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Widdowson et al.

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[54] BOTTOM POURED INGOTS

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[52] **U.S. Cl.**.....**164/119,** 249/109, 164/133, 164/306

[51] **Int. Cl.**.....**B22d 27/14**

[58] **Field of Search**.....164/119, 62, 66, 113, 120, 164/244, 363, 61, 133, 337, 306–311, 335, 47; 249/106, 107, 108, 109, 110

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[57] **ABSTRACT**

In the known bottom poured method of casting steel ingots molten metal is poured down a runner system communicating with the bottom of the ingot mould. With the invention the runner system is made pressure tight and a pressurized gas is applied to the top of the upstanding runner of the runner system to displace some of the metal in the runner system into the mould. The mould may be of the bottle top type with a heat conducting plug for making a non-gas tight closure at the top of the mould, and pressurized gas may be applied so that metal in the mould contacts the plug.

4 Claims, 4 Drawing Figures

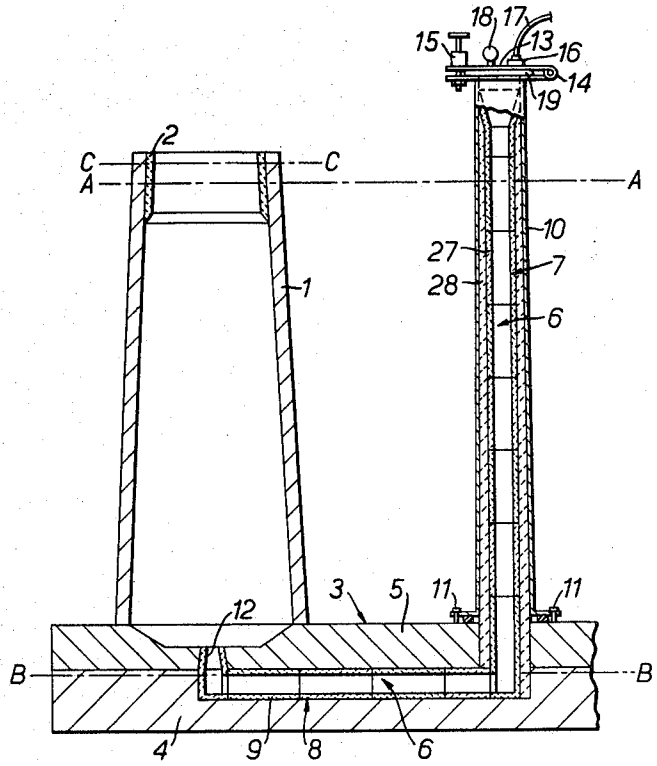
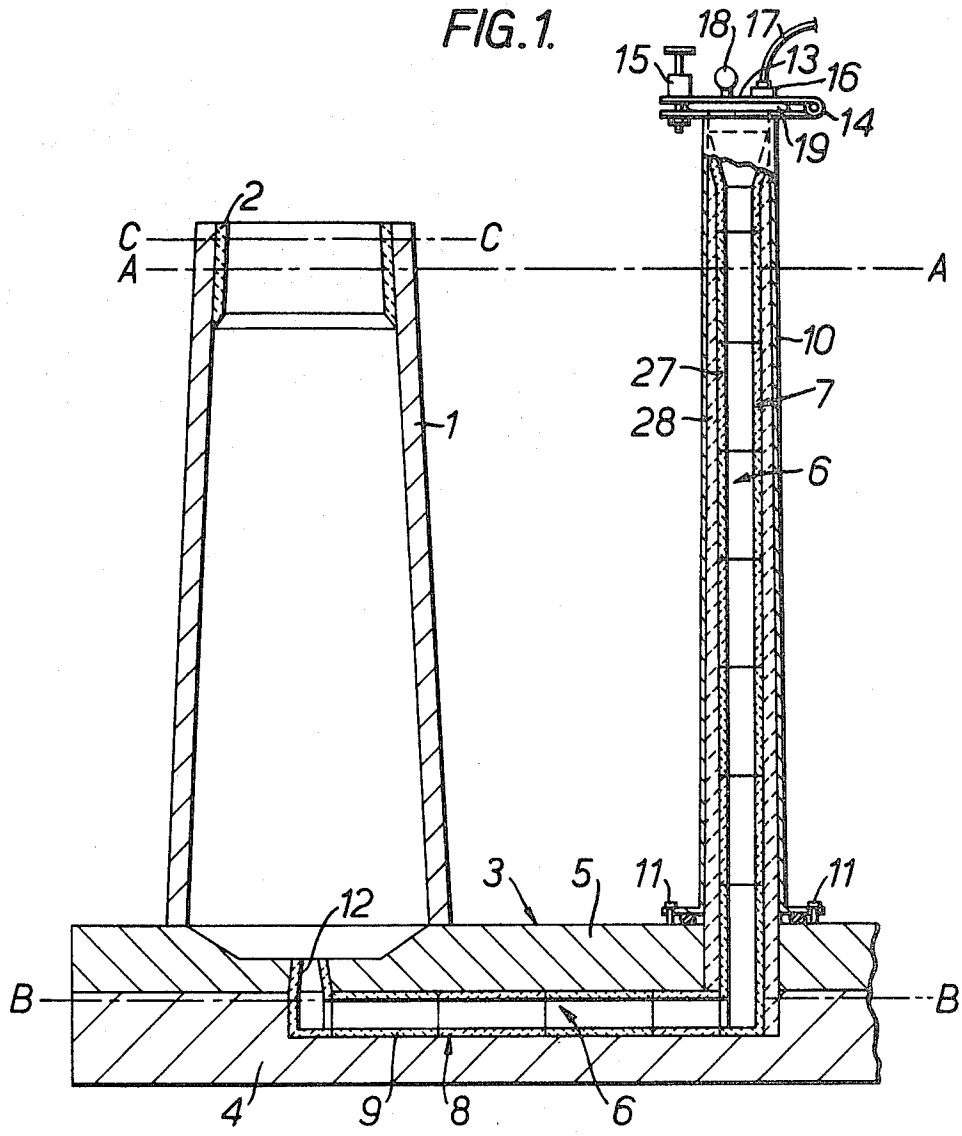


