United States Patent [19]

Vallak

[11] **3,766,965**

[45] **Oct. 23, 1973**

[54] **METHOD OF HOT TOPPING AN INGOT MOLD**

[76] Inventor: **Enn Vallak,** 15, rue Sautter, Geneva, Switzerland

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **164/123,** 164/126, 249/198
[51] **Int. Cl.** **B22d 7/10,** B22d 27/06
[58] **Field of Search** 164/122, 123, 125, 164/126; 249/198

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Primary Examiner—J. Spencer Overholser
Assistant Examiner—John E. Roethel
Attorney—Albert M. Parker

[57] **ABSTRACT**

The disclosure refers to a method for casting metal in an ingot mould by using a case or hot top to prevent pipe-formation in the ingot. The case or hot top is placed on or in the upper part of the mould and in contact with this part. The mould is filled with metal and then the case or hot top is moved off from the top of the ingot when a thin layer has solidified at the top of the ingot but before the ingot has completely solidified, in order to effect an air gap which is limited outwardly by the case or hot top and/or by a separate jacket.

13 Claims, 27 Drawing Figures

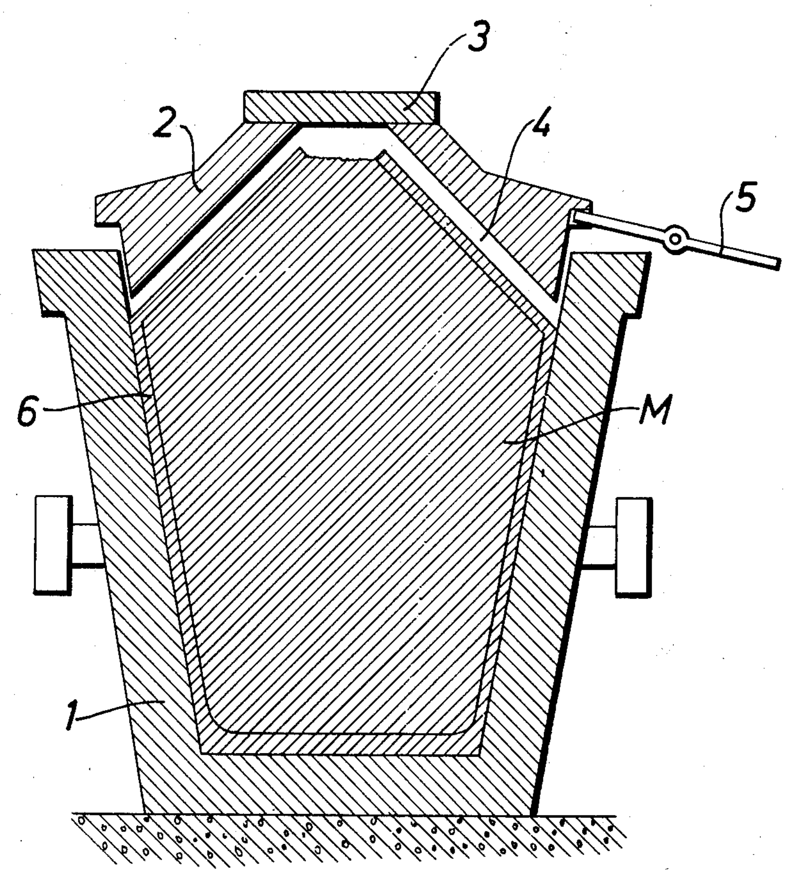


Fig.1

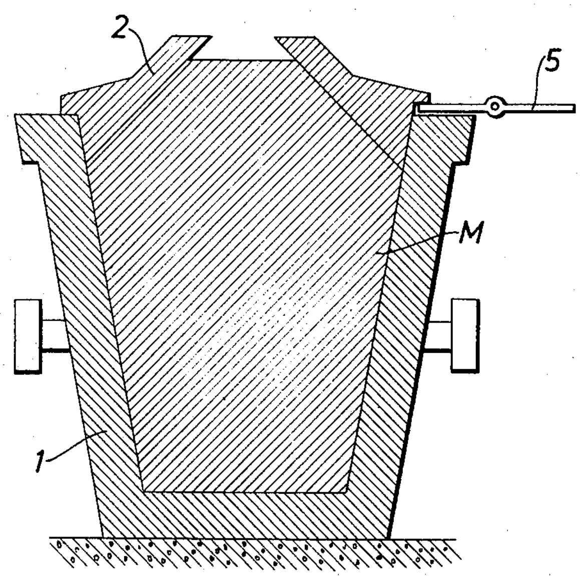


Fig. 2

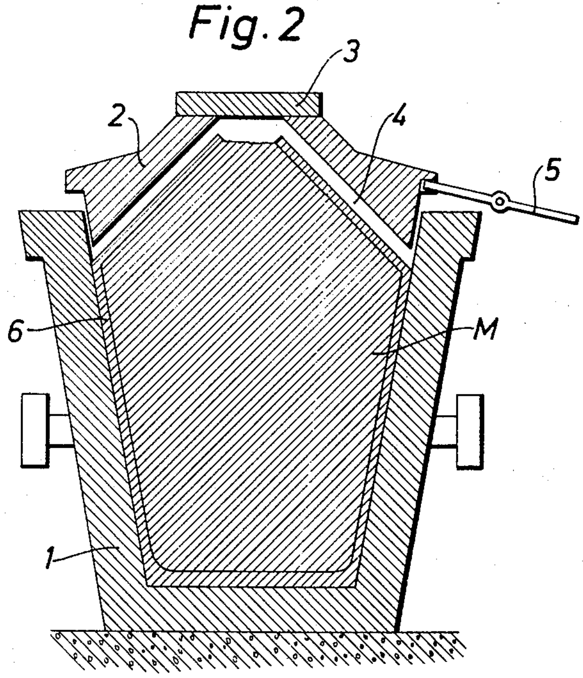


Fig. 3

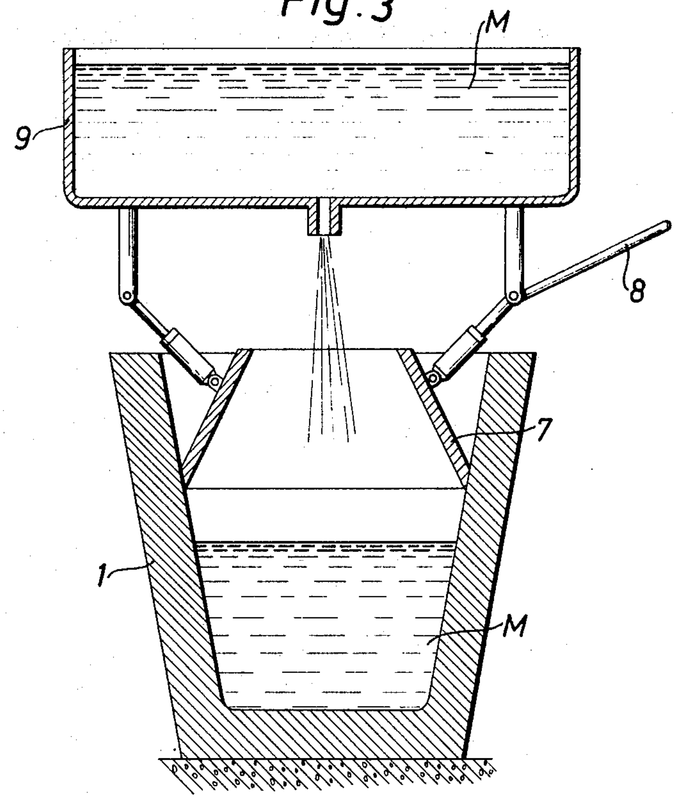


Fig. 7

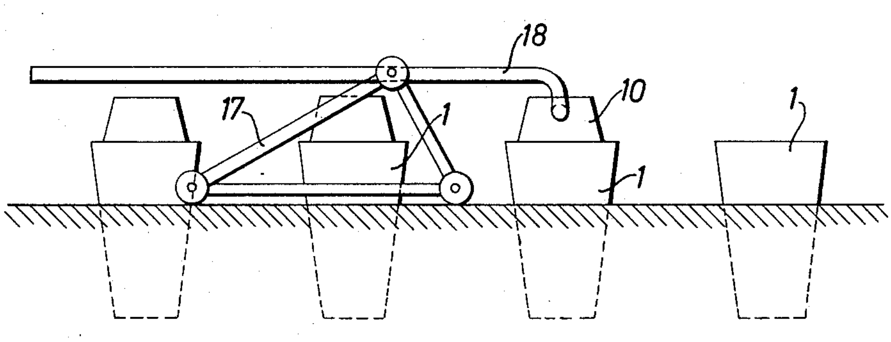


Fig. 4

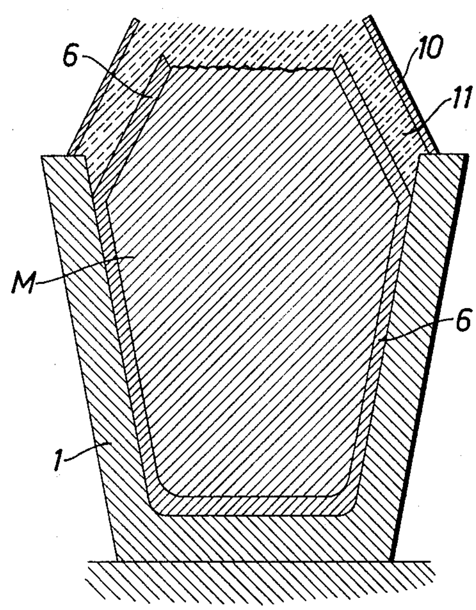


Fig.5

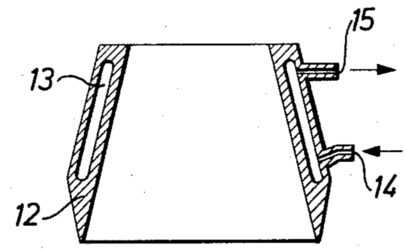


Fig.6

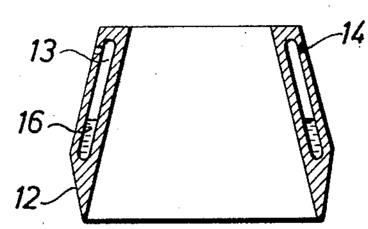


Fig. 8

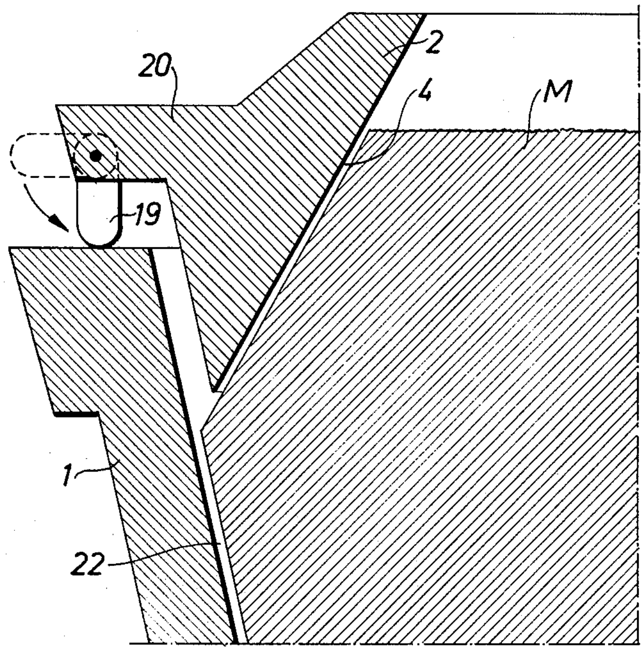


Fig. 9

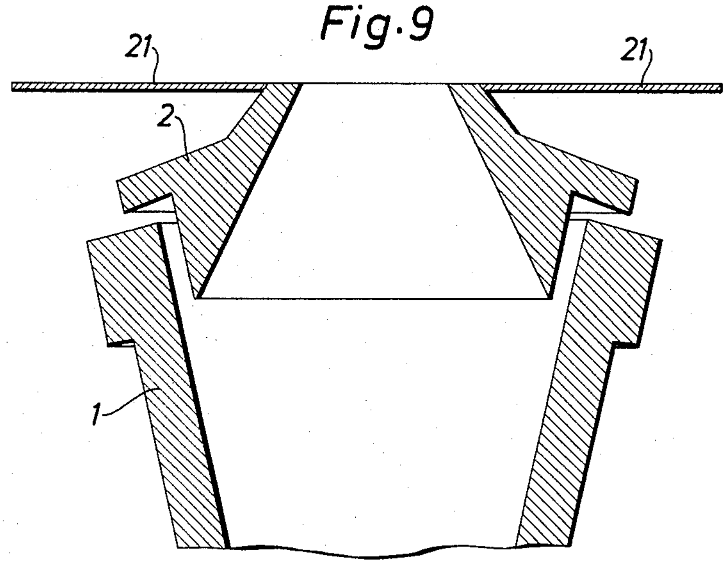


Fig.10

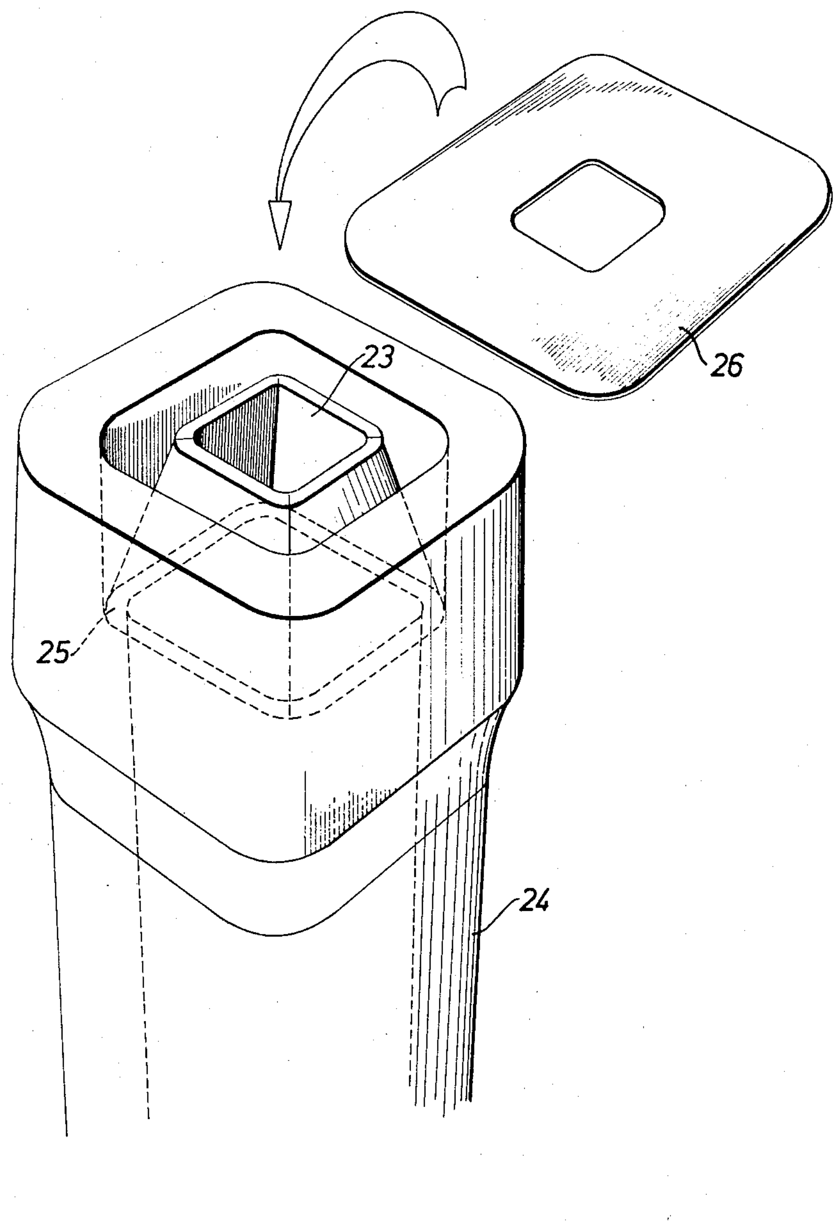


Fig. 11

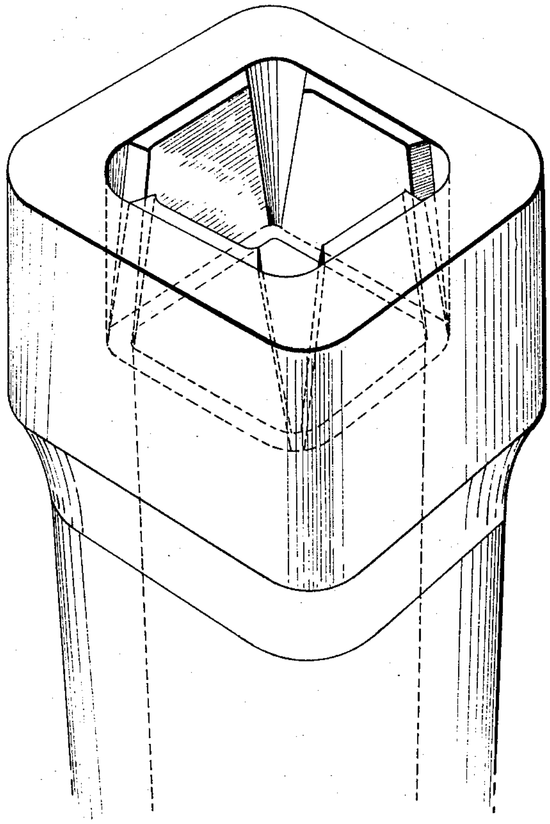


