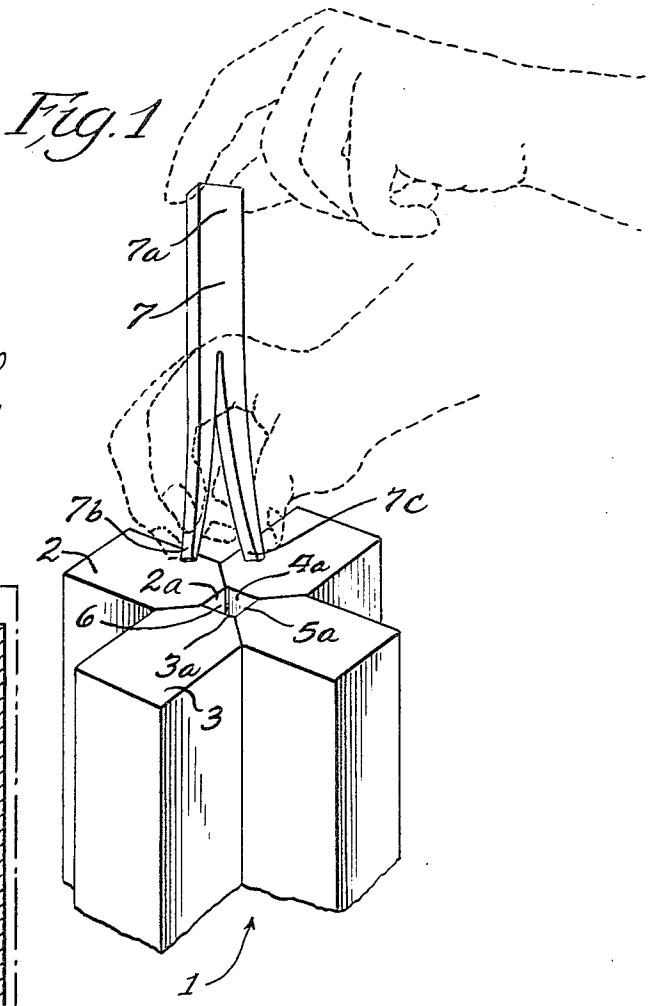
Oct. 21, 1969 E. SIMICH 3,474,000

VIBRATING WALL CONTINUOUS CASTING DEVICE WITH STARTER MEANS

Filed Nov. 3, 1966 3 Sheets-Sheet 1

Fig. 1



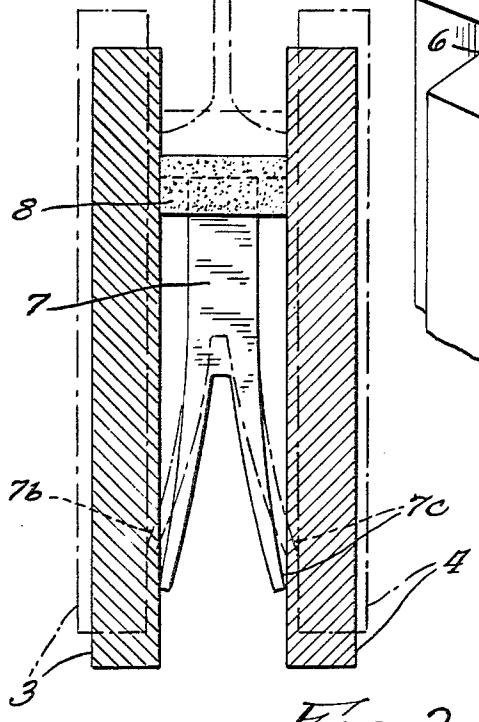


Fig. 2

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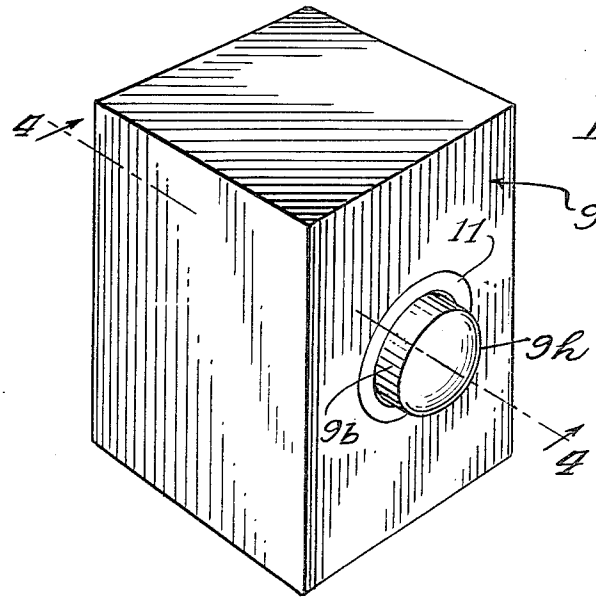

Fig. 3.