FIG. 1.



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FIG. 2.

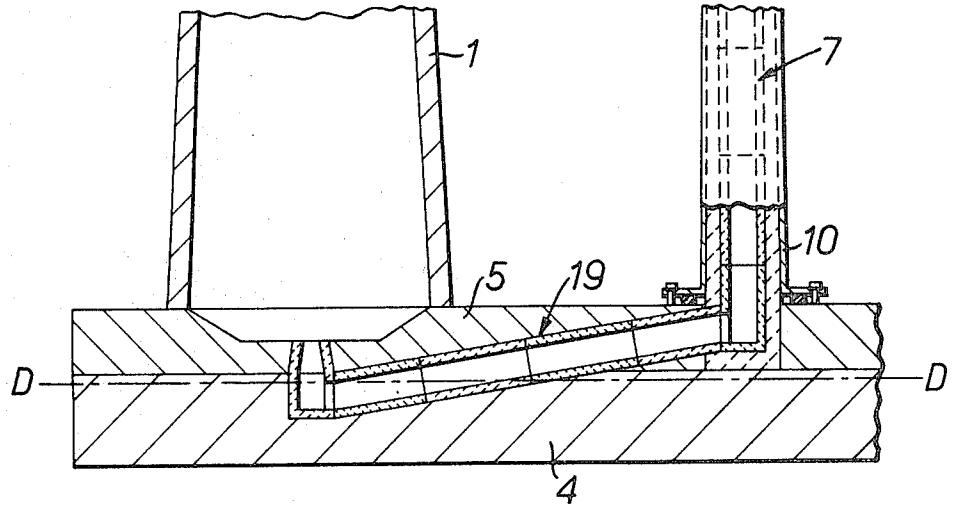