Fig. 12

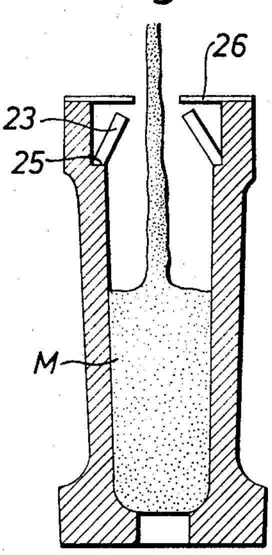


Fig. 13

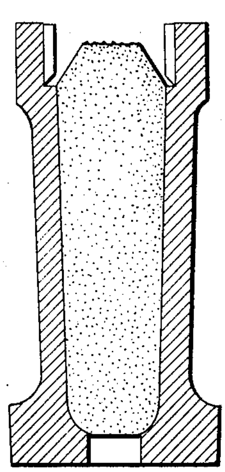


Fig. 14

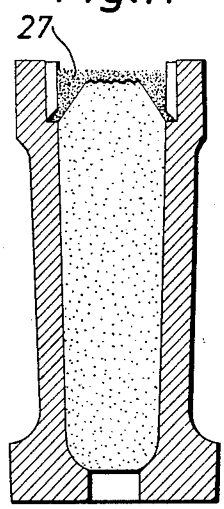


Fig.15

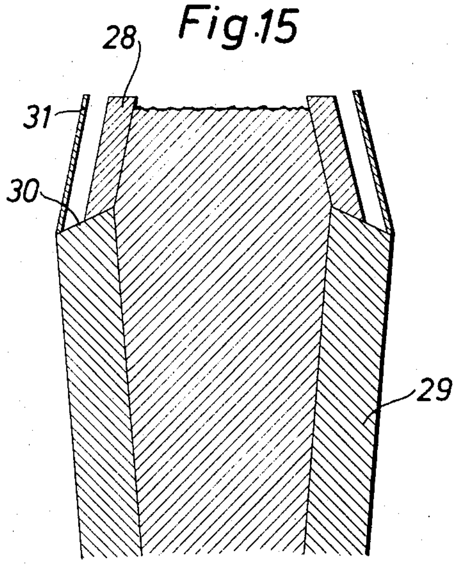


Fig.16

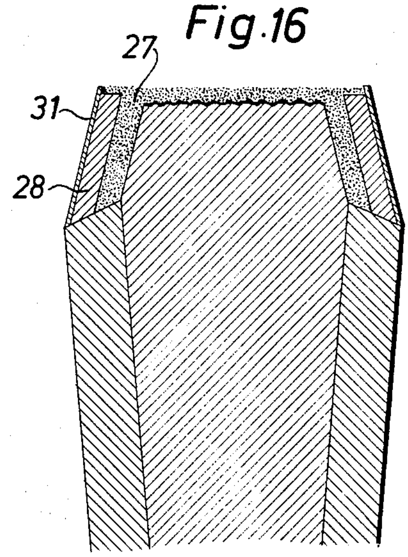


Fig.17

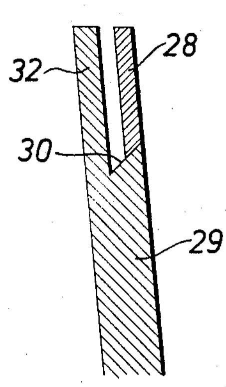


Fig.18

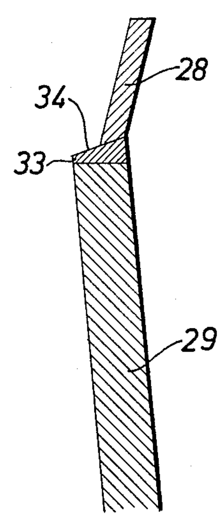


Fig.19

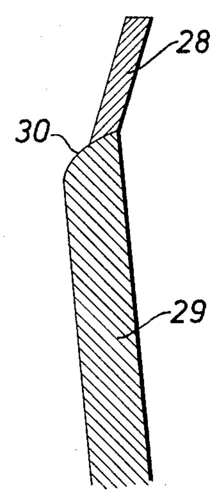


Fig.20

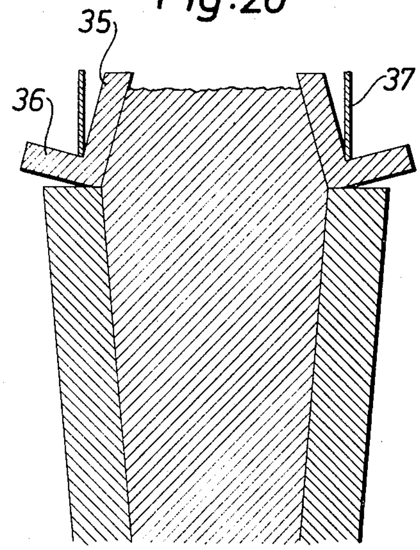


Fig.21

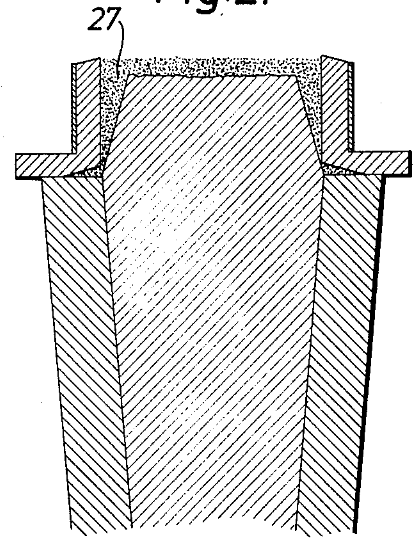


Fig.22

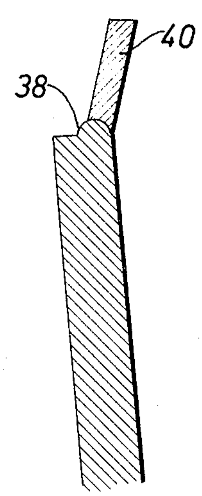


Fig.23

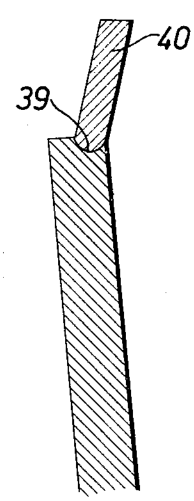


Fig.24

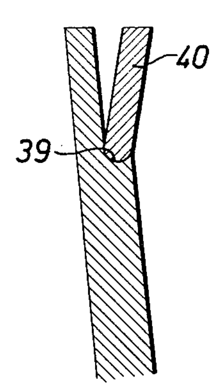


Fig.27

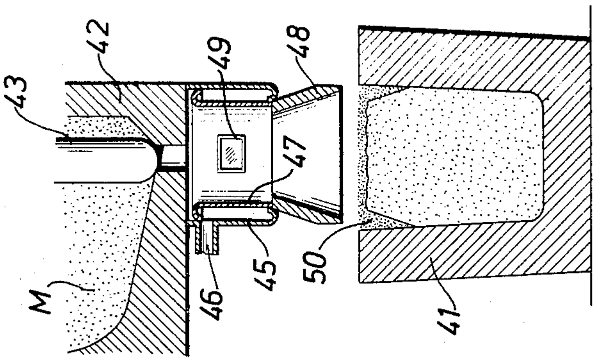


Fig.26

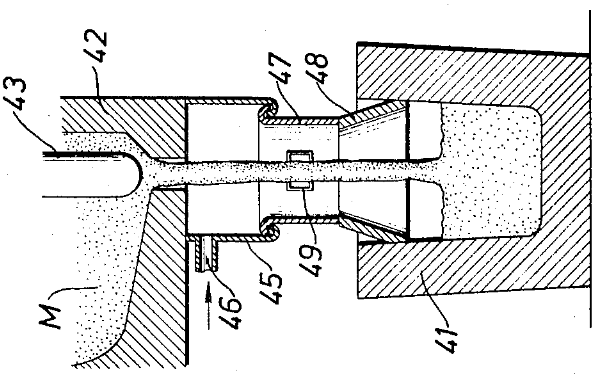
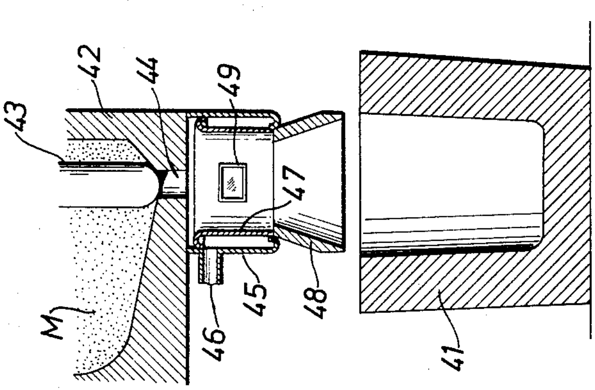


Fig.25



METHOD OF HOT TOPPING AN INGOT MOLD