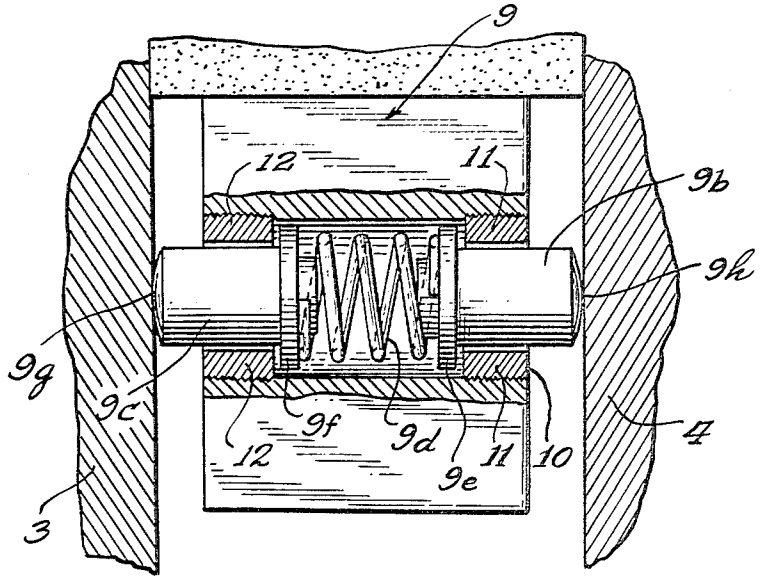

Fig. 4.

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Fig. 5.

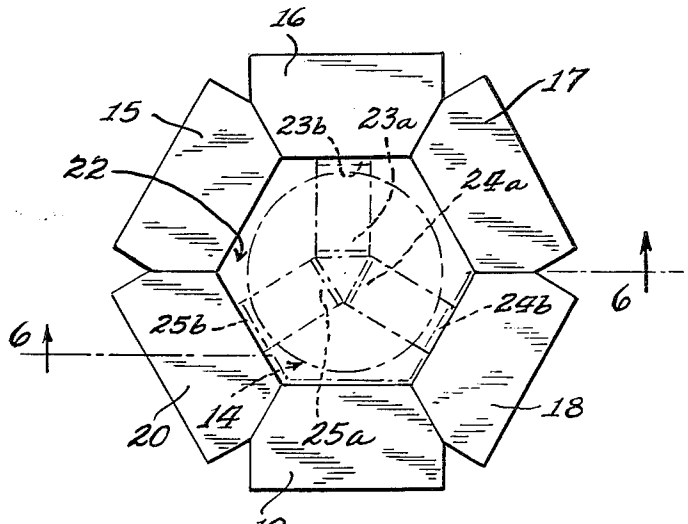
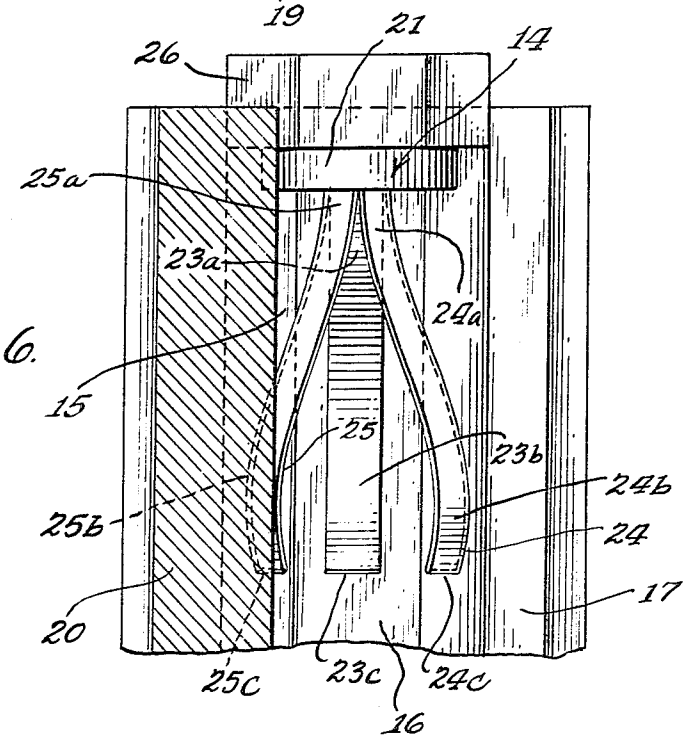


Fig. 6.