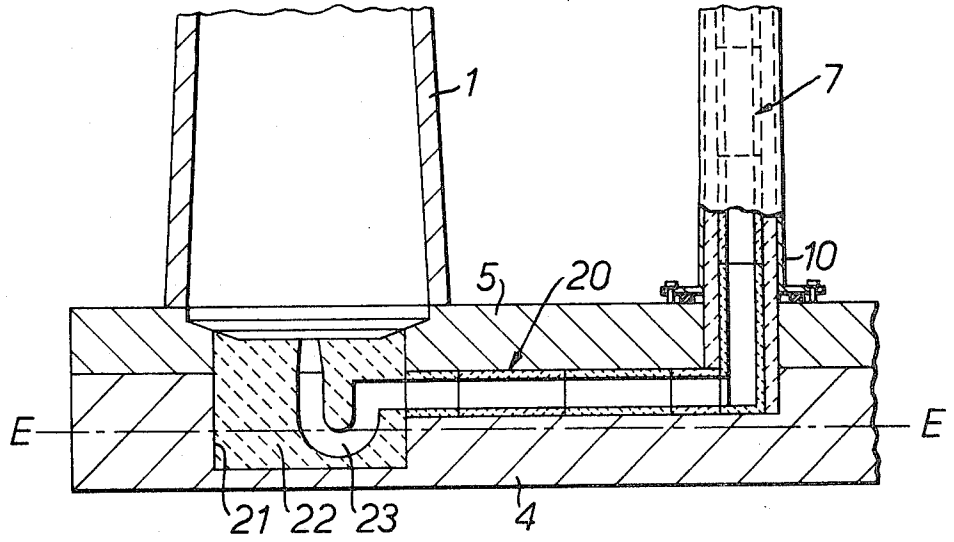
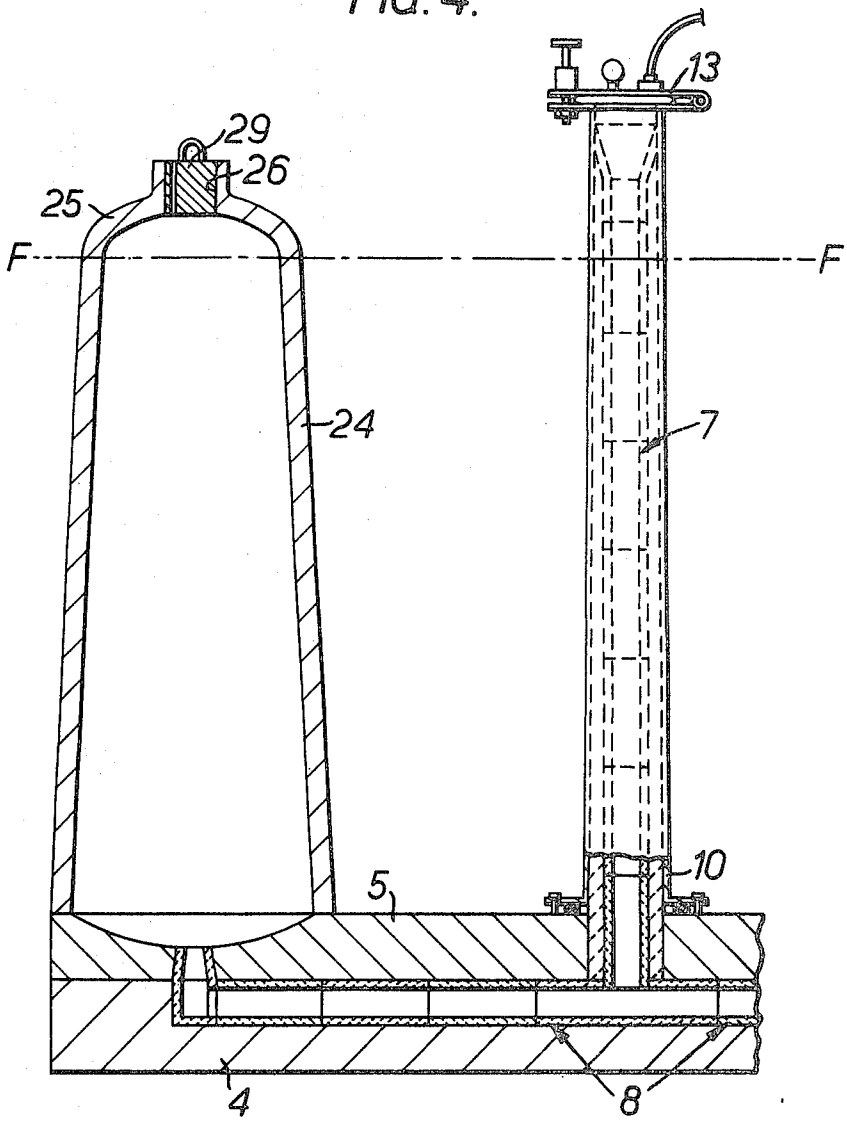


