June 17, 1969 G. L. WILLAN 3,450,823

METAL MELTING FURNACES

Filed Aug. 21, 1967 Sheet 1 of 5

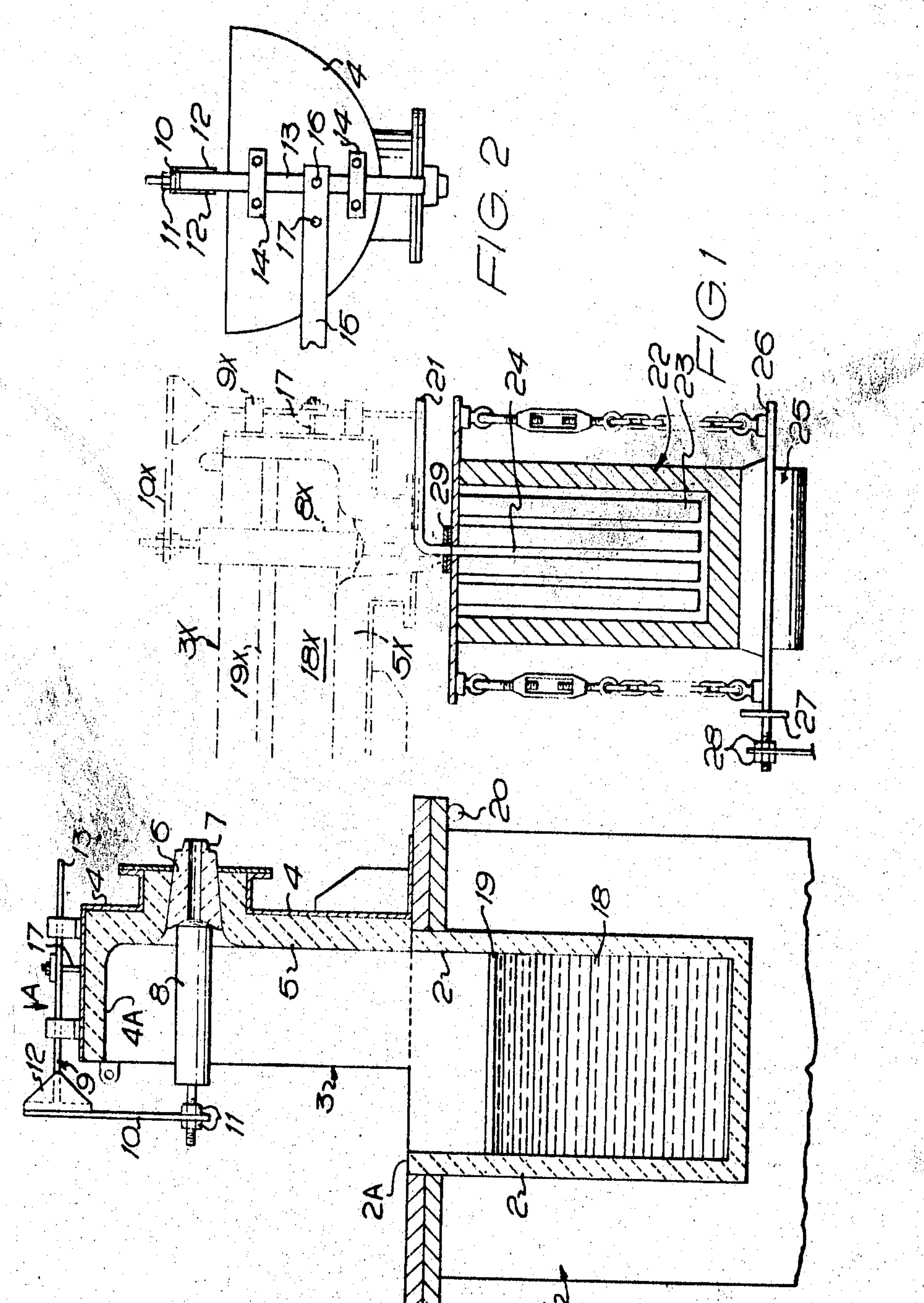

FIG. 1

FIG. 2

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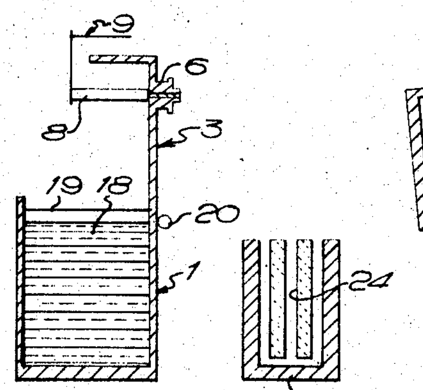

