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2,959,829

CASTING METHOD AND APPARATUS

Filed Sept. 9, 1957

3 Sheets-Sheet 1

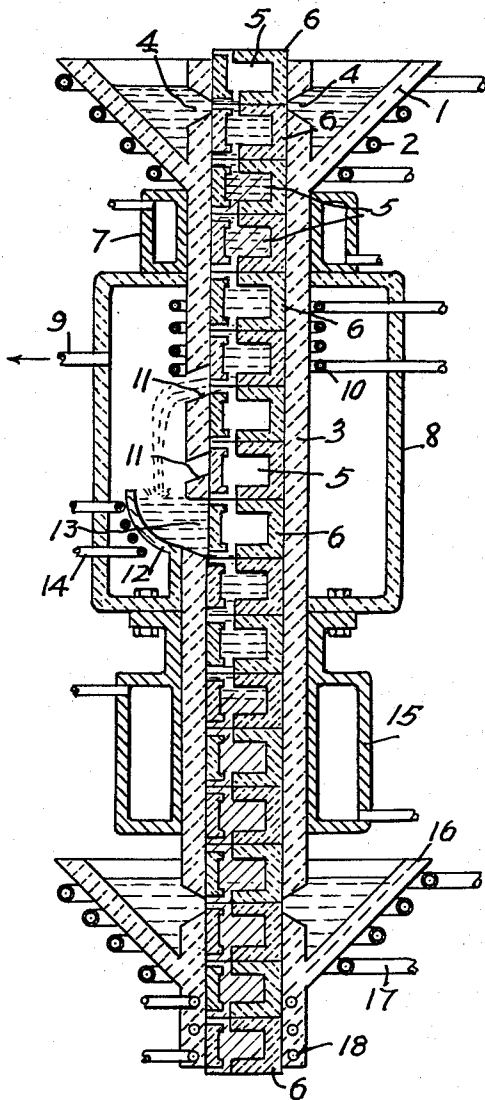


Fig. 1

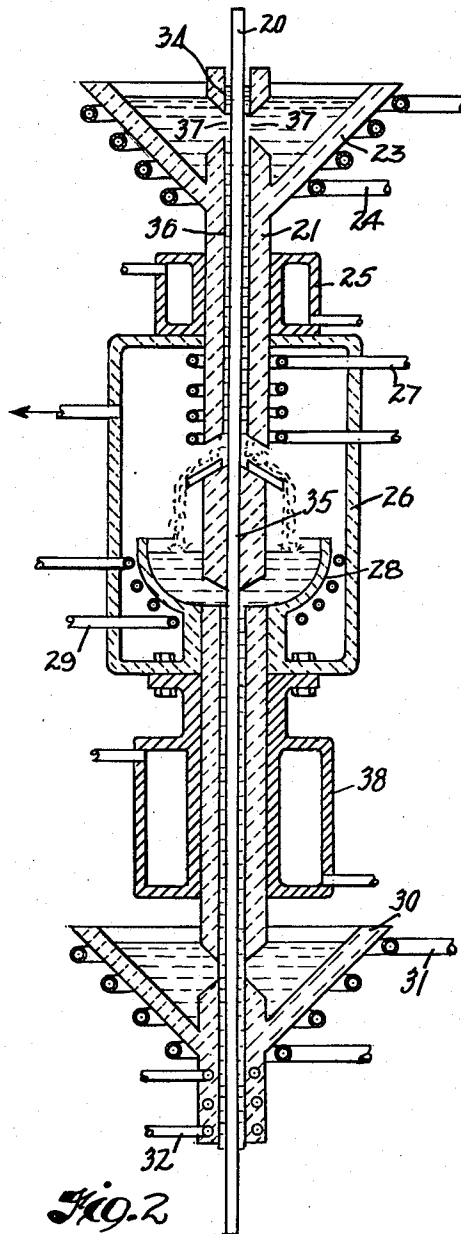


