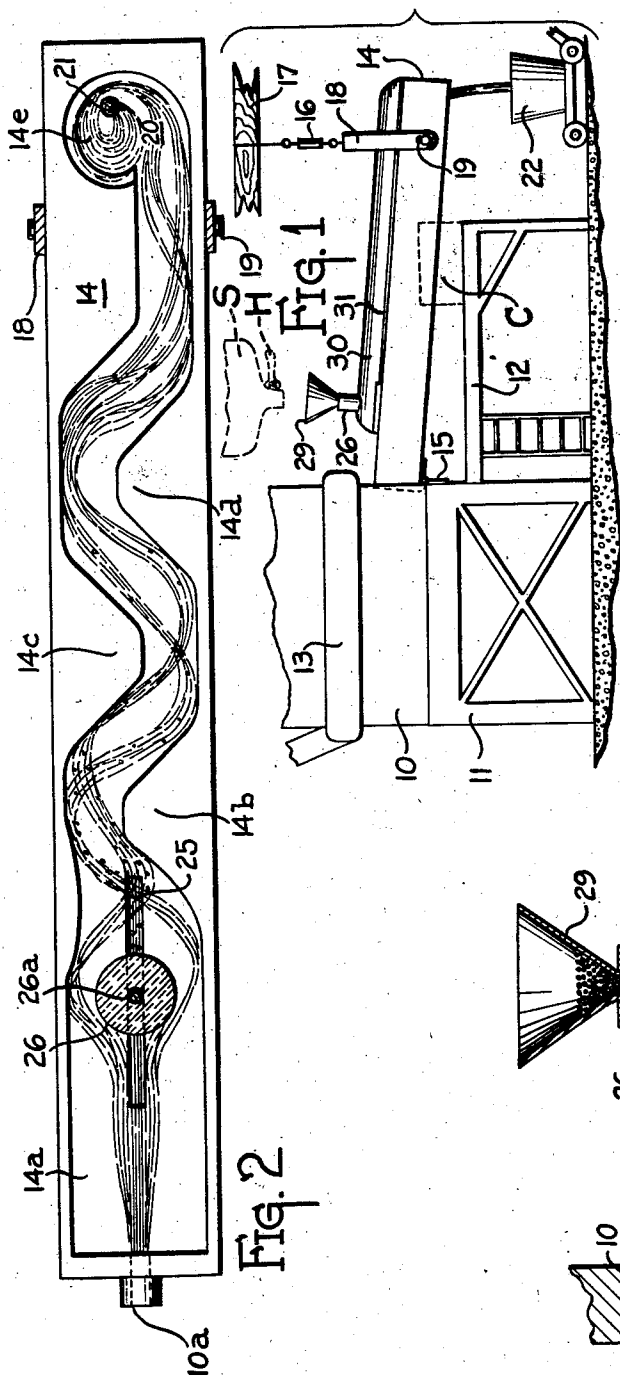
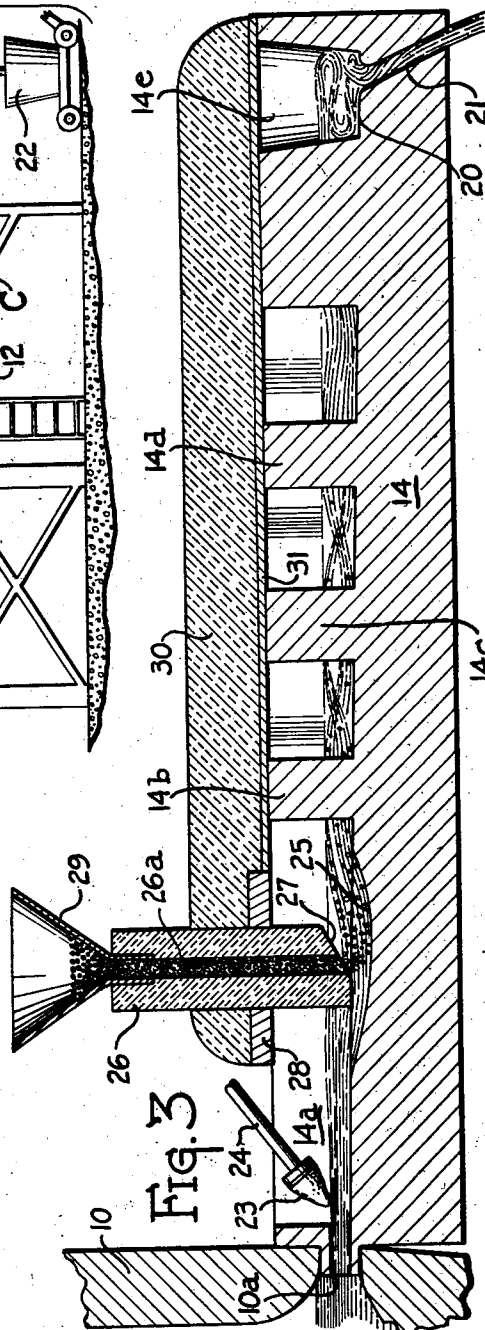