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VIBRATING WALL CONTINUOUS CASTING DEVICE WITH STARTER MEANS

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Int. Cl. B22d *11/08, 27/08*

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ABSTRACT OF THE DISCLOSURE

A starter plug in a continuous casting mold of a type having separate mold sections which vibrate for propagating the casting through the mold cavity. The starter plug has means for gripping contact against walls of selected mold sections to resist movement of the plug through the mold cavity until the gripping contact is overcome by the driving force of casting as it is propagated through the mold cavity.

This invention relates to the art of continuous casting of metals and alloys thereof, and more particularly to improved devices for facilitating initiation of casting in a continuous casting machine.

In the type of continuous casting machine shown in United States Patent No. 3,075,264 issued to James N. Wognum, the mold cavity into which the liquid metal is poured is surrounded by two or more mold sections which define the mold cavity. The mold cavity extends entirely through the mold from its top edge to its lower edge so that the liquid metal poured in the top portion of the cavity can become solidified in the cavity and emerge at its lower end as a solid continuous cast length.

If liquid metal is poured directly into the mold cavity at the start of casting, there is nothing to prevent it from pouring all the way through the cavity before solidification takes place so that the continuous casting of a solid length never begins. In order to permit pouring of the liquid metal into the cavity and begin the solidification of the metal which, in turn, keeps the liquid metal from pouring through the cavity, it is necessary to employ some type of solid starting plug which precedes the liquid metal flow and travels through the mold cavity at the same speed as proposed for the casting.

In the device shown in said United States Patent 3,075,264, the mold sections are provided with a vibratory motion which propagates or drives the casting through the cavity of the mold. In molds where the sections do not propagate the casting, it is necessary to employ a solid starter plug of approximately the same cross-section as the cavity of the mold and employ special means to pull it through the mold ahead of the molten metal at the same speed intended for withdrawal of the casting. This is a cumbersome technique because external withdrawal means is required for propagating the starter plug. In addition, the speed of the starter plug must be adjusted by the speed of the external withdrawal means to synchronize it with casting speed and this presents difficulty. Also, the propagation of the starter plug must be initiated simultaneously with the start of metal pouring so that the starter plug does not lead the molten metal and prevent proper filling of the mold cavity.

With the propagating type of mold disclosed in said United States Patent 3,075,264, it has been discovered that the vibratory propagating motion of the mold sections can be advantageously utilized when an improved starter plug having defined characteristics is employed, and it is the principal object of this invention to provide such an improved starter plug.

In order to accomplish this objective, it is another object to provide one form of such a starter plug which has

a fork-like or clothespin shape with two prongs at one end with the spacing of the prongs a distance greater than the spacing of two opposite walls of the mold cavity into which the plug is to be fit. It is preferred that the starter plug be made of wood, plastic or other inexpensive resilient material so that the prongs can be squeezed toward each other and inserted with their pronged end leading into the upper end of the mold cavity. As the prongs are released, their resilience urges them against the opposing walls of the mold so that they frictionally contact the walls. As the mold sections are actuated, the resilience of the prongs is such that they can compress and expand according to the movement of the walls of the mold which they contact. Enough resilience is provided in the prongs of the starter plug to provide enough normal force between the prongs and the mold walls to initially frictionally prevent slippage between the plug and the mold walls prior to the pouring of metal into the mold. This insures that the starter plug will not begin to propagate through the mold cavity until the metal pouring is initiated.

It has been found that any presence of moisture in the mold cavity at the time hot liquid metal is poured into the cavity causes vaporization of the moisture immediately and reacts explosively if the water present is sufficient. If a wooden starter plug is employed, it usually has sufficient moisture in it so that this possible explosive condition can exist. In order to overcome this problem, it is another object of the invention to provide an auxiliary plug above the starter plug which auxiliary plug is substantially free of moisture. A suitable material for this auxiliary plug is graphite because, unlike wood, it can be readily dried thoroughly without destroying its structure. Wood requires complete charring to guarantee dryness. Further, graphite is a good heat conductor which provides rapid cooling of the leading end of the cast metal to thereby insure metal freezing.