FIG. 3

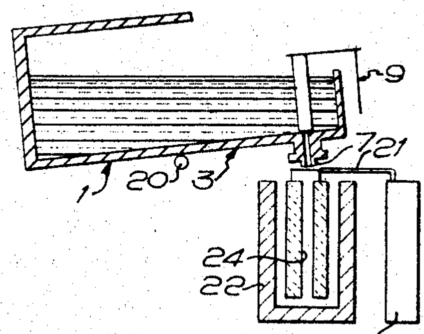

FIG. 4

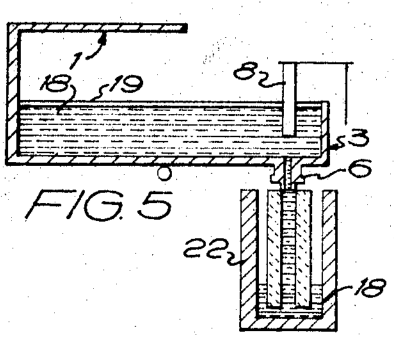

FIG. 5

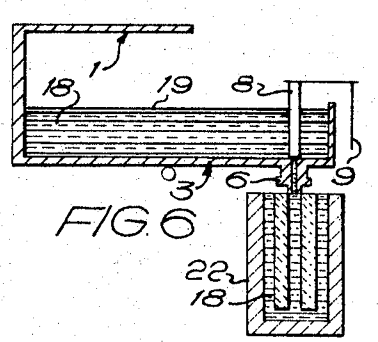

FIG. 6

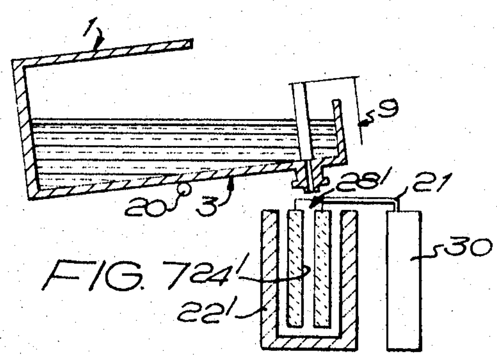

FIG. 7

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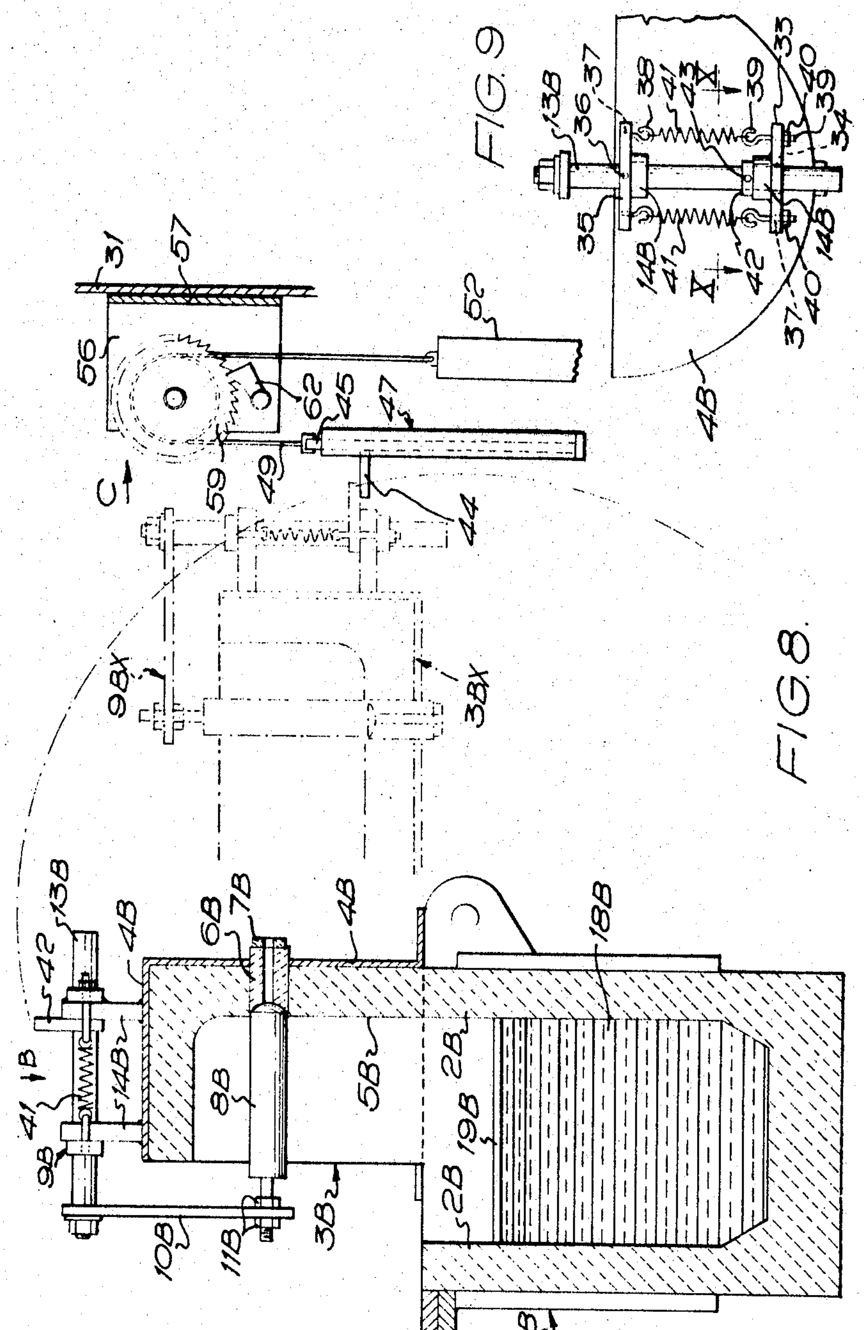