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METHOD OF AND APPARATUS FOR INTRODUCING ADDITION
INGREDIENTS INTO MOLTEN METALS
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METHOD OF AND APPARATUS FOR INTRODUCING ADDITION INGREDIENTS INTO MOLTEN METALS

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7 Claims. (Cl. 266-34)

This invention relates to a method of and an apparatus for adding ingredients to molten metals to control the physical and/or chemical characteristics of a metal.

In the prior art, the general method of mixing addition ingredients to molten metals, as for example, steel, has involved the addition of the materials while the molten metal was in an open ladle, and thereafter by mechanical means the molten metal was stirred or agitated until it appeared that the addition material had been thoroughly dissolved and a homogeneous mixture had been obtained. This method of adding ingredients to molten metals was subject to many difficulties which tended somewhat to destroy the usefulness of the resulting metal, particularly in that the mixtures were not uniform.

A serious disadvantage of the old method is that the molten metal in the open ladle during the mixing period was subject to cooling, this being particularly true during the stirring period and in some cases a period of time was necessary to allow the added ingredients to dissolve in the metal before pouring into molds, which further aggravated the situation. In order to overcome this difficulty, the temperature of the molten metal was made inordinately high so that the cooling of the metal would still leave the temperature remain sufficiently high to allow pouring. If the metal is heated to the high temperature necessary to overcome this disadvantage, there is a tendency for the addition ingredients to become oxidized or otherwise destroyed and, inasmuch as this destruction could not be accurately gauged, it was substantially impossible to control accurately the amount of addition materials that would be finally included in the metals as poured into molds.

Furthermore, the fact that the addition materials in the old method had to be introduced into the molten metal from the upper surface, it was extremely difficult to dissolve the materials and it often happened that a large percentage of the addition material floated to the surface of the molten metals and was not dissolved. While the addition materials floated on the surface, subject to the high temperatures of the melt, they were often oxidized by the air and made incapable of being dissolved.

Another disadvantage with this method of dissolving addition ingredients into a melt was that there was no assurance that they would be uniformly disbursed through the body of the molten metal in the ladle, with the result that the "pour" would not be homogeneous and gave non-uniform

results in that some of the metal would contain a larger percentage of the addition ingredients.

The present invention provides a method of and an apparatus for the introduction of ingredients into molten metals for the purpose of forming alloys, deoxidizing or desulphurizing the metal, or the addition of any material which is desirable to control the physical and/or chemical characteristics of a metal. At the same time, the invention obviates the difficulties pointed out in the previous paragraphs in that it provides a method of adding ingredients to molten metals which introduces the ingredients in an easily-controlled, definite, accurate, and efficient way so that uniform results can be obtained in the treated metals.

A means is provided by this invention to convey molten metal from a cupola furnace to a pouring ladle so designed that the ingredients to be added to the molten metal are placed in contact with the molten metal in the conveying means whereby the ingredients will be substantially dissolved in the molten metal before entering the ladle. The conveyor is so designed that the ingredients are placed in contact with the molten metal in such a manner that the ingredients will be completely surrounded and submerged in the molten metal to be reacted upon by the high temperatures to assure that all the addition ingredients intended to be added to per unit volume of the molten metal will be completely dissolved therein to assure uniform mixtures in the ladle.