It is still another object of this invention to provide alternate constructions for the starter plug which employ certain similar basic properties as the fork-like type, the main one being resilient means for retaining the plug in the mold cavity so that it does not propagate through the mold passageway until the metal pouring is initiated.

Other objects and advantages of this invention can be understood by reference to the accompanying drawings in which:

FIG. 1 shows a perspective view of the four sections of a mold of the type shown in U.S. Patent 3,075,264 and indicates an operator positioning one embodiment of a starter plug employing the principles of this invention in the cavity of the mold prior to introduction of liquid metal into the mold;

FIG. 2 shows a sectional view of the mold of FIG. 1 with the starting plug shown in FIG. 1 positioned in the mold cavity in preparation for the introduction of molten metal from a tundish indicated generally above the mold;

FIG. 3 shows an alternate construction, in perspective, for a starter plug; and

FIG. 4 shows a side elevation in partial section of the starter plug shown in FIG. 3;

FIG. 5 shows an alternate construction of the mold and starter plug;

FIG. 6 shows a sectional side elevation of the construction of FIG. 5.

As indicated in FIG. 1, a typical propagating mold is indicated as having four columnar mold sections **2**, **3**, **4** and **5** which are positioned with their inner walls **2***a*, **3***a*, **4***a* and **5***a* forming a substantially square cross-section cavity **6**. As explained in U.S. Patent 3,075,264, these mold sections **2**, **3**, **4** and **5** are provided with a vibratory motion which causes them to drive the casting through the cavity **6**.

One form of the improved starter plug 7, as shown in FIG. 1, consists of a one-piece wooden, plastic or other material length which has a solid upper end 7*a* and a lower end divided into two separate prongs 7*b* and 7*c* which are spread apart from each other by a distance greater than the thickness of the end 7*a* which is approximately of square cross-section with dimensions slightly less than the cross-section of the mold cavity 6 which is indicated to be square, but can be rectangular or of other shapes.

In order to introduce the starter plug length 7 into the mold cavity 6, its two prongs 7*b* and 7*c* are squeezed toward each other to a dimension smaller than the spacing of two opposing walls of the mold cavity 6. The two prongs 7*b* and 7*c* are then introduced into the upper end of the mold cavity 6. The mold sections 2, 3, 4 and 5 can either have their motion initiated prior to the introduction of the starter plug 7 or their motion can be started after the starter plug is positioned in the cavity 6. After the starter plug 7 is fully contained within the cavity 6, as viewed in FIG. 2, an auxiliary plug 8 of approximately the cross-section of the mold cavity 6 is introduced directly against the upper end 7*a* of the starter plug 7. When auxiliary plug 8 is completely below the level of the mold cavity 6, the hot metal 13 can then be poured from the tundish 10 positioned above the mold 1.

When the starter plug 7 is positioned within the cavity 6 and the vibratory motion imparted to mold sections 2, 3, 4. and 5, the starter plug 7 will be caused to vibrate in an up and down manner corresponding to the up and down movement of the mold sections it contacts. The limits of the motion are indicated in an exaggerated manner in FIG. 2. The position of starter plug 7 at the upper limit of its movement is shown in dotted outline and the lower limit is shown in solid outline. This movement is a result of the above-mentioned frictional engagement of prongs 7*b* and 7*c* with two opposed mold sections, sections 3 and 4 in this case, which are vibrating in an orbital manner. Because there is no slippage between the prongs 7*b* and 7*c* and the mold sections 3 and 4 during this initial up and down movement of the starter plug 7, the prongs 7*b* and 7*c* contact the same regions of the mold sections 3 and 4 throughout. Initially, when the hot metal is poured into the mold cavity 6 above the top surface of the auxiliary plug 8, the up and down movement of the starter plug 7 continues to be urged by the mold sections. The prongs 7*b* and 7*c* are provided with sufficient resilience to impart a frictional force between prongs 7*b* and 7*c* and mold sections 3 and 4, which is sufficient to keep the starter plug 7 from propagating under the combined downward forces of the weight of the starting plug 7, the auxiliary plug 8, and the initial molten metal poured. In a very short period of time the metal cools and begins to harden. As hardening progresses, metal begins to be driven by the vibration of the mold sections 2, 3, 4, and 5, and, in turn, the metal begins to drive the starter plug 7 through the mold cavity 6 as the frictional grip of the starter plug 7 is overcome.