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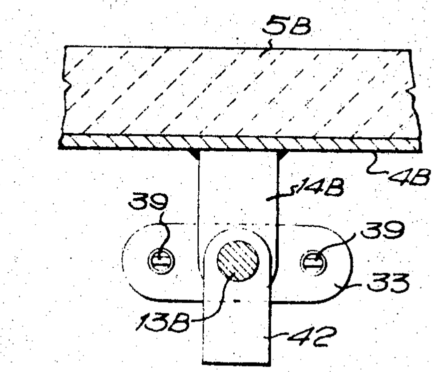


FIG. 10

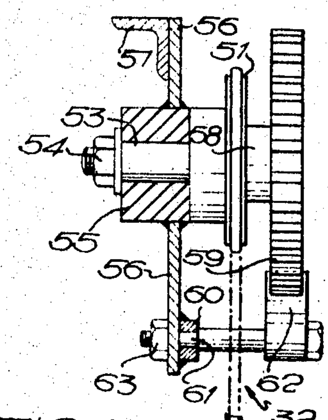
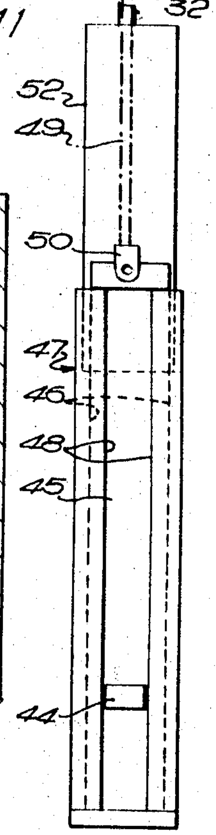


