July 31, 1928. 1,678,976

J. A. DURFEE

METHOD OF AND APPARATUS FOR CASTING INGOTS

Filed Nov. 20, 1926 2 Sheets-Sheet 1

Fig. 1.

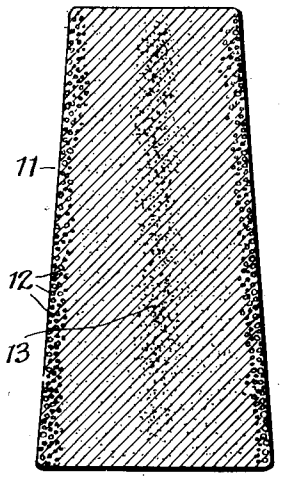


Fig. 2.

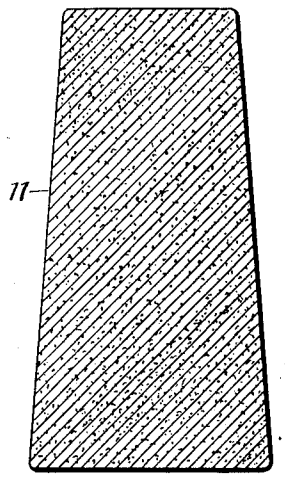


Fig. 3.

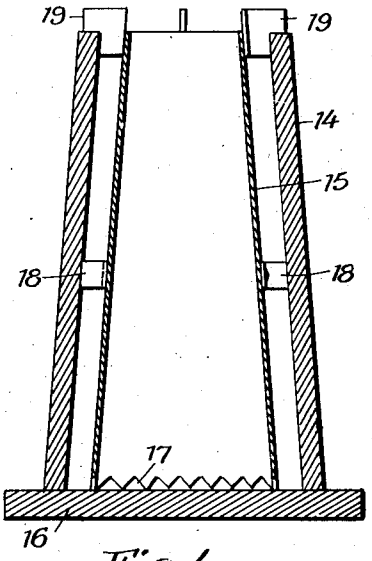


Fig. 5.

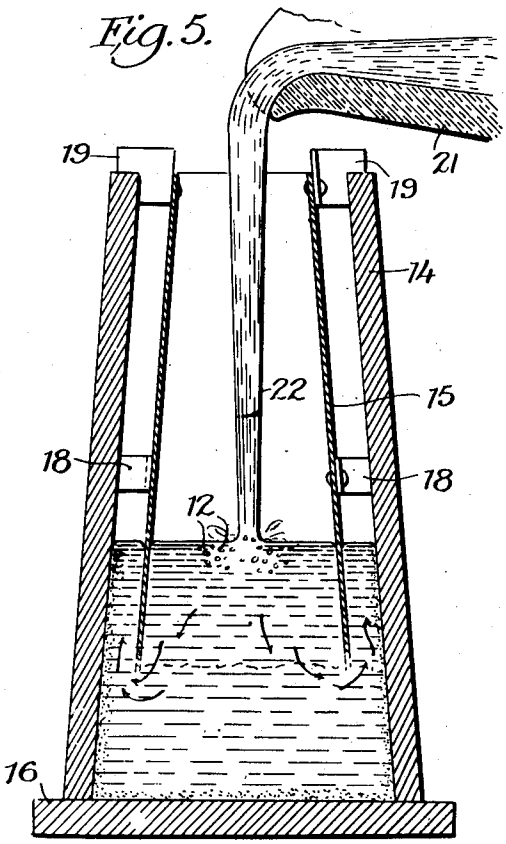
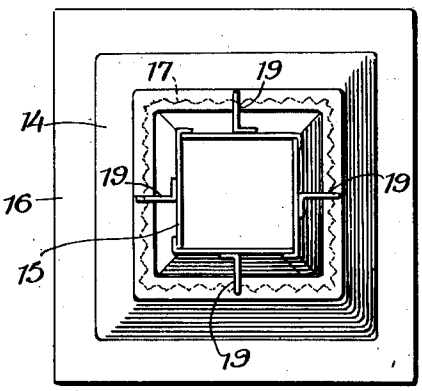


Fig. 4.