Although the starter plug 7 can be made of different materials, such as wood or plastic, if the material, such as wood, inherently contains or retains moisture, it is desirable to employ the auxiliary plug 8 made of a material which does not retain any appreciable amounts of moisture or which can be readily dried to a moisture-free condition. A very satisfactory material for the starter plug 8 is graphite, although a metal plug of a higher melting point than the metal being poured can also be used. Graphite is inexpensive and readily available and, so, is quite satisfactory. By having the dry auxiliary plug 8 between the molten metal 13 and the starter plug 7, if there is any moisture absorbed in the starter plug 7, the liquid metal 13 never strikes it to create the hazardous condition of instantaneous formation of vapor which, as mentioned above, can be a harmful explosive condition resulting in serious splatter of molten metal.

After the starter plug 7 completely passes through the cavity 6, it will fall away. The auxiliary plug 8 will follow it, but may adhere to the metal in contact with it which is then solidified. The auxiliary plug can be easily broken away from the metal and reused with the starter plug 7 during the next casting cycle.

Referring to FIGS. 3 and 4, alternate constructions of a starter plug can be made. The starter plug 9 shown in FIGS. 3 and 4 embodies the principal functional characteristics of the clothespin-shaped starter plug 7. Starter plug 9 consists of solid wood, plastic, or other material having a cross-section less than that of the cavity 6. Friction knobs 9*b* and 9*c*, separated by a spring 9*d*, are secured into a bored hole 10 by means of lock nuts 11 and 12. Spring 9*d* forces the friction knobs 9*b* and 9*c* apart from each other, the outward movement of the friction knobs 9*b* and 9*c* being limited by the engagement of the base portions 9*e* and 9*f* with the lock nuts 11 and 12. The axial lengths of friction knobs 9*b* and 9*c* are such that, when fully separated by spring 9*d*, the distance between end portions 9*g* and 9*h* of the knobs is greater than the amount of greatest separation of mold sections 3 and 4. Spring 9*d* must have a spring constant to produce sufficient normal force between friction knobs 9*b* and 9*c* and fully extended mold sections 3 and 4 to maintain an adequate frictional grip between the knobs 9*b* and 9*c* and the mold sections 3 and 4.

Starter plug 9 is introduced into the mold cavity 6 after squeezing friction knobs 9*b* and 9*c* toward each other to a dimension smaller than the spacing of the two opposing mold sections 3 and 4. As with the clothespin-shaped starter plug 7, starter plug 9 may be inserted either prior to or subsequent to the initiation of the mold section vibration.

The operation thereafter is similar to that described for the plug 7. The plug 9 will not propagate through the mold cavity 6 until molten metal is poured and hardening of the metal has progressed sufficiently.

Still another embodiment of the invention is indicated in FIGS. 5 and 6 where a starter plug 14 is shown as applied to a casting mold having six mold sections 15, 16, 17, 18, 19 and 20. As taught by U.S. Patent No. 3,075,264, the action of this mold may be such that every other mold section operates with the same in-phase movement. For example, each mold section follows an orbital path involving a first portion of movement toward said longitudinal axis of the mold cavity and forward toward the discharge end thereof to provide a driving force on the metal casting to propagate it through the cavity. The second portion of movement involves moving the mold section in retraction away from the longitudinal axis and in return movement toward the receiving end of the mold cavity to thus complete a closed loop of orbital movement. By having every other mold section move in phase simultaneously toward the longitudinal axis of the mold cavity during the first portion of movement and then follow simultaneously with the second portion of movement away from the longitudinal axis, the components of movement of these alternate mold sections along the longitudinal axis of the mold correspond identically to each other. For example, the movements of mold sections 15, 17 and 19 correspond to each other and the movements of mold sections 16, 18 and 20 correspond to each other.

In order to accommodate a starter plug to this arrangement of mold sections, it is desirable to have the starter plug engage all three of one set of alternate mold sections which move in phase with each other. This is accomplished, in the embodiment shown, by the starter plug 14 which has a circular top portion 21 of small enough diameter to fit into the cavity 22 of the mold. It is circular for convenience, but can have a hexagonal shape corresponding to the opening of the mold cavity. Depending from the top portion 21 of the starter plug 14 are three leaf spring prongs 23, 24 and 25, which are suitably con-

nected at their upper ends 23*a*, 24*a* and 25*a*, to the top portion 21. Each connection can be made by inserting the upper end of a prong in an opening in the top portion 21 and gluing it in place.