FIG. 11



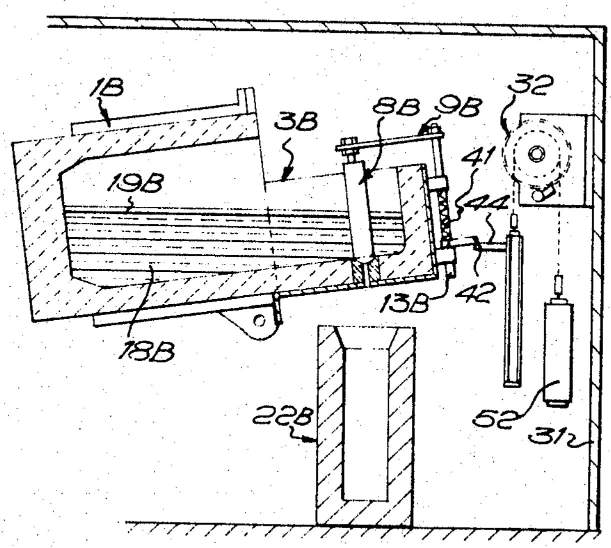


FIG. 12

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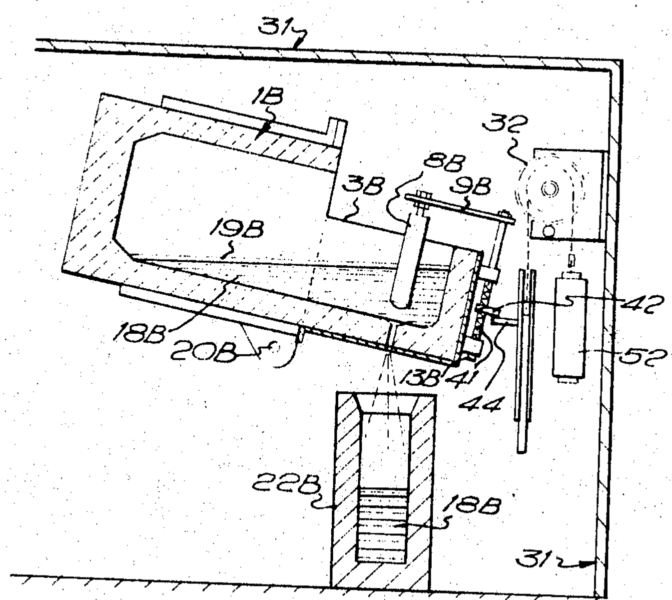

FIG. 13

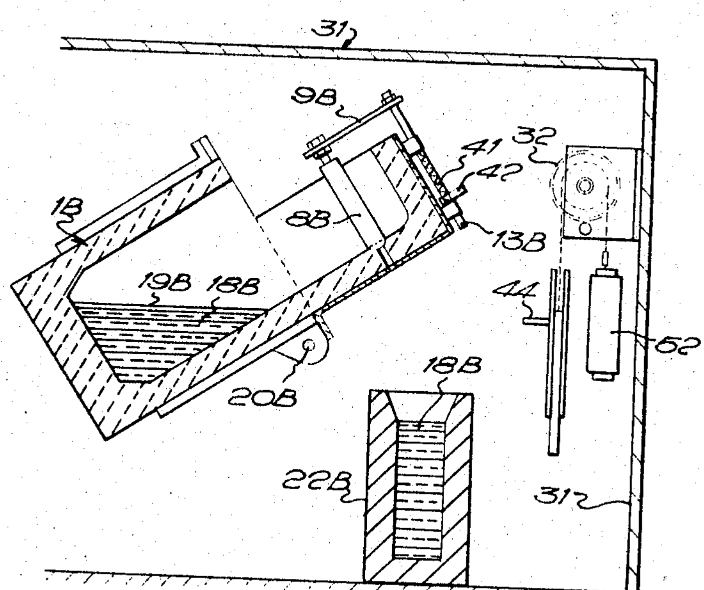

FIG. 14

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METAL MELTING FURNACES

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Int. Cl. H05b 7/18
U.S. Cl. 13—10 3 Claims

ABSTRACT OF THE DISCLOSURE

An electric metal melting furnace is provided with a launder extending from the furnace wall at one side, the end of the launder remote from the furnace having a closing wall, the furnace and launder having a tilting axis parallel to the intersection of the rim of the furnace and the rim of the launder, and the launder having an outlet nozzle generally perpendicular to both the tilting axis and the longitudinal (i.e., normally vertical) axis of the furnace, together with removable means for closing the nozzle, and, particularly for vacuum melting, the removable means comprises a stopper automatically withdrawable to open the nozzle and automatically replaceable to close the nozzle.

This invention relates to metal melting furnaces, especially but not exclusively of the electric arc or electric induction type, in which latter type pouring is effected by tilting the furnace body about an axis usually passing substantially through the pouring lip of the furnace.

In pouring, whether into a ladle, a shank or directly into a mould, and whether to produce bars, billets etc. or actual articles e.g. investment casting, there is turbulence of the metal and of any slag or dross floating on the surface of the metal prior to pouring, as the metal passes over the lip of the furnace, as it drops in a stream into the receiving vessel, and when it falls on the bottom of the receiving vessel. This results in mixing of the slag and metal, and the slag does not normally separate out again by flotation before the metal solidifies, the presence of slag and non-metallic materials in the solidified metal frequently producing undesirable results in the finished material or product.

A refractory weir system has been employed in a launder into which a furnace pours, to form slag traps at depending weirs and cause cleaner metal to flow over upstanding weirs. However, this method is only about 90 to 95% efficient in restraining slag or dross, and also leaves a considerable quantity of metal in the launder after pouring. Also, when used for vacuum casting, the launder has to be put into the vacuum tank before the commencement of melting, and therefore, it is not possible to ensure that the launder is at an adequate temperature when the metal is poured through it some considerable time after.

In addition the stream of metal is in intimate contact with the atmosphere—unless pouring takes place in a vacuum—and this can result in a serious degree of oxidation, which in turn leads to loss of oxidizable alloying elements from the melt and produces undesirable non-metallic inclusion and oxide films. Gases such as oxygen, nitrogen and hydrogen can also be absorbed and held in solution until such time as partial or complete solidification forces them out of solution, causing porosity, blow holes and unsoundness generally.