To do this a turbulence is caused in the flow of the molten metal through the conveyor means by baffles which tend to reverse the direction of flow and cause a "folding over" of the metal upon itself so as to cover any non-included ingredients which may be floating upon the surface of the molten metal. At the distal end of the conveying means immediately above or adjacent the ladle an enclosure is provided having a vent in its bottom immediately above the ladle so that the molten metal will tend to collect in the enclosure and cause a rotating or swirling action which centers in the vent through which the molten metal flows into the ladle. All non-included ingredients which are still floating upon the surfaces of the molten metal in the swirl will be drawn into the core of the stream of molten metal and discharged through the vent so as to assure that the ingredients will be subjected to the high temperature of the molten metal and carried to the bottom of the metal in the ladle by the downwardly flowing stream

of molten metal discharging from the vent. This will insure maximum inclusion with a minimum of oxidation.

It is, therefore, a principal object of this invention to provide a method which will be efficient and accurate for adding ingredients to molten metals for the purpose of controlling physical and/or chemical characteristics of the metal.

It is a further object of this invention to provide an apparatus which will facilitate the introduction of ingredients into molten metals in an accurate and efficient manner which enables an operator to control the physical and/or chemical characteristic of a metal.

It is a further object of this invention to provide a method for the introduction of various ingredients to molten metals, such as, alloys, deoxidizing and desulphurizing agents, which will facilitate maximum inclusion of the ingredient into the molten metal to thereby assure accurate control and uniform results.

It is a further object of this invention to provide a method and an apparatus for its application for introducing various ingredients into molten metal; a method which is very flexible in operation and can be readily controlled to include into the metals any desirable percentage of the ingredients and assure maximum inclusion under all circumstances to obtain uniform results.

Other objects and advantages of this invention relating to the arrangement, operation and function of the related elements of the structure, to various details of construction, to combinations of parts and to economies of manufacture, will be apparent to those skilled in the art upon consideration of the following description and appended claims, reference being had to the accompanying drawing forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

Figure 1 is an elevational view of the invention when combined in operative position with a cupola furnace.

Figure 2 is a plan view of the conveyor.

Figure 3 is a cross-sectional view.

Referring to the drawing, particularly to Figure 1, the general organization of the apparatus for introducing various ingredients to molten metals is shown. A cupola furnace 10 is provided having a supporting base 11 and a laterally disposed platform 12 for an attendant. The cupola furnace is of the usual type having an air duct 13 adjacent its tuyères. Below the air duct 13 a molten metal conveyor means 14 is provided which is held in cooperative relation with the furnace 10 along a radial line by means of a hinge contrivance 15 which allows the conveyor 14 to be raised and lowered at its distal end by means of a turnbuckle 16, one end of which is anchored to a fixed overhead portion 17 and the other end being attached to a stirrup 18 fixedly attached to the conveyor by means of a transverse pin 19.

The conveyor means 14 closely cooperates with the outlet vent of the cupola furnace (Figure 3) adjacent its inner end and extends radially therefrom. At the point of cooperation between the furnace and conveyor means, an inlet 10A is provided which issues into a trough-like portion 14A of the conveyor so that the molten metal will flow along the floor of the trough 14A. Inasmuch as the conveyor 14 is adjusted so that the distal end adjacent the stirrup 18 is lower than the inlet 10A at the cupola, the molten

metal will flow from the furnace through the trough-like portion 14A under the influence of gravity. The speed of flow of the metal can be controlled by either the size of the opening in the inlet 10A or by the slope of the conveyor 14, or both.

The trough 14A is made tortuous by providing baffles 14B, 14C and 14D on its inner side surfaces which are positioned in staggered relation and tend to narrow the stream of the molten metal and to cause it to flow in a turbulent manner so as to "throw back" on itself and turn over as it comes in contact with each of the baffles as is shown clearly by the light flow lines of Figure 2. Adjacent the distal end of the conveyor 14, near the stirrup 18, a substantially circular enclosure 14E is provided, whose sides may be slightly convergent and whose floor 20 is provided with a vent or aperture 21 so aligned as to be substantially vertical over a ladle 22 which is positioned immediately below it during the pouring operation to catch the molten metal discharging from the vent. The molten metal flowing in the trough 14A of the conveyor means 14 enters the enclosure 14E adjacent one side thereof so that as the metal flows into the enclosure 14E a rotation is obtained which causes a swirl centering over the vent 21 whereby the molten metal discharges from the center of the swirl to fall into the open ladle 22.

