 3, 1885
1,853,842	Bates et al.	Apr. 12, 1932
1,853,843	Bates et al.	Apr. 12, 1932
1,914,354	Adam, Jr.	June 20, 1933
2,101,675	Ferguson	Dec. 7, 1937
2,140,607	Thompson	Dec. 20, 1938
2,186,718	Ferguson	Jan. 9, 1940
2,224,982	Morin	Dec. 17, 1940
2,528,208	Bonsack et al.	Oct. 31, 1950
2,536,325	Tama	Jan. 2, 1951
2,616,800	Wartman	Nov. 4, 1952

FOREIGN PATENTS

623,999	France	Mar. 28, 1927
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