The object of the invention is to provide a metal melting furnace with means substantially overcoming the above difficulties.

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According to the present invention, a metal melting furnace is provided with a launder extending from the furnace wall at one side, the end of the launder remote from the furnace having a closing wall, the furnace and launder having a tilting axis parallel to the intersection of the rim of the furnace and the rim of the launder, and the launder having an outlet nozzle generally perpendicular to both the tilting axis and the longitudinal (i.e., normally vertical) axis of the furnace, together with removable means for closing the nozzle.

The furnace is maintained in its normal upright position (i.e., with the launder extending upwards) during melting, slag or dross collecting and floating on the molten metal. To effect pouring, the furnace and launder are tilted until the slag has lapped over the closed nozzle and is separated therefrom by the molten metal, the closing means for the nozzle then being removed to permit the molten metal to run off from below the slag (instead of through it) in a clean, coherent stream, free from slag or dross. A small quantity of metal may be retained in the launder to avoid any likelihood of slag or dross passing through the nozzle, or the slag or dross may be run off with but a little molten metal into a separate vessel for subsequent reclamation of the constituents for re-use or processing as by-products.

If it is intended that the entire contents of the furnace be run off during a single pouring operation, the closing means for the nozzle may consist of a disc of suitable metal to be melted away soon after the slag or dross has lapped over it, the furnace being tilted back to a non-pouring position just before the slag is due to be discharged. The delay in melting of the disc should be sufficient for an appreciable depth of metal to have flowed over the nozzle, to ensure considerable displacement of the slag or dross from the nozzle at the commencement of pouring. On the other hand, if it is desirable to stop the flow of metal—as when changing from one mould to another—the closing means for the nozzle conveniently comprises a stopper inside the launder, with operating mechanism, the stopper also serving to prevent the slag or dross from passing through the nozzle in both the initial and final stages of pouring.

The launder may consist of a fabricated or cast metal shell lined with suitable refractory material, which may be monolithic or in the form of bricks or tiles. The launder may be secured to the furnace by cotter pins, bolts, studs, or quick release clamps, and may be permanently fastened to the furnace body, or adapted to be fitted just prior to pouring of the metal and removed after the furnace is empty. In the latter case, the refractory lining of the launder may be heated prior to fitting to the furnace, as by flame impingement or electrical resistance heating, to ensure that the refractory lining is brought up to a suitable temperature to prevent chilling of the metal by the launder lining when casting, and so avoid the need for excessive superheating in the furnace. This also ensures that full accessibility of the furnace is obtained during the melting down stage, as a considerable volume of scrap and alloying materials have to be charged into the furnace during this period. Removal of the launder also facilitates the cleaning from it of any adhering slag, skull, or metal, as well as replacement of the stopper and nozzle; however, a number of launders, say two or three, may be available for any individual furnace.

Use of the extended launder enables good slag/metal conditions to be maintained and/or controlled, and the slag used to provide protection against atmospheric contamination, to produce clean steels or alloys and/or remove non-metallic inclusions by means of slags of controlled composition. The use of the extended launder further prevents mixing of the slag and metal during the pouring operation, by also providing that the bottom face of the nozzle can be brought into sealing contact with the top of the mould or other receiving vessel, and having that receiver purged with an inert gas, such as argon, before pouring. It is possible to complete pouring without the metal coming into contact with the atmosphere.

However, the invention may also be applied to vacuum casting, with similar advantages, it having been common practice to use a separate launder with refractory weirs (as described previously) in the vacuum tank to "clean" the metal during transfer from furnace to mould, with attendant drawbacks (previously referred to).

According to a further feature of the invention, a metal melting furnace is provided with a launder extending from the wall at one side of the furnace, the end of the launder remote from the furnace having a closing wall, the furnace and launder having a tilting axis parallel to the intersection between the rim of the launder and the rim of the furnace, and the launder having an outlet nozzle generally perpendicular to both the tilting axis and the longitudinal (i.e., normally vertical) axis of the furnace, together with a stopper normally closing the nozzle, means for automatically withdrawing the stopper upon completion of tilting of the furnace and launder to a generally horizontal position, and means for automatically replacing the stopper upon commencement of tilting of the furnace and launder back to an upright position.