Fig. 2

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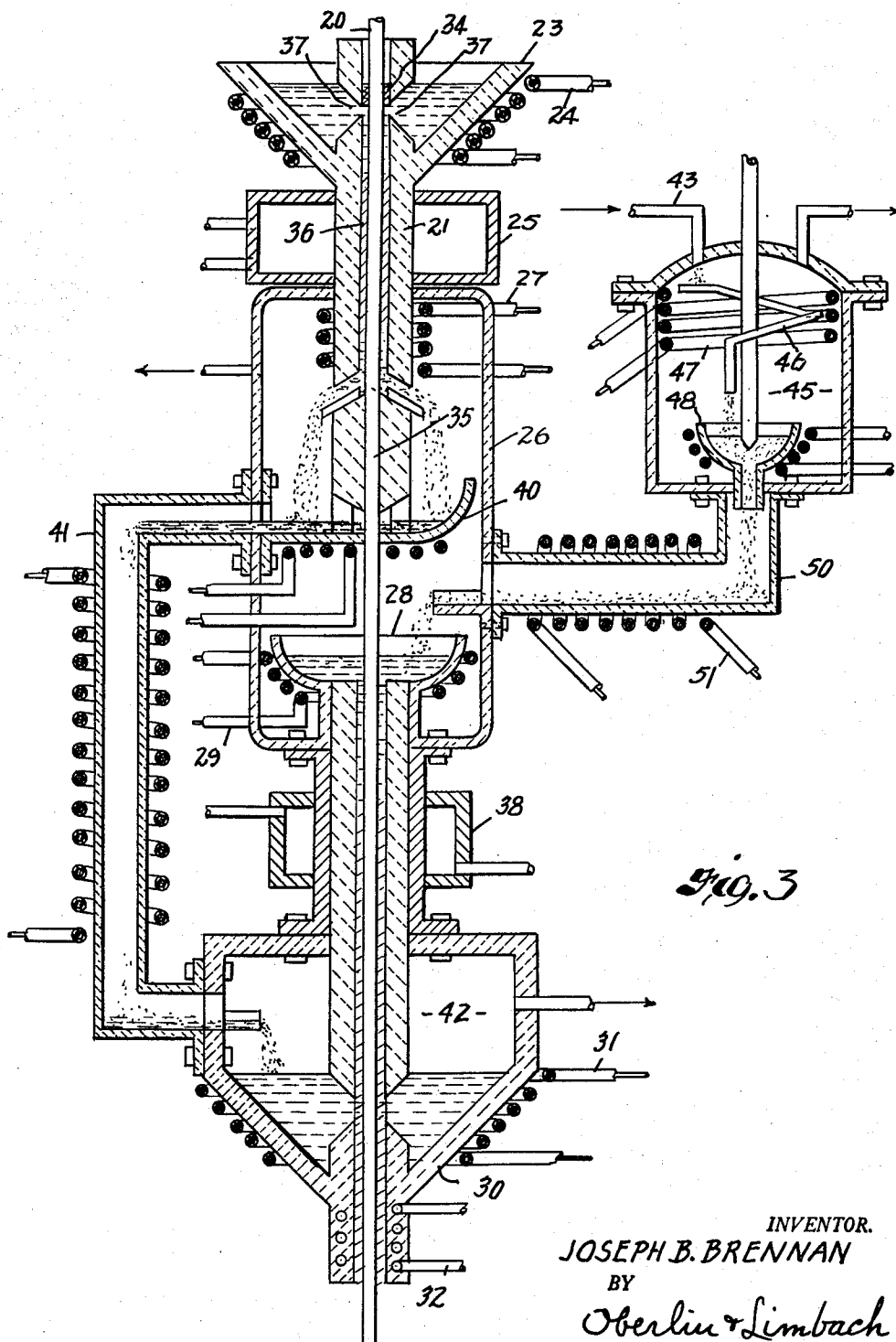
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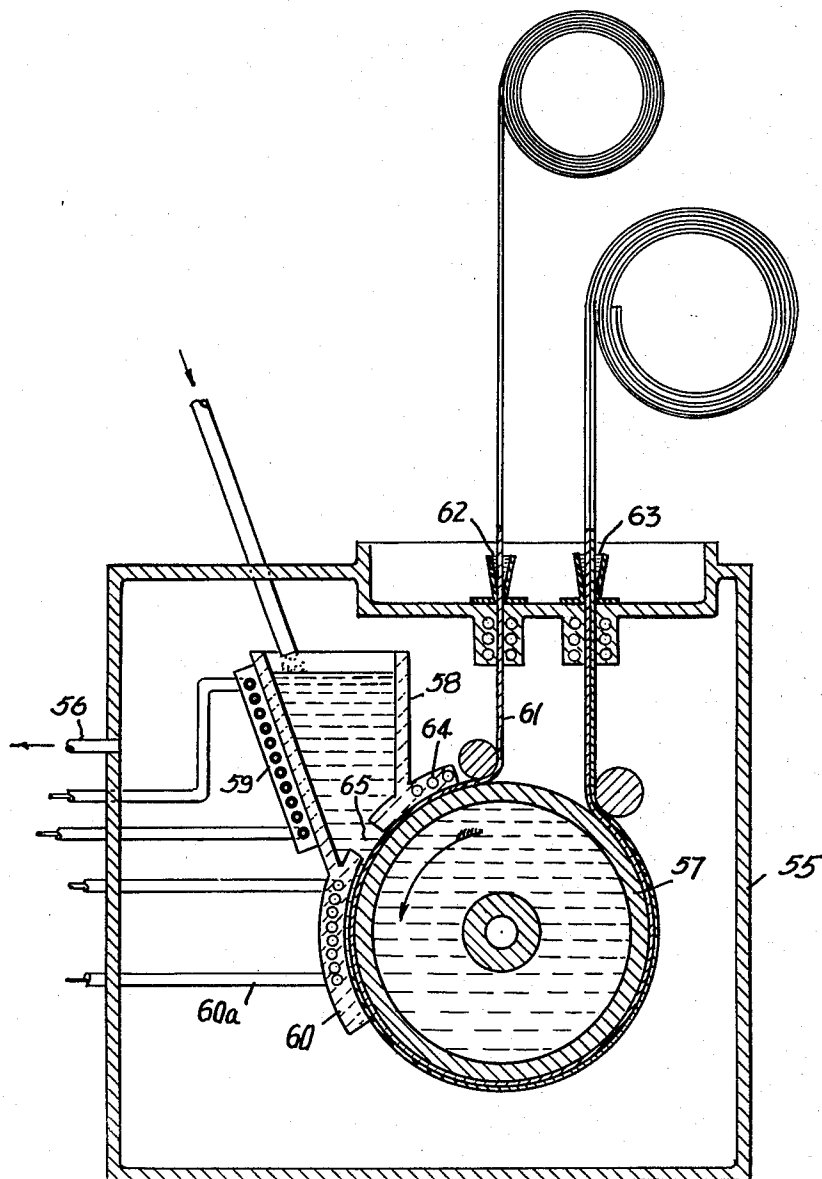