FIG. 3.



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FIG. 4.



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BOTTOM POURED INGOTS

When an ingot is cast by the top poured casting process in which metal is poured into the ingot mould from the top, splashing may occur on to the sides of the ingot mould. The splashed metal solidifies quickly, with the result that the surface of the ingot has defects. To overcome this and other disadvantages it is known to use the bottom poured casting process in which single ingots or groups of ingots are cast by pouring the metal from a ladle down a runner system communicating with the bottom of the mould or moulds. A disadvantage of the bottom poured casting process is that some metal remains in the upstanding runner and cross runner or runners forming the runner system, and has to be scrapped. The resulting loss in yield may be as much as 5 percent when a single ingot is cast.

Furthermore, in comparison with the top poured casting process, known bottom pouring involves significant extra ingot costs represented by the refractory materials for the runner system which cannot be re-used, and additional casting equipment, and additional labor required for assembly.

According to the present invention a method of bottom poured casting in which molten metal is poured into an upstanding runner which forms part of a runner system communicating with the lower end of an ingot mould is characterized in that metal is first poured into the upstanding runner to enter the mould, and a fluid under pressure is then applied to the metal in the upstanding runner to displace at least some of the metal remaining in the runner system into the mould. This results in a saving of molten metal.

According to another aspect of the invention, apparatus for bottom poured casting including an upstanding runner and a base having a cross runner therein, the upstanding runner and cross runner forming a runner system so arranged that in use molten metal can be poured into the upstanding runner to flow via the cross runner into an ingot mould positioned in use on the base, is characterized by means for sealing the runner system whereby a fluid under pressure can in use be applied to the metal in the upstanding runner to displace at least some of the metal remaining in the runner system into the mould.

An advantage of the invention is that the upstanding runner being completely evacuated of metal, may be re-used, thus reducing material and labor costs.

The metal can first be poured into the runner system to fill the mould to a level below the desired level, and then the desired level can subsequently be attained upon application of said fluid under pressure. Preferably the pressure of the fluid is maintained for a period to enable metal to solidify sufficiently to prevent it running out of the mould upon release of the pressure.

The pressure may be controlled in any suitable way to ensure that the molten metal reaches the desired level in the ingot mould, and in one method pressurized gas is applied until bubbles escape from the top of the metal in the mould.

The upstanding runner or trumpet used in known bottom poured casting apparatus is normally made of refractory holloware enclosed within a trumpet casting or castings. This assembly is not pressure tight and accordingly the means for sealing the runner system preferably includes a pressure tube of any desired cross section adapted to surround the upstanding runner and to be secured to the base in a pressure tight manner. The means for sealing the runner system preferably also includes a cover adapted to be connected in a pressure tight manner to the upper end of the pressure tube after metal has been poured into the upstanding runner, said cover having a passage through which fluid can be applied under pressure to the metal.