As before, the furnace is maintained in its normal upright position (i.e., with the launder extending upwards) during melting, slag or dross collecting and floating on the molten metal. To effect pouring, the furnace and launder are tilted until the slag has lapped over the closed nozzle and is separated therefrom by the molten metal, the means for withdrawing the stopper being preset to open the nozzle only when an appreciable depth of metal has flowed over the nozzle, for molten metal to run off from below the slag (instead of through it) in a clean, coherent stream, free from slag or dross. When the desired amount of metal has been run off the furnace is tilted back and the stopper is automatically replaced before any slag or dross comes into contact with the nozzle.

Again the launder may be of the same construction and matérials and with the attendant advantages as previously described but for vacuum melting it is of course necessary to fit a removable type launder prior to the commencement of melting.

With either furnace it is possible to tilt the furnace forward, prior to pouring, so as to wash the refractory surfaces of the launder with hot metal, and then back so as to return the metal to the furnace for heating to correct pouring temperature, the heating of the launder in this way ensuring that the metal is not unnecessarily superheated and is poured at as low a temperature as possible. The nozzle may be encircled by some form of electric resistance heater, e.g., a split ring 80/20 nickel/chrome heating element or a split ring of silicon carbide or graphite, to reduce any tendency for metal washed over the launder (to heat the latter as described above) to solidify on the nozzle or stopper and prevent easy opening of the stopper in the subsequent pouring operation.

While in all cases it is necessary to leave a small volume of metal in the launder to ensure that no slag or dross enters the nozzle, this constitutes a very much smaller proportion of the cast than in the case of a launder with weirs.

The means for automatically replacing the stopper is conveniently some form of spring-loading, and the means for automatically withdrawing the stopper may then consist of an arm extending laterally and rigidly with respect to the nozzle, and a striker adapted to be mounted in the path of the arm and adjustable in level for presetting the position of the furnace and launder at which the stopper is withdrawn by engagement between the striker and the arm. The mounting for the striker is preferably such as to provide for automatic adjustment of the level of the striker between successive pouring operations with the same melt, to allow for the quantity of metal run off at each preceding pouring operation. Thus the striker may be supported in a vertical guide by a chain passing over a chain wheel or sprocket to a balance weight, the sprocket being provided with a ratchet and pawl permitting downward movement only of the striker after withdrawal of the nozzle; the ratchet and pawl provide for the initial adjustment of the level of the striker. The sprocket may be journalled on a bracket adapted to be bolted to the inside of a side wall of a vacuum tank within which the furnace and launder and one or more moulds are to be enclosed. The usual gear may be provided for tilting the furnace (and the launder), with the addition, preferably, of means to indicate the extent of tilting for each of a succession of pouring operations.

The invention will now be described in greater detail with reference to two embodiments and pouring techniques shown in the accompanying drawings in which:

FIGURE 1 is a longitudinal section through an induction furnace which is shown in the melting position and is provided with a launder, an adjacent mould, and with the launder indicated in chain dotted line in a pouring position;

FIGURE 2 is a view of the launder in the direction of arrow A of FIGURE 1;

FIGURES 3 to 7 are a series of diagrammatic views of a sequence of operation of the apparatus of FIGURES 1 and 2;

FIGURE 8 is a longitudinal section through another embodiment of induction furnace and launder, also showing an adjacent mould, automatic means for actuating the stopper, and with the launder indicated in chain-dotted line in a pouring position;

FIGURE 9 is a view in the direction of arrow B of FIGURE 8, showing detail of the stopper displacement means;

FIGURE 10 is a section, to a larger scale, on the line X—X of FIGURE 8;

FIGURE 11 is a view in the direction of arrow C of FIGURE 8; and

FIGURES 12 to 14 are a series of diagrammatic views of a sequence of operation of the apparatus of FIGURES 8 to 11.

In FIGURES 1 to 7, a conventional induction furnace e.g., of 10 cwt. capacity, is indicated at **1** and provided with a refractory wall **2**. A launder, indicated generally at **3** includes an outer steel shell **4** with a closing wall **4A** and a refractory lining **5** which lining provides an extension from the rim **2A** of the furnace wall **2**. The launder **3** is apertured at its end remote from the furnace **1** to receive a refractory nozzle **6**, with a projecting nose **7**, which is controlled by a refractory stopper **8** operated by mechanism **9**. This mechanism is best seen in FIGURES 1 and 2 and consists of a bar **10** attached at one end to the stopper by nuts **11** and attached at its other end by brackets **12** to a slide rod **13**, slideable in brackets **14** bolted to the steel shell **4** of the launder. Displacement of the slide rod **13** is effected by a handle **15** pivoted at **16** to the rod **13** and located on a pin **17** which serves as a fulcrum, upward or downward movement of the slide rod **13** transmitting that same movement to the stopper **8** by the bar **10**.

