This invention relates to a refractory bottom plug for ingot molds of the "big end up" type.

Such ingot molds are provided in their bottoms with downwardly tapered holes which are closed with cooperatively formed plugs of a refractory material before molten ingot metal is teemed into the mold. When the ingot has cooled sufficiently to solidity and substantially to contract, the formed ingot is loosened by jarring and the mold is stripped from it. Quite commonly the refractory plug separates from the body of the ingot and is sealed in the mold by a skin of congealed metal. This necessitates the laborious operation of hammering and chiseling the plug from the bottom opening of the mold.

It is thus desirable to provide a bottom plug for ingot molds with such means or so to form the plug that it will be firmly engaged with the congealed metal of the ingot and will be withdrawn from the bottom opening of the mold with the ingot when it is stripped. Resort has been had to various expedients in order to obtain this effect and all of such expedients have involved some disadvantageous features either in use of the ingot mold plug or in the expense or difficulty of its manufacture. For example, ingot mold plugs have been made which do not wedge tightly in the bottom opening of the ingot mold so that they may be floated to the surface of the ingot as the ingot metal begins to solidify. Metal plates or straps have been provided in the upper region of the ingot mold plug to weld to the ingot metal during solidification. Also the plugs have been formed with through-holes which are closed with auxiliary plugs, or branching holes formed to extend divergently into the body of the plug have been provided.

In practical use all of such ingot mold plugs have proven to be of doubtful value inasmuch as a floating plug frequently is entrapped in the ingot as it solidifies; the provision of metal plates and inserts unduly increases the cost of the plugs; through-holes tend to leakage and frequently fall adequately to bond the refractory plug to the body of the ingot, and holes branching divergently in the plug body are difficult to form and frequently break the plug regionally as the ingot metal contracts.

The object of my invention is to provide an ingot mold bottom plug including means which may be easily and inexpensively provided, serving firmly to bond the plug with the ingot solidified from metal in the mold in a manner to insure the removal of the plug from the mold with the ingot.

In the accompanying drawings

Fig. I is a vertical sectional view through an ingot mold and stool showing a bottom closure plug partly in elevation and partly in vertical section, in position to close the bottom opening of the mold.

Fig. II is a plan view of an ingot mold plug in accordance with my invention.

Fig. III is a view showing the ingot mold plug of Fig. II partly in elevation and partly in vertical section.

Fig. IV is a plan view of an ingot mold plug in accordance with my invention which presents a slight modification over the plug shown in Figs. II and III.

Fig. V is an elevational view of the modified ingot mold plug shown in Fig. IV.

Referring first to Fig. I of the drawings, the ingot mold shown therein is designated by letter A and is shown mounted on a stool B which in usual manner has a central hole C therein. The opening a in the bottom of the ingot mold A is closed by a refractory closure plug D which is tapered to conform to the downward taper of the bottom opening a and which has a plurality of cavities 2 extended downwardly from the upper surface 3 thereof a substantial distance into the body of the plug. In Fig. I molten metal D is being teemed into the mold cavity and has entered the body of the plug 1 to fill the three downwardly extended holes or cavities 2 therein.

Referring now particularly to Figs. II and III of the drawings it will be seen that the three cavities 2 extended downwardly from the upper surface 3 of the plug body 1 which are spaced symmetrically about the vertical axis of the plug and that they terminate within the plug body and within the periphery of the body as defined by circular bounding surface 4 tapering from the upper surface 3 to the under surface 5 of the plug. The three holes 2 all lie in radii of the plug body 1 which are spaced substantially from each other, and preferably as shown lie in three equally spaced radii.

Cavities or holes 2 extend from the upper surface 3 of the plug downwardly a substantial distance, such as about one-fourth to one-half the height of the plug. As shown in Fig. I all of these cavities are filled with ingot metal standing within the mold, and as the metal of the ingot solidifies there are formed in the body of the plug three teats integral with the body of the ingot and extended downwardly from the base thereof. As the ingot shrinks during solidification, such shrinkage causes these three teats to exert from the points of their location clamping forces di-
rected toward the vertical axis of the ingot mold plug, serving firmly to clamp the plug to the base of the ingot. The more accurately the cavities 2 are located on equally spaced radial lines, the more accurately will the clamping forces be directed toward the vertical center line, or vertical axis, of the plug and the more uniformly will those forces be distributed.

I have discovered that the provision of three cavities spaced from the vertical axis of the plug and lying in relatively spaced radial lines is critical in clamping the refractory plug without breaking to the base of the ingot so firmly that it is withdrawn from the mold with the ingot. The provision of two cavities spaced from the vertical axis of the plug, results in the exertion of directly opposed forces as the ingot shrinks during solidification, frequently to break the plug and to destroy its engagement by the ingot. Because of the relatively small dimensions of an ingot mold bottom plug the provision of more than three cavities of substantial depth and adequate cross-sectional area so weakens the body of the plug that it frequently is broken by the shrinkage of the ingot transmitted by the teats formed in the plug cavities; and the provision of four ingot-engaging cavities additionally presents in an increased order the disadvantage attendant on the provision of two such cavities.

A great practical advantage of my ingot mold bottom plug is that by the proper arrangement of three cavities in the plug body the ingot in shrinking so grips the plug that it is unnecessary otherwise to interlock the ingot metal forming the plug-engaging teats with the body of the plug. Particularly it is unnecessary to incline the cavities to the vertical axis of the plug, or to make them of increased area near their bottoms to give a keyed engagement with an ingot. It thus is possible in manufacturing the plug to form the three ingot-engaging cavities of the plug in a single operation by using a molding plunger equipped with three cavity-forming projections, or fingers; whereas the provision of inclined, key-form, or branching cavities requires a separate operation for the formation of each cavity or branch. This fact permits ingot mold plugs made in accordance with my invention to be provided as economically as standard ingot mold bottom plugs which are not so equipped.

The modified ingot mold plug shown in Figs. IV and V of the drawings is illustrative of the fact that the cross-sectional contour of the ingot-engaging cavities is a matter of minor importance. Thus in the plug shown in Figs. IV and V of the drawings the cavities 2 are triangular in cross-section and are arranged with an apex of each presented toward the vertical axis of the plug body. In use this modified form of ingot mold bottom plug functions as well as the form shown in Figs. II and III of the drawings; the percentage of plugs which are broken by shrinkage of the ingot to remain at least partially in the bottom opening of the ingot mold being equally small with both forms of plug. In manufacturing, the circular cross-sectional contour of the cavities shown in Figs. II and III is preferred, because the circular fingers of the plug mold plunger enter and leave the moist body of clay being molded more smoothly and with less tearing than do analogous fingers of an angular cross-section. From the viewpoint of manufacturing economy the form of plug shown in Figs. II and III is therefore to be preferred.

I claim as my invention:
1. A refractory closure plug for an ingot mold having in the bottom thereof a downwardly tapered hole, consisting of a downwardly tapered refractory body circular in cross-section, and three independent cavities extended downward from the upper surface of the plug substantially into the body thereof and terminated within the said body; the said cavities being parallel to and spaced from the vertical axis of the plug on relatively spaced radial lines of the body; and three independent cavities extended downward from the upper surface of the plug substantially into the body thereof and terminated within the said body; the said cavities being parallel to and spaced from the vertical axis of the plug on equidistant spaced radial lines of the body, to receive therein ingot metal and to provide in solidification of the ingot three teats extended from the body of the ingot and under the shrinkage thereof clamping the plug to the ingot by forces directed toward the vertical axis of the plug.

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The following references are of record in the file of this patent:

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