Fig. 4

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2,959,829

CASTING METHOD AND APPARATUS

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7 Claims. (Cl. 22—57.3)

The present invention relates generally as indicated to a casting apparatus, and more particularly to a casting apparatus of the type disclosed in my application Serial No. 532,692, filed September 6, 1955, now Patent No. 2,804,664, which in turn was copending with Serial No. 225,949, filed May 12, 1951 (now Patent No. 2,716,790, granted September 6, 1955), and wherein molds are adapted to be successively shoved longitudinally through a guide tube past a casting zone whereat the molds are successively filled, and then through a chilling zone whereat the molds and metal therein are cooled to solidify the castings therein. The present invention also contemplates the forming of a cast metal layer on a rod or strip by longitudinally moving the latter through casting and chilling zones.

It is an object of this invention to provide a casting apparatus and method of the type indicated in which the casting and chilling operations are performed fluid-sealed from the atmosphere in a chamber, specifically a vacuum chamber, which is remote from the molten metal supply so that the operator is not required to be stationed close to the intense heat emanating from the molten metal supply crucible.

It is another object of this invention to provide a casting apparatus and method of the character indicated wherein molds or cores (rods or strips, for example) are shoved longitudinally through a guide, the guide being provided with a feed opening to which molten metal is fed and which feed opening successively registers with openings leading into the successive mold cavities or with spaces between such core and the guide as the molds (or cores) are moved longitudinally through the guide.