Adjacent the upper end of the conveyor 14 and near the inlet 10A, a means is provided for introducing into the stream of molten metal, flowing in the trough 14A, various ingredients which are to be introduced into the metal for controlling the physical and/or chemical characteristics thereof. In order to introduce the ingredients into the molten metal, it is preferable to completely surround them as quickly as possible with the molten metal to assure maximum inclusion or dissolving of the ingredient in the molten metal. It is preferable to introduce these materials as near as possible to the outlet of the cupola furnace allowing at the same time sufficient space so that an operator can control the inlet 10A by means of a plug of soft refractory material 23 on the end of a rod 24.

The floor of the trough 14A of the conveyor is provided with an elongated slot 25 paralleling the flow of the molten metal having its greatest depth at a central position and gradually from this point in either direction approaching the surface of the trough 14A. This provides a narrow groove through which a portion of the molten metal flows in its path down the conveyor 14. Immediately above the elongated slot 25, and, preferably at its central position, a refractory tube 26 is provided having an aperture 26A whose lower end rests upon the floor of the trough 14A by bridging the elongated slot 25. The leeward side of the refractory tube is cut away at 27 so that the molten metal which flows through the trough 14A divides its stream and flows on either side of the tube 26 and is then "thrown back" from the side walls of the trough 14A to fall upon the molten metal flowing through the slot 25 underneath the end of the tube 26. The cut away portion 27 is designed to impede this flow of the molten metal as little as possible.

The central aperture 26A of the refractory tube 26 is positioned centrally over the slot 25 and may be made of any dimensions to suit the type of material which is to be added to the molten metal. The tube 26 is held in its vertical position on the conveyor means by means of a support

28 which bridges the top side of the trough 14A. Adjacent the upper end of the refractory tube 26 a funnel means 29 is provided which cooperates with the center aperture 26A of the tube and provides a ready means for introducing the ingredients into the tube so that they may flow therethrough and issue into the slot 25 in the trough where they come in contact with the flow of molten metal. It is obvious that the funnel 29 can be of various sizes with varying converging angles to suit the speed at which it is desired to have the ingredients flow therethrough for introduction into the stream of molten metal flowing in the trough 14A.

In order to prevent the cooling of the molten metal as it flows through the conveyor 14 and to keep extraneous material out of the conveyor, a layer of refractory material 30 is provided which covers the upper surface of the conveyor and maintains the heat losses at a minimum. This refractory layer may be of rigid material or, if desirable, may be of loose material supported on the conveyor by means of a plate 31 of any suitable material.

When it is desired to withdraw an amount of molten metal from the cupola furnace for the pouring of molds in which it is necessary to use a metal having predetermined physical and/or chemical characteristics, the invention is utilized as follows: It is to be understood that, in accordance with the usual practice in operating cupola furnaces of the general type disclosed, an operator has an accurate control of the molten metal which issues from the cupola by maintaining a careful check upon the scrap materials which are loaded into the upper end of the cupola. Inasmuch as the operator can control the chemical and physical properties of the metal which issues from the furnace, and knowing the type of metal that he desires for pouring his molds, he can add to the molten metal as it flows through the trough 14A of the conveyor 14 such ingredients as will give the final result he desires.

As is well-known in the art, the vent opening of the cupola furnace is controlled by an operator who, in the present instance, may conveniently stand upon the platform 12 from which point he can easily control the flow of molten metal flowing through the inlet 10A. When a sufficient quantity of metal has flowed through the opening 10A, it is closed through the medium of the soft refractory material 23 positioned on the end of tamping rod 24 so as to close the opening and thereby stop the flow of molten metal. When it is desired to again open the vent, the operator merely removes the refractory material 23 which he has previously positioned in the inlet 10A.

The operator, knowing the characteristics of the metal issuing from the cupola, can calculate the amount of materials that must be added to the molten metal in order to obtain the desired characteristics in the final mixture before it is poured into the molds. The amount of material to be added can be calculated either in terms of weight or in terms of volume and is added to the molten metal in the conveyor trough 14A before the ladle has become filled with molten metal. This mixing period is preferably in the second and third quarters of the pouring period which tends to give a homogeneous mixture in the final pour.