FIELD OF THE INVENTION

The present invention relates to a method and means for casting metals, particularly iron and steel, in ingot moulds or other casting moulds using a case or hot top, the inside of which preferably tapers upwardly, to prevent so-called pipe-formation in an ingot formed in the mould.

DESCRIPTION OF THE PRIOR ART

In the casting of iron, steel and other metals in ingot moulds so-called hot tops are used at the upper end of the ingot mould to prevent said pipe-formation in the ingot. Many different designs for such hot tops are known, both of combustible and non-combustible material. These are founded on the assumption that the upper part of the ingot must not be cooled too rapidly and for this purpose extra heat may be supplied by burning the hot top or heat losses may be avoided by permitting the hot top to be heat-insulating. The burnable and heat-insulating hot tops have the drawback that they are consumed every time an ingot is cast, and are expensive and often subjected to damage.

SUMMARY OF THE INVENTION

The method according to the present invention avoids these drawbacks. Substantially characteristic of the invention is that the case or hot top is placed on or in the upper part of the ingot mould and in contact with this part and that after the ingot mould has been filled with metal the case or hot top is moved off from the top of the ingot when a thin layer has solidified at the top of the ingot but before the ingot has completely solidified, in order to effect an air gap which is limited outwardly by the case or hot top and/or by a separate jacket. Into this air gap a heat-insulating and/or exothermic material may be inserted and applied around and possibly on top of the ingot.