Another object of this invention is to provide a casting apparatus and, as well, a new method of casting wherein metal is supplied into molds or dies and is solidified therein followed by remelting and draining of the solidified metal for degassing of the metal and evacuation of the molds or dies, the remelted and degasified metal being flowed back into the emptied molds or dies wherein it is finally solidified.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features herein-after fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

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In said annexed drawings:

Fig. 1 is a vertical cross-section view of one form of apparatus constituting the present invention;

Fig. 2 is a vertical cross-section view of another form of apparatus;

Fig. 3 is a vertical cross-section view of yet another form of apparatus; and

Fig. 4 is a vertical cross-section view of laminating apparatus.

Referring now more particularly to Fig. 1 of the drawing, there is provided at the top a molten metal supply container 1 which may be made of Al_2O_3 when the metal being cast is aluminum.

Associated with the container 1 is a high frequency induction heating coil 2 which, in the case of the casting of aluminum, is operated at 400,000 cycles per second and 30 kva. to maintain the casting metal at a temperature of about 1250° F.

The container 1 herein constitutes the upper end of a mold guide member 3, said guide member being formed with an opening 4 through the wall thereof through which molten metal flows into the cavities 5 of the molds 6 which are adapted to be guided by and shoved downwardly through said guide member. The metal in the molds 6 and in contact therearound provides a fluid-tight seal for the operations to be performed as later explained.

In the present case, the molds 6 are in the form of cylindrical blocks of fused Al_2O_3 , there preferably being sprues at the top and bottom of each mold so that the metal in one mold will be in communication with the metal in the molds 6 therebeneath.

Accordingly, when the molds 6 are successively shoved downwardly through the guide member 3, the cavities 5 thereof will successively be filled with molten metal from container 1.

A cooling unit 7 is disposed below the container 1 in surrounding relation to the molds 6 in that region of the guide member 3 so as to effect solidification of the metal in the molds 6 as the latter are moved downwardly through said guide member. Said cooling unit 7 in the case of casting of aluminum should preferably be arranged to cool the molds 6 and the metal therein to a temperature of approximately 600° F.

As a further feature of this invention, there is disposed below the cooling unit 7 and around the guide member 3 a vacuum chamber housing 8 in which a desired vacuum is maintained through the vacuum line connection 9.

Within said vacuum chamber housing 8 and surrounding the guide member 3 is a high frequency induction heating coil 10 which is effective to remelt the metal in the molds 6 as the latter move through the high frequency heating field of the coil 10.

As the molds pass downwardly in register with the openings 11 in the wall of the guide member 3, the molten metal runs out and drips down into a receptacle 12 from where the molten metal in degasified condition refills the evacuated molds 6 through the opening 13. There is also a high frequency heating coil 14 associated with the receptacle 11 effective to maintain the metal at the proper temperature, namely, about 1250° F. in the case of aluminum.

As the refilled molds 6 continue to be shoved downwardly, they pass through another cooling unit 15 effective

tive to resolidify the metal therein, and finally the molds 6 pass successively through container 16, the molten metal therein constituting a fluid-tight seal around the molds 6 to eliminate air leakage into the vacuum casting and chilling zones.

The metal in container 16 may be heated by frequency coil 17 and the metal may be the same as the casting metal; aluminum, for example. Said metal will not be in contact with the molds 6 for sufficient time to remelt the vacuum cast and solidified metal therein. In any case, a cooling coil 18 may be provided at the lower end of guide member 3.

Obviously, a lower melting point metal may be used as the fluid seal provided that it is compatible with the castings and will not react with or contaminate the same.

As the molds 6 emerge from the lower end of the guide member 3, they and the metal casting therein may be at a temperature of approximately 600° F.

It is to be noted that, by reason of the conducting of the casting operations under vacuum, the air pressure acting on the upper and lower ends of the column of molds 6 is effective to tend to hold the molds together in engagement.

It is to be noted further that the molds 6 in the casting zone are interconnected together so that there is a continuous molten shrink head of metal disposed above the progressively upwardly solidified castings, the solidified metal serving as a vacuum seal in combination with the fluid seal at the top and bottom of the guide member 3.