With the ladle 12 in position under the vent 21, the operator removes the refractory material 23 from the inlet 10A and allows a substantially

uniform flow of molten metal to become established through the trough 14A so that the "turning over" or "folding back" operation described with reference to the baffles 14B, 14C and 14D, is well established and also that the molten metal fills enclosure 14E with a swirling action centering in the aperture 21 from which the molten metal flows into the ladle. At this time the operator adds the ingredients which are to be dissolved into the molten metal. These may be added either manually or semi-automatically, as desired.

A very convenient method of accomplishing this is to place a container C on the platform 12, near the operator, which contains a relatively large supply of material to be added. A measure of predetermined volume may be utilized in transferring the ingredients from the container C to the funnel 29 where they flow through the aperture 26A of the refractory tube to the slot 25 in the trough 14A, as has already been described.

Another method of measuring the ingredients may involve the use of a semi-automatic measuring device indicated diagrammatically at S. In this case, the device S is positioned immediately above the funnel 29 and when the operator actuates a handle H, a predetermined quantity of the ingredient to be added flows from the container S into the funnel 29, with the same results already described.

As has already been described, ingredients to be added slowly flow from the funnel 29 through the aperture 26A into the trough 14A and float upon the molten metal which is flowing through the slot 25 under the tube 26 and are carried along the trough 14A until the molten metal, which is flowing around the outside of the tube 26A, is thrown back by the side walls of the trough to fold over upon the molten metal which is issuing from the trough 25, carrying on its surface the added ingredients. This folding over of the molten metal upon the ingredients completely surrounds and submerges them and raises their temperature to a point where they may be readily included into the molten metal. The metal then continues through the tortuous path in the conveyor and the folding operations continue and assure that any material which has not been completely included in the molten metal will be again submerged. Each time the molten metal is given a reverse in direction of flow, this action takes place.

The molten metal then continues further along the conveyor 14 until the enclosure 14E is reached at the distal end immediately above the ladle. The fact that the molten metal enters the enclosure tangentially creates a swirl, which centers over the vent 21 and the molten metal tends to be removed from the enclosure adjacent a central location so that any material which has not been included in the metal during its passage through the tortuous way above the enclosure will, at this point, tend to float toward the inner part of the swirl and will be drawn into the core of the molten metal flowing through the vent into the ladle below.

The remaining non-included material is, therefore, carried in the core of the stream of the molten metal issuing from the vent 21 and is carried by the force of gravity to the bottom of the ladle where it is completely covered with the molten metal. This assures maximum inclusion of the added ingredients.

In case the materials to be added to the molten

metal are relatively coarse and are broken up into particles of relatively large size, it is advantageous to expose the materials for as long a period as possible to the high temperatures of the molten metal and it is, therefore, added to the molten metal as early as possible in the conveyor. Should, however, the added ingredients be finely divided or in powdery form, they may be added at the swirl at the distal end of the conveyor. The small particles will readily reach the high temperature of the molten metal and will be readily dissolved in the molten metal.

The above method and apparatus has been used with success for adding various alloying material to metal, such as, manganese, nickel, chromium, vanadium, titanium, molybdenum, copper, etc., and it is clear that any type of material which is capable of being dissolved in the molten metal, such as, deoxidizing and desulphurizing agents, may also be added in this way. Graphitic carbon is also readily added by this process.

It is to be understood that the above detailed description of the present invention is intended to disclose an embodiment thereof to those skilled in the art, but that the invention is not to be construed as limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawing, since the invention is capable of being practiced and carried out in various ways without departing from the spirit of the invention. The language used in the specification relating to the operation and function of the elements of the invention is employed for purposes of description and not of limitation, and it is not intended to limit the scope of the following claims beyond the requirements of the prior art.