BRIEF DESCRIPTION OF THE DRAWING

The invention is illustrated in the accompanying schematical drawings in which

FIG. 1 shows the case in the form of a hot top, in contact with the ingot, and

FIG. 2 in raised position.

FIG. 3 shows another embodiment of the case and

FIG. 4 an ingot the top of which has been heat-insulated.

FIGS. 5 and 6 show schematically in section two embodiments of a water-cooled hot top or case.

FIG. 7 shows how the case can be suspended in a transportable trolley.

FIG. 8 shows a suitable means for fixing the air gap and

FIG. 9 shows a protecting device at the upper part of the case or hot top.

FIG. 10 shows an ingot mould with a multi piece case and protecting device and

FIG. 11 shows this case in raised position.

FIGS. 12–14 illustrate the manufacture of an ingot using a divided, collapsible case.

FIGS. 15 and 16 show an ingot mould with a divided, slidable case which is surrounded by a jacket or collar.

FIGS. 17–19 show other examples of slidable, divided cases arranged in or on the ingot mould.

FIGS. 20 and 21 show an ingot mould with a collapsible, divided case surrounded by a collar.

FIGS. 22–24 show further examples of collapsible, divided cases and

FIGS. 25–27 show a suitable arrangement for teeming metal into an ingot mould while using a protective gas.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The invention will be more fully understood from the following detailed description, with reference to the accompanying drawing.

The ingot mould may be of arbitrary shape and made of different material from case to case, but it is preferably conical.

The metal M is poured into an ingot mould in the normal manner after application of a hot top **2** at the top of the mould (FIG. **1**). When the mould is filled the hot top is suitably provided with a lid **3** (FIG. **2**). The case or hot top may be made of various materials, for example cast iron, copper or ceramic material or some other heat-resistant, possibly heat-insulating material, although heat-conducting material is often advantageous in the initial stage to rapidly conduct heat from the ingot.

After a few seconds or so a thin layer **6** will have chilled or solidified at the outer surface of the casting metal M due to heat being conducted through the bottom and walls of the ingot mould and through the hot top **2.** When this shell has been formed and has become sufficiently thick to prevent the molten metal inside from escaping, the case or hot top **2** is raised a small distance so that an air gap **4** is formed between the shell **6** and the inner surface of the case or hot top (FIG. **2**). This air gap, which in certain cases, for example, may be 3–30 mm wide, acts as heatinsulation to prevent the upper part of the ingot from cooling too rapidly which might cause pipe-formation. The air gap should not be too wide so that air circulation can arise. Furthermore the hot top should be designed so that the air gap **4** in the position according to FIG. **2** is not in communication with the air outside. In this raised position, the inner surfaces of the case or hot top **2** reflect the heat radiation back towards the ingot, and this effect can be improved by suitably treating or coating the surface with heat-reflecting material.

The movement of the case or hot top can be performed in various ways, manually or mechanically, hydraulically, pneumatically or electrically. FIGS. **1** and **2** show schematically a pivotable lever **5** which can possibly be activated by a bimetal body or thermostat means or by a time-controlled mechanism when the temperatures at the inner surface of the hot top have reached a value less than the solidification temperature of the ingot.

A heat-insulating and/or exothermic material may be inserted in the air gap after removal of the lid **3.**

The hot top described may be replaced by a gas or liquid-cooled metallic case **7** (FIG. **3**) which effects the rapid and brief cooling and which is movably positioned near the upper end of the ingot mould, completely or partially immersed in the ingot mould **1.** The reference **8** shows schematically a movement mechanism for the case and the reference **9** a casting ladle to which this mechanism may be attached. Each ingot mould has its own case or one common case may be used for several ingot moulds, the case being movable attached to the ladle or some other movable device. If each ingot mould is provided with a case, a certain time must pass after the mould and the case have been filled with metal so that the solidifying layer becomes sufficiently thick, and the case is then lifted slightly from the ingot so that an insulating air gap is formed. As in FIG. 1 the case may be coated with heat-reflecting material. The air gap may be filled with heat-insulating and/or exothermic material which further increases the insulating effect.

If a common, transportable case is used the case can only be arranged to take care of the formation of the shell and need not act as outer wall for the air gap or support for the heat-insulating and/or exothermic material. In this case, however, solid heat-insulating and/or exothermic material may be inserted between the case and the ingot after raising the case slightly. The case is then completely removed and moved over to the next mould.

If the exposed hot top is higher than the upper edge of the ingot mould, the air gap may be bounded by a loose sheath or jacket **10** (FIG. **4**), for example of sheet metal, which may be coated with heat-reflecting material. The gap between the hot top and jacket may be filled with heat-insulating and/or exothermic material **11**. The container for this material may be supported by the ladle so that it is easily accessible.

The sheath or jacket may also consist of a cylindrical collar of sheet metal, for example, being of the same height or slightly lower than the case, the cylindrical collar having an upper opening which allows the case to pass through it. The cylindrical collar is in this case placed on the ingot mould so that it surrounds the lower part of the case also placed on the mould, or the entire case, depending on the height of the collar. When the case is removed from the top of the ingot the air gap will be limited outwardly by the collar or by the case and collar together, depending on whether the case is completely removed or only moved a short distance from the top of the ingot. The insulating and/or exothermic material may be inserted into the air gap thus limited. If a conical or cylindrical jacket is used having an upper opening through which the case can pass, the insulating and/or exothermic material can be placed between the case and the jacket so that this material gradually surrounds the top of the ingot as the case is moved off after completed teeming and after a solidified layer has been obtained at the top of the ingot. The insulating and/or exothermic material may also be placed in this way if the case or hot top is arranged in the ingot mould, the upper part of which thus serves the same purpose as such a jacket. The inner side of this upper part of the ingot mould may be coated with a heat-reflecting material.