Each of the prongs extends downwardly and bows outwardly to a maximum in regions 23*b*, 24*b* 25*b* which, when not constrained, extend radially a further distance than the width of the cavity 22. The lower ends 23*c*, 24*c* and 25*c* are turned in slightly to facilitate entry of the starter plug into the cavity with minimum snagging possibilities and to thereafter minimize snagging.

In operation, the three prongs 23, 24 and 25 of the starter plug 14 are squeezed radially toward each other and their lower ends are then inserted into the cavity 22 of the mold. Upon release, these prongs 23, 24 and 25 are urged by their own resilience outwardly against the mold sections 16, 18 and 20, as indicated. The same functional features of the starter plug will exist if its prongs are instead inserted to contact the other set of mold sections 15, 17 and 19. The starter plug 14 is then pushed down into the mold cavity 22. An auxiliary plug 26 of the same characteristics as auxiliary plug 8 previously referred to, is then positioned on the top portion 21 of the starter plug 14. This auxiliary plug 26 is then pressed downwardly from a position as indicated in FIG. 6 to thereafter position both the starter plug 14 and the auxiliary plug 26 below the upper level of the mold cavity 22 so that both are concealed and there is room above the auxiliary plug 26 for a supply of molten metal to be poured.

When pouring commences, action of the starter plug 14 is substantially identical to the previous two embodiments of starter plugs shown and described. Propagation of the starter plug does not commence through the cavity 22 until sufficient driving force of the metal being cast is provided and this occurs as solidification of the molten metal commences.

It should be apparent that the starter plug 14 is one which has resilient prongs or arms which engage alternate mold sections having the same in-phase orbital movement. This is likewise true of the first two embodiments and, employing this principle, a suitable starter plug can be made for a mold having any number of orbiting mold sections. If eight mold sections are employed, and they are all equally spaced around the mold cavity, it will suffice to employ only a two pronged or projection starter plug because two of the mold sections in phase with each other will be located directly opposite each other. In other words, the starter plug need only contact at least two substantially oppositely positioned mold sections following the same in phase orbital movement.

It should also be understood that, even though three different forms of the invention have been shown, it should be apparent that all three forms can be suitably designed to accommodate a mold with any desired number of mold sections. The clothespin type plug 7 can be easily manufactured with three prongs to replace the plug 14. Likewise, it should be quite evident that three spring loaded plungers can be mounted on a plug in the same radial pattern as for the positioning of the prongs on the starter plug 14. This will accommodate the plug 9 type to the use shown for the plug 14.

Although only certain embodiments of the invention have been shown and described, it should be understood that it can be made in many different ways without departing from the true scope of the invention as defined by the appended claims.

I claim:

1. The combination in a continuous casting mold of a type having a cavity surrounded by opposed mold sections which vibrate through small orbital paths of movement for propagating a casting through the mold cavity comprising, a starter plug positioned in the cavity of the mold, said plug having a plurality of mold contact portions and resilient means for urging said contact portions into gripping contact against the inside walls of certain of the mold sections and thereby resist movement of the plug through the mold cavity until the resisting force of the gripping contact is overcome by the driving force of the casting propagating through the mold cavity.

2. A starter plug as defined by claim 1 characterized by, the grip of the contact portions against the mold sections being frictional.

3. A starter plug as defined by claim 1 characterized by, said plug having at least two contact portions which are aligned to contact a corresponding number of non-adjacent mold sections.

4. A starter plug as defined by claim 1 characterized by, said plug having at least two contact portions which are aligned so that each contact portion contacts a mold section which is immediately non-adjacent to a mold section contacted by another of said contact portions.

5. A starter plug as defined by claim 1 characterized by, the contact portions being portions of bifurcations extending from one end of the plug.

6. A starter plug as defined by claim 1 characterized by, the contact portions being portions of the prongs of a fork-like plug body.

7. A starter plug as defined by claim 1 characterized by, the contact portions being plungers which are guided from the sides of the plug for transverse movement relative to the mold section walls.

8. The combination as defined by claim 1 characterized by, said starter plug having an auxiliary plug for positioning behind the plug toward the entrance of the mold cavity, at least the other covering of said auxiliary plug being made of a material which does not readily absorb water containing moisture.

9. The combination as defined by claim 1 characterized by, said starter plug having an auxiliary plug for positioning behind the plug toward the entrance of the mold cavity, at least the outer covering of said auxiliary plug being made of graphite and said auxiliary plug being of a transverse cross-section corresponding approximately to the size and shape of the cross-section of the mold cavity.

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164—83, 280