In known apparatus the cross runner is horizontal and is formed by a channel in the base, the channel having a refractory lining. Conveniently the base is constituted by a base plate, in which the channel is formed, covered by an upper plate. With such an arrangement it is difficult to displace the molten metal remaining in the cross runner, and to overcome this in one arrangement according to the invention the cross runner is inclined to the horizontal and extends downwardly away from the upstanding runner. When pressurized fluid is now applied, the molten metal in both the upstanding runner and the major part of the cross runner can be displaced without the fluid entering the ingot mould.

In another arrangement according to the invention the cross runner has a bend adjacent to the end that communicates with the ingot mould, said bend being so shaped that pressurized fluid introduced into the upstanding runner can enter, and displace molten metal from, that part of the cross runner between said bend and the upstanding runner without entering the mould. Thus the major part of the cross runner can be horizontal which is more convenient from the point of view of manufacturing the base.

The ingot mould may be of the bottle top type with a heat conducting plug for making a non gas tight closure at the top of the mould. With such an ingot mould the pressurized fluid can be applied to ensure that metal in the mould contacts the plug. The mould can first be filled to a level below the plug, so that only upon application of pressurized fluid is contact made with the plug. Alternatively sufficient metal may be first introduced into the mould to contact the plug, and pressurized fluid is then applied to displace more metal into the mould to compensate for the contraction that takes place as a result of metal solidifying. In both cases if fluid pressure were not applied a thin skin of solidified metal is initially formed in contact with the plug. This skin would then contract away from the plug leaving an air gap and when this occurs the effectiveness of the plug as a heat sink is greatly reduced. Solidification would continue with the liquid metal losing contact with the skin, (because of the decrease in volume accompanying liquid to solid transformation) and a further skin would then form on top of the residual liquid through radiation and convection heat losses to the initial skin. The liquid level then again falls and this process continues until ingot solidification is complete resulting in an ingot with only a thin skin enclosing an intermittent primary pipe. The application of fluid pressure prolongs contact of the initially formed skin with the plug and furthermore prevents contraction of liquid metal away from the solidifying skin over the period until the solidification of the runner assembly is complete. The net result is that contraction cavaties are contained within a substantial solidified skin which remains intact during rolling. Using either of these methods has the additional advantage that undesirable open primary pipe in the top of the ingot can be avoided.

Any of the techniques described enable the cross section of the upstanding runner to be increased without incurring loss of yield. Air entrainment invariably occurs during filling of the runner, resulting in turbulence during mould filling which produces ingot surface defects. Such entrainment is reduced with increase in trumpet diameter although with conventional casting techniques runner scrap losses would proportionately increase.

Preferred embodiments of the invention are illustrated in the accompanying drawings in which:

FIG. 1 is a cross section through apparatus for bottom poured casting,

FIG. 2 is a detail of a modification of the apparatus of FIG. 1,

FIG. 3 is a detail of another modification of the apparatus of FIG. 1,

FIG. 4 is a cross section through another apparatus for bottom poured casting.

FIG. 1 shows conventional bottom poured casting apparatus modified in accordance with the invention. The ingot mould 1, having a hot top 2, is positioned on a base 3 consisting of a base plate 4 and an upper plate 5. A runner system 6 communicates with the lower end of the ingot mould 1.

The runner system 6 is formed by an upstanding runner 7 and a cross runner 8. The cross runner 8 is formed by a channel in the base plate 4 which is covered by the upper plate 5. The cross runner 8 is lined with refractory material 9. The upstanding runner 7 is formed of sleeves 27 of refractory materi-

al, but in accordance with the invention, the runner **7** is surrounded by a pressure tight metal tube **10** which is secured in a pressure tight manner to the upper plate **5** of the base **3** by means of bolts **11**. The space between the runner **7** and the tube **10** is filled with packing material **28** such as fire brick waste, sand, or suitable moulding material although this is not essential. The upper plate **5** has an aperture **12** which communicates with the cross runner **8** so that, in use, molten metal can be poured into upstanding runner **7** to flow into the ingot mould **1** positioned on base **3**.