The vacuum in the chamber housing 8 may be about 5 microns which has been found to effect thorough degassing in a matter of 1/2 second in combination with the dripping of the remelted and drain metal through the vacuum chamber. In contrast, a pool of metal sufficient to fill the molds 6 as they pass down would require 20 minute exposure to 5 micron pressure for equivalent degassing.

In the event that the molds 6 are of porous nature, it is desirable to interpose between said molds 6 impervious plugs or discs of a dense ceramic material, dense aluminum oxide or metal to prevent leakage of atmosphere into the vacuum chamber. These plugs or discs would be of the same cross-section size as the molds 6 and may be made out of dense aluminum oxide or other ceramic material. As aforesaid metal plugs or discs may be used, but, in general, ceramic material is preferred.

Referring now to Fig. 2, the apparatus there shown is quite similar to that of Fig. 1 except that, instead of moving successive molds 6 down through a guide member 3, an elongated core 20 in the form of a rod, wire, or strip is thus moved through the guide member 21 to cast onto one side, both sides, or all around, said core 20 a layer of different material of lower melting point.

As before, the Fig. 2 guide member 21 is provided with a molten metal container 23 at the upper end, there being an induction heating coil 24 therearound to maintain the metal therein in molten condition.

Below the molten metal container 23 is a cooling unit 25 and therebelow is a vacuum chamber housing 26 which contains an induction heating coil 27 and a reservoir 28 for molten metal which is maintained in molten condition by another induction heating coil 29.

Below the vacuum chamber 26 is another cooling unit, and finally, just before the product issues from the lower end of the guide member 21, there is provided a container 30 which contains fluid metal heated by the induction heating coil to provide a pool of molten metal which effectively forms a seal around the product. Finally, there is a cooling coil 32 around the lower end of the guide member 21.

At the upper end of the guide member 21 and near the middle, as indicated by the reference numerals 34 and 35, the guide member is splined or otherwise formed to center the core 20 with respect to the longitudinally extending passage 36 through the guide member. The

portion 35 closely embraces core 20 so that melted metal will drip therefrom into reservoir 28.

It can be seen that, as the core 20 is moved downwardly through the guide member 21, it will be accurately guided by said portions 34 and 35 and molten metal will be cast therearound from the container 23 through the feed openings 37, and as the molten metal filling the spaces between the core 20 and the guide member passage 36 moves downwardly, the metal solidifies by the cooling action of the cooling unit 25. As can be seen, the molten metal in the container 23 serves as a seal against leakage of atmospheric air into the vacuum chamber 26.

After the metal has thus been solidified, it is remelted as it passes through the induction heating coil 27 in the vacuum chamber 26, the melted metal dripping in particulate form for effective degassing in the vacuum chamber, the degassed metal being collected in a pool in the reservoir 28 for recasting into the spaces between the core 20 and the lower end portion of the passage 36 through the guide member 21. The metal, while in such pool, is subjected to still further degassing.

The recast and degassed metal is then solidified as the core 20 carries the same through the cooling unit 38. The molten metal in the bottom container 30 serves as a fluid seal.

Finally, the core 20 and the metal cast thereagainst is subjected to still further cooling when passing through the cooling coil 32.

In the case of a steel core, that is a wire, rod, or strip, the casting metal may be any one of a variety of lower melting point metals, such as aluminum, copper, bronze, tin, or lead alloys, etc.

By way of specific example, a steel strip 20 of 1" x 1/8" size was moved through the guide member 21 at the rate of 15 ft./min. and a layer of 50-50 tin and lead of .020" thickness was applied on opposite sides of said steel strip, the tin-lead alloy being heated to approximately 650° F. by means of an induction heating coil operating at a frequency of 9600 cycles, 20 kva.

The cooling unit 25 was of the type through which cold water is circulated at a rate to cool the tin-lead casting to approximately a temperature of 300° F. and then, in passing through the induction heating coil 27, the tin-lead alloy was remelted, the coil 27 being operated at 2000 frequency and 10 kva.