In all cases the hot top itself may also be coated with heat-reflecting material, for example with the help of a spray gun, and the insulating material may also be heat-emitting, i.e., exothermal.

The invention offers, amongst others, the advantage that in its simplest embodiment it can be used for cheap types of steel where conventional hot tops are too expensive and that thanks to its flexibility in choise of type and quantity of heat-insulating and/or exothermic material, it can be adapted to a very large number of cases. Furthermore, the danger of the steel becoming contaminated, as is usual when liquid steel comes into contact with normal insulating or exothermic boxes (where some parts may loosen from the box) is completely eliminated. In the present case the heat-insulating and/or exothermic material comes into contact with the steel surface which has already solidified. The case may possibly be cooled by being in the form of a cooling jacket having inlets and outlets for cooling medium, for example water, or it may be provided with such a cooling jacket. FIG. **5** shows one embodiment of a liquid-cooled case or hot top, intended to be limited up in the manner described above. The case **12** has a hollow part **13** which is in communication with a coolant circulation system by means of an inlet **14** and an outlet **15**. FIG. **6** shows a similar embodiment in which the liquid circulation system has been omitted and instead a suitable quantity of coolant **16** is introduced each time through the inlet and allowed to boil away while the ingot solidifies.

FIG. **7** shows an embodiment with a movable trolley **17** which can serve several ingot moulds **1**. The trolley has a pivotable arm **18** in which the case **10** is suspended and is moved from mould to mould and lifted when casting is completed, as described above. Heat-insulating and/or exothermic material has been applied on the two first moulds and the case **10** has been placed over the third mould and is ready to be moved over to the fourth mould.

The case or hot top may be provided around its circumference with a number of spacers **19** which are pivotably journalled at a peripheral flange **20** arranged to abut the upper edge of the mould. Before the case or the hot top **2** is lifted each spacer **19** assumes the position indicated with a dotted line in FIG. **8**. When the case or hot top is lifted, the spacer **19** falls down automatically, thus fixing or determining the distance, i.e., the air gap **4**, between the head of the ingot and the case or hot top.

FIG. **9** shows a protective sheet **21** at the upper part of the case or hot top, which extends outside the edge of the mould **1**. The protective sheet **21** prevents the molten metal from running down between the case or hot top and the mould, which may happen if the filling device breaks down or in some other way does not function satisfactorily.

The insulating and/or exothermic material inserted in the air gap **4** may with advantage contain a sintering material such as, for example, dry sulphite lye. This sintering material has the task of preventing the fine particles in the heat-insulating and/or exothermic material from falling down into the air gap which is always formed between the ingot and the mould. This air gap is designated **22** in FIG. **8**.

FIGS. **10–14** show a case **23** which is arranged in a mould **24** and rests against an edge **25** therein. The case **23** consists of four sections which are arranged to be moved from the top of the ingot. In order to protect the outside of the case during teeming, a collar **26**, for example of sheet metal, is applied on top of the mould as shown in FIGS. **10** and **12**. When teeming is completed and after a thin layer has formed around the top of the ingot, the case is moved off by folding these sections to the side as shown in FIGS. **11** and **13** in order to leave place possibly for an insulating and/or exothermic material **27** which is then applied in the air gap formed between the case and the ingot, and possibly on the upper surface of the top of the ingot.

In the embodiments according to FIGS. **15-19** a multi piece case **28** is used, the sections being arranged to be moved laterally by means of a parallel displacement away from the contact surface of respective sections at the top of the ingot. For this purpose the mould **29** is provided with oblique or rounded sliding surfaces **30** with which the sections of the case cooperate while sliding away from the top of the ingot. According to FIGS. **15** and **16** the case is placed on top of the mould, the movement of the sections being limited by a jacket or collar **31**, for example of sheet metal. When the sections of the case are removed from the top of the ingot, therefore, an air gap is obtained inside these sections, into which the heat-insulating and/or exothermic material **27** may be introduced to cover the top of the ingot. According to FIG. **17** said collar is formed by the upper part **32** of the mould **29**, this being provided with oblique sliding surfaces **30** on its inside which surfaces cooperate with the sections of the case **28.** In this case the lower surface of the case can be even more bevelled so that the case will lean inwards as shown in FIG. **15.** If the upper edge of an existing mould does not slope sufficiently, a special insert **33** provided with inclined surfaces **34** may be applied on the mould as shown in FIG. **18.** In the embodiments according to FIGS. **18** and **19** an outer jacket or collar may be used in the same manner as previously described.

FIGS. **20–24** show further examples of multi piece cases, the sections being arranged to fold to the side. According to FIG. **20** the sections of the case **35** are provided, each with outwardly directed part **36** and the sections are surrounded by a jacket or collar **37** forming a block or support for the sections of the case **35** when they are folded out from the top of the ingot as shown in FIG. **21.** As is clear from FIGS. **22–24**, the mould may be provided with projective part **38** or a groove **39** having substantially semicircular cross-section, the sections of the case **40** cooperating with said projective part **38** or groove **39.**

When casting in moulds with elongate cross-section which are used in the manufacture of ingots intended to be rolled into sheet form, the case may consist of only two rectangular plates arranged in the mould along its longitudinal sides. These plates are moved off from the top of the ingot when teeming is completed in order to leave space possibly for an insulating and/or exothermic material. In this case conventional hot tops may be arranged to rest against the elongate plates which can be folded from the top of the ingot. A case divided into four sections may also be used in the type of mould mentioned above, the case being placed on the mould and possibly surrounded by a jacket or collar as described previously. Such a case, or a similar divided case for other types of moulds, may suitably be provided with support members in the form of corner plates, for example, each being permanently attached to the outside of one of the sections of the case and extending freely over the adjacent section so that these corner plates will overlap the openings which are obtained between two sections when the sections are moved to the side away from the ingot. This overlapping of the corner plates prevents the insulating and/or exothermic material from running out from the gap between the case and the top of the ingot. These corner plates may also be provided with members — (for example, the free ends of the corner plates may be bent inwardly) — which cooperate with stops on the sections so that the sections are fixed to each other when the case has been opened.