At the upper end of the upstanding runner **7** there is a cover **13** which is adapted to be connected in a pressure tight manner to the upper end of the pressure tube **10** after metal has been poured into the upstanding runner **7**. The cover **13** is hinged at **14** and has a locking device **15** for holding it in the sealed position. Sealing of the cover **13** to the tube **10** is by means of metal, rubber, asbestos, refractory cement seals or other sealing compounds **19**. The cover **13** has a passage **16** through it connected to a pressurized gas line **17** for supplying pressurized gas to the upper end of the upstanding runner **7**. On top of the cover **13** there is a gauge or manometer **18** for indicating the pressure within the upstanding runner **7**.

In use, with the cover **13** open, molten metal is first poured into the upstanding runner **7** to enter the mould **1** until it reaches the level indicated by the dotted line AA. Hot topping compound may be applied to the top of the ingot in the normal way and also preferably to the top of the upstanding runner **7** to maintain a liquid metal surface.

The cover **13** is then closed and sealed to the tube **10** and pressurized gas is applied to the metal in the upstanding runner **7** via the gas line **17** to displace at least some of the metal remaining in the runner system into mould **1** to mix with the metal in the mould **1**. The pressure is increased until the level of the metal in the upstanding runner **7** reaches the level BB and the level in the ingot mould reaches the desired level CC. The pressure of the gas is indicated by the manometer **18** and must be sufficient to reduce the metal level to the level BB, but not beyond BB, if gas is not to be introduced into the cross runner **8** and ingot. For example, if the dimension AA to BB is 53 inches, a superimposed gas pressure of 1 atmosphere is necessary to depress the metal level from AA to BB. This pressure is maintained sufficiently for a period to enable the metal remaining in the cross runner **8** to have solidified fully. For example, 4 to 5 minutes may be required for a runner system with a 2 inch bore.

The pressure tube **10** and cover **13** must of course be locked to the base and to the tube **10** respectively sufficiently securely to withstand the pressures involved.

Using this method only the metal that remains in the cross runner **8** has to be scrapped.

FIG. **2** shows a modification of the apparatus shown in FIG. **1** in which the cross runner **19** is inclined to the horizontal and extends downwardly away from the bottom of the upstanding runner **7**. With the apparatus modified in this way, the level of the metal in the runner system can be lowered to the level DD upon application of pressurized gas without pressurized gas entering the ingot. In this way only a small amount of metal, which has to be scrapped, is left in the cross runner **19**.

FIG. **3** shows an alternative modification to the apparatus shown in FIG. **1** which has the advantage over the apparatus shown in FIG. **2** in that cross runner **20** is horizontal for the greater part of its length. The base plate **4** and upper plate **5** are easier to manufacture with a horizontal runner than with the inclined cross runner of FIG. **2**. The base plate **4** and upper plate **5** have a recess **21** which receives a block **22** of refractory material through which there is a bore **23** forming a part of the cross runner. The bore **23** has a bend which is so shaped that when pressurized fluid is introduced into the upstanding runner **7**, the level of the metal can be lowered to the level EE without gas entering the ingot. In this way molten metal can be displaced from that part of the cross runner **20** between the bend and the upstanding runner **7**.

Instead of using the manometer **18**, an alternative method of controlling the pressure of the gas supplied to the upstanding runner **7** in the apparatus of any of FIGS. **1** to **3** is to provide sufficient pressure until gas bubbles are seen to escape from the top of the liquid metal in the mould **1**. This indicates that the runner system has been evacuated and the pressure is then simply maintained at this value until a skin has solidified at the bottom of the mould sufficiently to seal the runner system from the ingot mould.