The vacuum chamber 26 was maintained at a pressure of 10 microns to effect thorough degassing of the tin-lead alloy as the same dripped down into the pool. In the pool, the tin-lead alloy was heated to about 550° F. by the 2000 frequency, 10 kva. induction coil 28. Then, as the bimetal moved downwardly through the guide member 21, the tin-lead layer was cooled to about 300° F. in passing through the water-cooling unit 38.

Finally, the solidified tin-lead alloy layer and strip therebetween passed in communication with the fluid metal in the lower container 30, said metal preferably being the same tin-lead alloy heated to about 400° F. by the induction coil 31 operating at 2000 cycles, 10 kva. However, such contact of the tin-lead alloy in the bottom container 30 was not sufficient to remelt the previously solidified tin-lead layers on the steel strip but was effective in preventing leakage of air into the vacuum chamber 26.

As the bimetal casting emerged from the lower end of the guide member 21, the solidified tin-lead alloy layer was at a temperature of about 300° F.

It will be appreciated that other metals such as the Muntz metals and bismuth alloys could just as well have been used as the fluid-sealing metal in the bottom container 30. In fact, fluids other than molten metals may be employed, such as molten silicone grease, or glycerin.

Referring now to Fig. 3, the apparatus there shown is similar to that of Fig. 2, and to that extent the same reference numerals have been employed to denote the same or similar components,

The Fig. 3 apparatus is concerned with application of, for example, an aluminum coating on a rod, wire, or strip of steel. In this case, after degreasing, pickling, and fluxing of the steel core 20 in well known manner, as by use of a solvent or an alkali cleaner (for degreasing), a hydrochloric acid bath (for pickling), and a zinc chloride bath (for fluxing), said core 20 is passed through container 23 for fused salt, for instance, one having the following composition:

	Percent
KCl -----	47 (37 to 57)
NaCl -----	35 (25 to 45)
Na ₃ AlF ₆ -----	12 (8 to 20)
AlF ₃ -----	6 (.5 to 12)

The temperature of the fused salt bath in container 23 is preferably maintained at a temperature from about 1300°-1400° F. but satisfactory results are achieved at temperatures between about 1250° to 1600° F.

As the salt-coated core 20 passes through guide 21, the salt is solidified by cooling unit 25 and then re-melted within induction coil 27 or other heating means. The remelted salt drains from the core 20 into trough 40 in vacuum chamber housing 26 wherefrom it is conducted through heated conduit 41 into the vacuum chamber 42 associated with the vessel 30.

A further characterizing feature of the Fig. 3 apparatus is that the molten metal, in this case aluminum for example, is supplied in de-gassed condition into vessel 28 for casting onto the salt-treated steel core 20. Such degassing of the aluminum is accomplished by dripping molten aluminum from supply pipe 43 into vacuum chamber 45 and onto helical trough 46 whereon the metal, maintained molten by induction coil 47, flows in thin layer form exposed to vacuum and wherefrom the metal again drips into vessel 48.

A surrounding induction coil 49 keeps the metal in molten condition in vessel 48 and again further de-gassing is effected by dripping of the metal from vessel 48 into vacuum-exposed conduit 50, the metal being heated by coil 51 around said conduit. Finally, the metal again drips into vessel 28 from which it is applied against the salt-treated core 20.

Now, as the aluminum-coated core 20 passes through cooling unit 38, the aluminum coating is solidified and the exit end of the guide 21 is fluid-sealed from atmospheric exposure by the fused salt in vessel 30, the finished aluminum-coated core 20 emerging from the lower end of said guide 21. The present method produces an aluminum-coated steel core 20 which is readily formable by reason of the elimination of brittle iron-aluminum compounds between the steel and aluminum which otherwise result from simply applying aluminum to steel without the prior salt treatment.

Referring to Fig 4, there is shown therein a vacuum chamber housing 55, as of ceramic material, to which a vacuum line 56 is connected to maintain a pressure of about 350 microns therein. Mounted for rotation in said housing is a water-cooled roll 57, a container 58 for molten metal such as copper, for example, which is heated by induction coil 59, and a die 60 which has an induction coil 60^a associated therewith to maintain a slick or slippery surface on the copper which is cast against the metal strip 61, steel for example, which passes around said roll 57 into and out of the housing through fluid seals 62 and 63.