FIGURE 1 shows a charge **18** of molten metal with a slag **19** covering the metal being discharged by the pivoting of the co-joined furnace and launder about the axis **20**. An adjacent mould **22** is of conventional construction and contains a conventional non-splash runner arrangement **23** with a downgate **24**. The mould is supported on a conventional roller conveyor system **25** while bottom plate **26** serves to abut a vertical plate **27**, adjustable by nuts **28**, to ensure that the nose **7** of the nozzle is correctly aligned with the mouth **29** of the downgate **24** in a pouring position i.e., when the furnace and launder unit, **1, 3** is rotated about axis **20** and the launder is positioned as shown in chain-dotted line in FIGURE 1, indicated as 3X, with other components similarly identified with the suffix X. To avoid contamination by the atmosphere of the metal **18** to be cast, the mould **22** is shown being purged with an inert gas e.g., argon supplied along pipe **21** from a tank **30** (FIGURE 4) prior to pouring.

Pouring is illustrated in FIGURES 3 to 7 inclusive. In FIGURE 3, the melting and refining and/or alloying of the molten charge has been completed with the stopper **8** closing the nozzle **6** and with the mould **22** correctly positioned.

Then, as shown in FIGURE 4 the mould is purged with inert gas and while this is being effected the furnace and launder unit **1, 3** is rotated about axis **20** e.g. by mechanical or hydraulic means untl the nose **7** of the nozzle is in sealing contact with the mouth **29** of the downgate **24** when the stopper **8** is raised by actuation of the handle **15** and the apparatus is as shown in FIGURE 5 with the mould **22** being filled. FIGURE 6 shows the stopper closing the nozzle **6** after completion of filling. The furnace and ladle unit **1, 3** is then tilted back slightly to allow the filled mould to be removed along the roller conveyor system **25** and a second mould **22′** to be moved into correct pouring position and purged with inert gas as shown in FIGURE 7. After purging has been completed the furnace and launder unit is then lowered slightly so that, as previously the nose **7** of the nozzle is in sealing contact with the mouth **28′** of downgate **24′** of mould **22′**, ready for pouring again. This procedure may be repeated any number of times depending upon the volume of metal in the furnace **1** and the capacity of the moulds **22, 22′**. The casting technique described above is only one if many alternatives possible with the apparatus according to the invention. For instance only one mould of capacity to take the entire metal contents of the furnace could be employed or, in certain circumstances it may not be thought necessary to purge the mould or moulds with an inert gas. Obviously care must be taken to see that no slag or dross escapes through the nozzle when the furnace and launder unit is almost empty.

In FIGURES 8 to 14 showing a second embodiment and a second pouring technique, like component parts to those of FIGURES 1 to 7 have been given like reference numerals, but with the suffix B.

The significant difference over the apparatus of FIGURES 1 to 7 is that the apparatus of FIGURES 8 to 14 is contained in a conventional vacuum chamber indicated at **31** in FIGURES 12–14, with the stopper operating mechanism **9B** modified to take advanatge of mechanism **32** for automatically controlling the stopper.

The modified mechanism **9B** is best seen in FIGURES 8, 9, and 10 and consists of upper and lower bearing brackets **14B** for slide rod **13B**, the brackets being welded to the steel shell **4B**, with a plate **33** welded to the underside of the lower bearing bracket **14B** and apertured at **34** to allow the free passage of rod **13B**. A plate **35**, similar in shape to plate **33** is fitted on the rod **13B** and adjustably secured on the rod by means of a screw **36**. Each plate **33, 35** is provided with two tapped holes **37**, the holes of the upper plate receiving hooks **38** and the holes of the lower plate receiving adjustable hooks **39** locked by nuts **40**. Between corresponding hooks of the upper and lower plates are secured two coil springs **41**. An arm **42** is fitted on the rod **13B** between the upper and lower brackets **14B** and is adjustably secured by a screw **43**, to determine the amount of movement of the stopper **8B**.

The means for actuating the mechanism **9B** is detailed in FIGURES 8 and 11, and consists of a striker **44**, in the arcuate path of the arm **43**, and secured to a rectangular section slide bar **45**, slideable in a passage **46** of corresponding section in a fabricated vertical guide **47**, the guide being provided with a vertical slot **48** to allow for the attachment of the striker to, and its projection from, the slide bar **45**. The upper end of the slide bar **45** is attached to one end of a chain **49**, through pivoted clevis **50**, the chain passing over a sprocket **51** and its other end being connected to a balance weight **52**. The sprocket **51** is rotatably supported on a journal **53** secured by a nut **54** in a bearing **55**, in turn welded to a vertical support plate **56**. To this support plate is welded an angle section member **57** which serves to attach the assembly to the wall of the vacuum chamber **31**. The journal **53** passes through and extends beyond the other side of the sprocket **51** to a portion **58** on which is mounted a ratchet wheel **59**. To the lower end of the support plate **56** is welded a bearing **60** to support a journal **61** of a pawl **62** engaging a tooth of the ratchet wheel **59**, the journal being secured in the bearing by a nut **63**.