FIG. **4** shows an apparatus generally similar to that of FIG. **1** but in use with a semi-closed ingot mould **24** of the bottle top type with tapered shoulders **25**. The ingot mould **24** is provided with a heat conducting plug **29** e.g. of cast iron adapted to make a non-gas tight closure with the opening **26** in the top of the mould **24**.

The ingot mould is filled as described before until the liquid metal in the mould **24** and upstanding runner **7** is at the level FF slightly below the opening **26** in the top of the mould **24**. Level FF is predetermined such that the remaining unfilled volume of the mould is slightly less than that occupied by the metal subsequently displaced from the runner system.

The plug **29** is now inserted into the opening **26** and the cover **13** is secured to the top of the pressure tube **10**. Gas pressure is applied so that the runner system is evacuated and the liquid metal is displaced into the mould **24** until the metal contacts the plug **29** and mould shoulders **25**. The plug **29** acts as a heat sink and molten metal in contact with the plug solidifies. A thick solidified zone will extend from the plug **29** as a result of maintaining the liquid metal in contact with the metal solidifying from plug **29** and tapered mould shoulders **25** by means of gas pressure. The advantage of this method is that the open or sub-surface primary pipe which would normally develop in a non-hot topped ingot is enclosed as secondary pipe within a solidified skin of appreciable thickness.

It is not essential that the molten metal is poured initially to reach only the level FF. The metal may be poured initially until it touches plug **29**, and the pressurized fluid may be subsequently applied to the upstanding runner merely in order to displace more metal into the mould to compensate for contraction that takes place within the mould as the metal solidifies.

In any of the embodiments of the invention described above the evacuated upstanding runner may be detached by removing bolts **11** and re-used several times.

The apparatus shown in FIG. **4** has several cross runners **8** so that several ingots can be cast simultaneously and it is to be understood that the apparatus shown in FIGS. **1** to **3** can similarly be arranged for casting several ingots simultaneously.

We claim:

1. A method of bottom poured casting in which molten metal is poured into an upstanding runner which together with a cross runner in a base for an ingot mould forms a runner system communicating with the lower end of a bottle top type of ingot mould positioned on the base, in which metal is first poured downwardly into the upstanding runner to enter the mould and fluid under pressure is then applied to the metal in the upstanding runner to displace at least some of the metal remaining in the runner system into the mould so that metal in the mould contacts a heat conducting plug which makes a non-gas tight closure at the top of the mould to solidify the metal at the top of the mould, and in which the pressure of said fluid is maintained for a period to displace more metal into the mould to compensate for the contraction that takes place as a result of metal solidifying at the top of the mould and to enable metal to solidify sufficiently to prevent it running out of the mould upon release of said pressure.

2. In a method of manufacturing a poured casting in a bottom filled, bottle top type of ingot mold connected with an upstanding and a cross runner system, the steps comprising: filling the mold and runner system with molten metal; applying fluid under pressure to the molten metal in the upstanding runner displacing at least some of the metal therein into the mold and completely filling it; extracting heat from the molten

metal at the top of the mold by contacting it with a gas pervious heat conducting plug and solidifying it while maintaining the fluid pressure on the molten metal in the runner system; continuing applying said fluid pressure in the runner system displacing more molten metal into the mold and compensating for contraction taking place as the metal solidifies at the top of the mold, and maintaining said pressure in the runner system at least until the metal in the mold has solidified sufficiently to prevent it from running out of the mold when the fluid pressure is released.

3. A method as claimed in claim 2 in which the fluid pressure displaces substantially all of the molten metal in the upstanding runner into the cross runner and into the ingot mold.

4. A method as claimed in claim 2 in which the fluid pressure displaces all of the molten metal in the upstanding runner into the cross runner and into the mold, and displaces substantially all of the molten metal in the cross runner into the mold.

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