Induction coil 64 located ahead of the molten metal supply port 65 is effective to heat preferably only the surface of the steel strip 61 to bonding temperature so that the copper will unite with the steel strip. Heat is extracted from the laminated strip metal preferably solely through the roll 57 which is effective to carry the steel strip with the cast copper layer through the die 60. Thus, the surface of the copper is continuously trowelled smooth.

Molten metal can be used as coolant or other tempera-

ture control means to control temperature of the solidification zones.

Remelting of castings and recasting can be resorted to with varying and stepped progressively increasing volume to attain the ultimate in perfection of complete degassing of the product by using a series of solidification sealing zones alternately with a series of melting degassing and casting chambers each vacuum chamber being of higher evacuation than the preceding one.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

1. Apparatus for the deposition of a coating about a core member including a vacuum chamber, guide tube means extending into and away from the vacuum chamber, an elongated core member adapted for movement through the guide tube means and vacuum chamber and cooperating with said guide tube means to define a cavity, a fused salt bath surrounding the guide tube means extending into the vacuum chamber and communicating with the interior thereof whereby such fused salt provides a fluid seal against the ingress of air into the chamber and simultaneously fills said defined cavity with the guide tube means extending into the vacuum chamber, cooling means stationed along the guide tube prior to the chamber to solidify the fused salt, heating means operative to remelt the salt within the vacuum chamber, crucible means within the chamber to receive the remelted salt, second crucible means in the chamber surrounding the core member and disposed below the first crucible means to communicate with the guide tube means extending away from the vacuum chamber, means to supply molten metal to the second crucible means within the chamber and expose the metal to the degassing influence of the vacuum chamber and to cast the metal about the salt-treated core member and into the cavity defined by said core member and cooperating guide tube means, cooling means disposed along the guide tube and subsequent to the vacuum chamber to solidify the molten metal, and an enclosed evacuated container of fused salt surrounding the guide tube means extending away from the vacuum chamber and communicating with the interior thereof to prevent the ingress of air into the vacuum chamber.

2. Apparatus as defined in claim 1 wherein said means for supplying molten metal to the second crucible means in the vacuum chamber includes an evacuated conduit which advances the molten metal in particulate form into said chamber.

3. Apparatus as defined in claim 1 further including conduit means connecting the crucible means in the vacuum chamber which receives the remelted salt with said enclosed evacuated container surrounding the guide tube means extending away from said chamber to flow the melted salt from said crucible means to said evacuated container.

4. In the method of vacuum casting by moving a mold member through the entrance and exit portions of a guide tube extending through a vacuum casting chamber and with which guide tube the mold member defines a casting cavity, the steps of providing a liquid seal about the entrance end of the guide tube composed of fused salt simultaneously to prevent the ingress of air into the vacuum chamber and fill such defined casting cavity and thereby treat the surface of the mold member, solidifying the salt prior to reaching the vacuum chamber, remelting the salt in the vacuum chamber and draining it from the guide tube, flowing molten metal into the vacuum chamber to expose the metal to the degassing influence thereof and then casting the metal in the guide tube and against the salt-treated surface of the mold member to fill such casting cavity, and

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then solidifying the molten metal in such casting cavity and adhering the solidified metal to the mold member.

5. A method as defined in claim 4 further including the step of passing the solidified metal through a fluid seal to prevent the ingress of air into the vacuum chamber.

6. A method as defined in claim 4 further including the steps of passing the solidified metal through an evacuated enclosure surrounding the guide tube, and exposing the solidified metal and mold member to a liquid seal of fused salt in such enclosure to prevent the ingress of air into the vacuum chamber.

7. A method as defined in claim 4 further including the steps of passing the solidified metal through an evacuated enclosure surrounding the guide tube, exposing

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the solidified metal and mold member to a liquid seal of fused salt to prevent the ingress of air into the vacuum chamber, and passing the remelted salt drained from the guide tube in the vacuum chamber to such evacuated enclosure to supply the liquid seal thereof.

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