What is claimed:

1. The method of introducing addition ingredients into molten metal, comprising creating a predetermined volumetric rate of flow of molten metal on a tortuous inclined tubular way to fill a container of predetermined volume, of adding a predetermined amount of addition ingredient adjacent the top of the inclined way at a predetermined rate, of maintaining the slope of the inclined way sufficient to create a turbulent flow in the molten metal, of creating a swirl in the molten metal in an enclosure on the lower end of the inclined way, and withdrawing the molten metal from the enclosure at the center of the swirl to fill the container, the rate of addition of the addition ingredient being capable of variation to suit the rate of flow of the molten metal as compared with the volume of the container to assure that the addition ingredient is added before the container is filled.
2. The method of introducing addition ingredients into molten metal, comprising creating a flow of molten metal on a tortuous inclined way terminating in a bottom-vented enclosure, adding the addition ingredient adjacent the top of the inclined way at a predetermined rate to the molten metal, and maintaining the slope of the inclined way sufficient to create a turbulent flow in the tortuous way, the molten metal thereby entering the enclosure at a rate to create a swirl centering in the vent in the bottom of the enclosure whereby non-included addition ingredients floating on the surface of the metal will be sucked into the core of the molten metal flowing out the vent into a container below.
3. The method of introducing addition ingredients into molten metal, comprising creating a

flow of molten metal on a tortuous inclined way, of adding the addition ingredient near the top of the inclined way, maintaining the slope of the inclined way sufficient to cause a turbulence in the flow of the molten metal to include the addition ingredient into the body of the molten metal, collecting the molten metal at the termination of the inclined way in an enclosure by a tangential flow whereby a swirl is created, and allowing the molten metal to flow out from the enclosure through a bottom vent to draw addition ingredients floating on the surface of the molten metal into the core of molten metal flowing through the vent into a ladle for pouring.

4. The method of introducing addition ingredients into molten metal comprising, creating a flow of molten metal on a tortuous inclined way, of adding the addition ingredient near the top of the inclined way, maintaining the slope of the inclined way sufficient to cause a turbulence in the flow of the molten metal whereby the molten metal will fold over at the bends of the tortuous way to cover any addition ingredients floating on its surface, creating a swirl in the molten metal at the lower end of the inclined way in an enclosure, and withdrawing the molten metal from the enclosure at the center of the swirl to insure maximum inclusion of the addition ingredient.

5. In a device of the class described, a controllable source of molten metal, a sloping tubular conveyor cooperating with the source to convey the molten metal from the source to a container under the influence of gravity, means extending below the surface of the molten metal flowing in the conveyor adjacent the upper end to introduce addition ingredients into the molten metal, baffle means in the conveyor to create a tortuous path, the rate of flow causing a turbulence in the molten metal flowing in the conveyor to insure inclusion of the addition ingredient into the molten metal, and bottom-vented enclosure means at the lower end of the conveyor to create a swirl in the molten metal adjacent the outlet of the conveyor to draw addition ingredient floating on the surface of the metal into the core of the metal flowing into the container.

6. In a device of the class described, an inclined tubular conveyor having a tortuous way for molten metal, a bottom-vented enclosure on the lower end of the conveyor into which the molten metal enters in a tangential direction from the tortuous way, and means adjacent the upper end of the conveyor to introduce addition ingredients into the center of the flowing molten metal, the slope of the inclined conveyor being sufficient to cause a turbulent flow in the molten metal down the tortuous way and to enter the enclosure at a rate sufficient to cause a swirl therein whereby addition ingredients floating on the surface of the molten metal will be drawn in the stream of metal issuing from the vent in the bottom of the enclosure.

7. In a device of the class described, a trough-like conveyor having a tortuous way for conveying molten metal from a source to a container, an inlet adjacent the upper end of the conveyor, a bottom-vented enclosure on the lower end of the conveyor tangentially connected with the tortuous way, a cover for the trough-like conveyor and the enclosure extending over the conveyor except a portion adjacent the inlet, a tube-like member extending upwardly from the floor of the trough-like conveyor adjacent the

inlet, funnel means cooperating with the upper end of the tube-like member adapted to contain addition ingredients to be added through the tube-like member to the molten metal flowing in the conveyor, a longitudinal slot in the floor of the trough-like conveyor coincident with the aperture in the tube-like member and a vent in the floor of the enclosure at the bottom end of the trough-like conveyor, the slope of the conveyor being such that molten metal will flow along the slot in the floor of the trough under the tube-like member and also around the tube-

like member, whereby a turbulence is created on the lower side of the tube-like member to introduce the addition ingredients into the center of the stream of molten metal, which then flows in the tortuous way into the enclosure in a tangential direction to create a swirl whose center is located over the vent in the floor of the enclosure, so that addition ingredients floating on the surface will be drawn into the stream of molten metal issuing from the vent into the container below.

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