A pouring sequence is illustrated by FIGURE 8 and FIGURES 12 to 14 inclusive. In FIGURE 8 the melting and refining and/or alloying of the molten charge can be considered completed, and the stopper **7B** is closing the nozzle **6B**, the mould **22B** is correctly positioned and the striker **44** is at the top of the vertical guide **47**.

The furnace and launder unit **1B, 3B** is then rotated about the axis **20B** until the metal **18B** and slag **19B** have lapped over the mouth over the closed nozzle **6B**, as shown in FIGURE 12. Continued rotation of the unit **1B, 3B** brings the arm **42** in contact with the striker **44** and eventually, with a correctly selected balance weight **52** against the rating of springs **41**, the striker **44** forces the arm **42** and slide rod **13B** upwards with respect to the launder **3B** which in trun raises the stopper **8B** which opens the nozzle so that pouring into the mould **22B** commences, as shown in FIGURE 13. During the opening of the nozzle the reaction of the springs **41** becomes sufficient to overcome the balance weight **52** which is raised to the position shown in FIGURE 13 by the downward movement of the striker **44**, so that the slide bar **45** projects from the vertical guide **47**. The rotation of the sprocket **51**, due to the movement of striker **44** and and balance weight **52**, produces corresponding rotation of the ratchet wheel **59**. Thus when mould **22B** is almost filled, anti-clockwise rotation of the furnace and launder unit **1B, 3B** about pivot **20B** ceases contact between the arm **42** and striker **44** so that springs **41** move the slide rod **13B** with respect to the launder **3B** which in turn moves the stopper **8B** to close the nozzle **6B**, because the striker **44** is maintained in the new, FIGURE 13 and FIGURE 14, position by pawl **62** engaging a tooth of the ratchet wheel. The mould **22B** is then removed e.g. by conveyor means and a second mould correctly positioned to be filled from the molten metal remaining in the furnace and launder unit **1B, 3B**. This completes the cycle of operations and the striker **44** is ready to open the nozzle **6B** in a more inclined position of the unit **1B, 3B** than was necessary for filling the first mentioned mould, the mechanism **32** thus automatically compensating for the amount of metal discharged into a previous mould.

With the apparatus of either FIGURE 1 or FIGURE 8 the launder may be preheated by any suitable method e.g. a gas flame for the FIGURE 1 apparatus and by washing the launder with the molten metal for the FIGURE 8 apparatus. Again, with either apparatus a small quantity of metal remaining in the unit **1B, 3B** to ensure that no slag or dross passes through the nozzle may be run off into a separate vessel, complete with slag, for reuse or processing as by-products.

What I claim is:

1. A metal melting furnace, comprising:

a furnace wall having a molten metal discharge opening,

a launder extending from the furnace wall at one side of the discharge opening, the launder being open along its whole length from the other side of the discharge opening, a wall closing the end of the launder remote from the furnace,

a tilting axis for the furnace and launder parallel to the intersection of the rim of the launder and the furnace wall,

an outlet nozzle in the launder near to the end wall of the launder and extending perpendicular to the tilting axis,

a stopper closing the nozzle, and

means for removing the stopper from the nozzle after tilting said furnace and said launder about said tilting axis so that the level of the liquid metal is above the discharge opening.

2. A metal melting furnace as in claim **1**, wherein the furnace and launder are mounted inside a vacuum chamber and the stopper is mounted inside the launder, the means for removing the stopper from the nozzle including:

a slide rod, extending parallel to the stopper,

a bar connecting the slide rod to the stopper,

brackets for slidably mounting the slide rod on the outside of the end wall of the launder,

an arm extending laterally from the slide rod,

a striker mounted in the vacuum chamber in a position to obstruct the path of the arm on the slide rod as the furnace and launder are tilted from a

position in which molten metal is contained wholly within the furnace to a position in which molten metal extends along the whole length of the launder, and

means also being provided for automatically replacing the stopper upon commencement of movement of the furnace and launder back to the initial upright position.

3. A metal melting furnace as in claim **2**, wherein the means for automatically replacing the stopper include springs acting on the slide rod.

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266—38; 13—9