The sections of the multi piece case or hot top may be coated with a heat-reflecting material. Such a material may be applied also to the jacket or collar used in this connection.

If necessary, particularly when casting with one piece case or a gas or liquid-cooled one piece case placed in the mould, a movable or not permanent seal may be applied between the lower end of the case and the mould in order to decrease and/or eliminate the slot which may occur between the lower end of the case and the mould wall due to variations in the dimensions of the mould. The seal, preferably consisting of copper and/or the same material as that of the case, may consist of four rectangular elements, for example, which are movably suspended at the lower part of the case on its outer side so that they can be freely moved between an upper position and a lower position. In the latter position the lower edge of each element extends outside the lower end of the case. The side of each element facing the wall of the mould suitably has a bevelled contact surface.

FIGS. **25–27** illustrate the manufacture of ingots in a mould **41** using protective gas during the actual teeming stage. The molten metal M is stored in a ladle **42** which may be stationary or movably arranged, for example as shown in FIG. **7** to serve a series of moulds. The ladle is provided with a valve or stopper **43** to regulate the teeming. The teeming opening **44** is surrounded by an outer tube **45** which is firmly connected to the ladle **42** and provided with an inlet **46** for a protective gas, and an inner tube **47** which is movably arranged in the outer tube **45** between an upper position (FIG. **25**) and a lower position (FIG. **26**). The outer tube may also be separated from the ladle or detachable from this. The inner tube **47** carries a case **48** which in this embodiment is intended to be placed in the mould. The arrangement may also be used for the type of case intended to be placed on the mould. As illustrated in FIG. **26**, the teeming is controlled visually through an inspection window **49** in the inner tube **47.** The inner tube **47** can be operated by a manual, mechanical, hydraulic, pneumatic or electric mechanism or by means of a device comprising a suitable combination of such operating devices.

During the teeming a protective gas is introduced through the inlet **46** into the space bounded by the tubes **45,47** and the case **48** in order to prevent the metal from oxidizing. The metal splashing out of the mould which may occur during teeming is eliminated by the tubes **45,47.** When teeming has been completed and after a thin shell has been formed on the top of the ingot, the case is moved off from the ingot to leave space for a heat-insulating and/or exothermic material **50** as shown in FIG. **27.**

As an example of protective gases which may be used, argon may be mentioned. The use of protective gas gives purer iron and/or steel, but the purity of other metals and metal alloys is also improved.

The case **48** may be whole or divided. It may also be gas or liquid-cooled as has been described previously in order to achieve rapid cooling of the top of the ingot immediately after completion of the teeming.

Protective gas may also be supplied when casting with conventional case or hot top.

Cooling medium may also be used even when the case is divided into two or four sections, for example.

As examples of heat-insulating material may be mentioned vermiculite, axonite, infusorial earth and powder of Siporex or Ytong (crushed porous concrete). As exothermic material burnable and aluminothermic material may be used.

I claim:

1. A method of casting in normal atmospheric pressure iron, steel, and other metals in ingot casting moulds using heat retaining means comprising a case to prevent so-called pipe-formation in the ingot formed in the mould, comprising the steps of placing said heat retaining means at the upper part of the ingot mould and in contact with said upper part; filling the ingot mould with molten metal; and, when a thin layer has solidified at the top of the ingot but before the ingot has completely solidified, moving off said heat retaining means a limited distance from the top of the ingot but still remaining in the vicinity of the ingot in order to provide an air gap which is limited outwardly by said heat retaining means.

2. The method of claim **1** wherein an agent comprising heat-insulating and exothermic material is inserted into said air gap.

3. The method of claim **1** wherein said heat retaining means is lifted up from the top of the ingot to produce an air gap between the ingot and said heat retaining means and wherein this movement is limited to provide an air gap sufficiently narrow to substantially avoid air currents therein.

4. The method of claim **3** wherein the air gap is fixed by spacers arranged to engage said heat retaining means and movable relative to the upper part of the ingot mould.

5. The method of claim **1**, wherein the heat retaining means is provided with a flange which is used when placing said heat retaining means on the top of the ingot mould.

6. The method of claim **1** wherein said heat retaining means are divided into sections placed at the upper part of the ingot mould and in contact with this upper part and wherein said sections are moved to outward displacement of the sections without lifting devices.

7. The method of claim **1** wherein said agent contains a heat-activating bonding material.

8. The method of claim **1** wherein the formation of the thin layer around the top of the ingot is accelerated by supplying a coolant to said heat retaining means.

9. The method of claim **1** wherein the molten metal is protected from oxidization, while the ingot mould is being filled, by a protective gas being brought to surround the metal after it leaves the supply point.

10. A method according to claim **1**, wherein the temperature on the inside of said heat retaining means is utilized to control the moving-off displacement of said means.

11. A method according to claim **1**, wherein the moving-off displacement of said heat retaining means is time-controlled.

12. A method according to claim **1**, wherein the walls of the ingot mould seal to the walls of said heat retaining means on moving off the latter from the top of the ingot in order outwardly to seal the air gap formed between said means and said ingot.

13. A method according to claim **1**, wherein the inner surfaces of said heat retaining means facing the ingot are made of material reflecting heat radiation.

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