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Fig. 6.

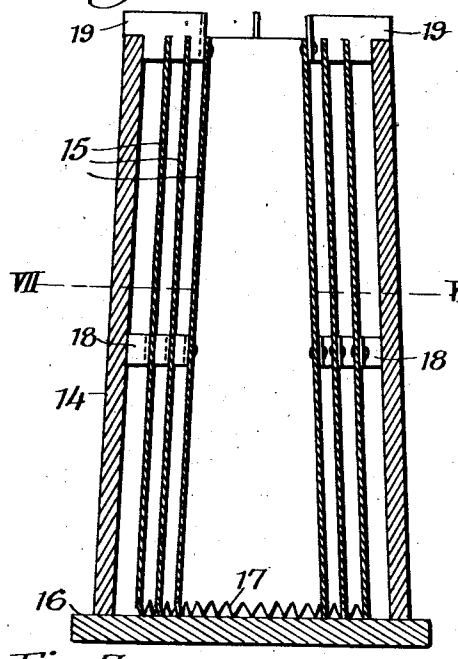


Fig. 8.

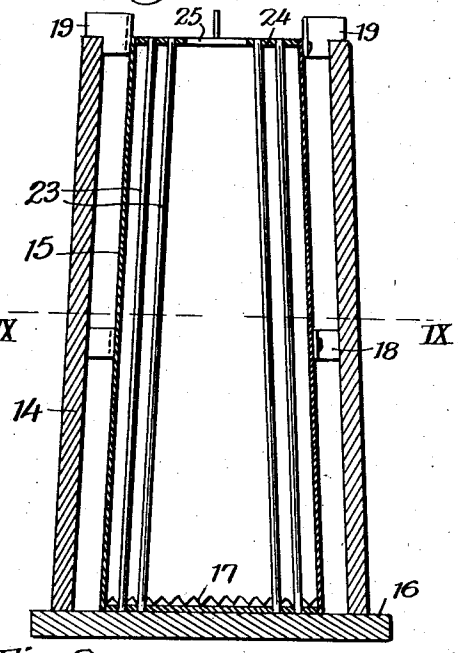


Fig. 7.

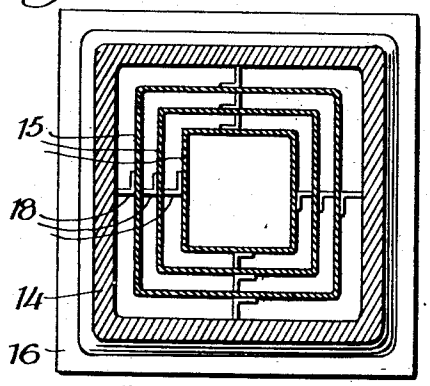


Fig. 9.

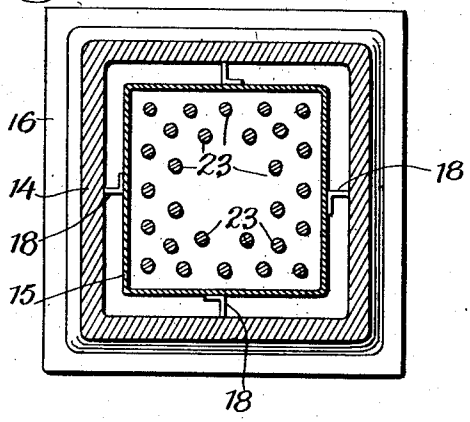
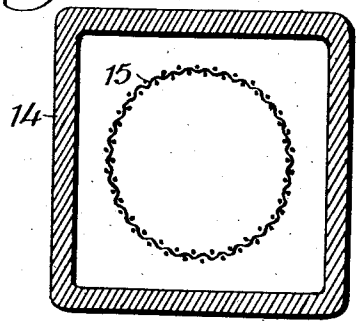


Fig. 10.



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Patented July 31, 1928. 1,678,976

UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR CASTING INGOTS.

Application filed November 20, 1926. Serial No. 149,692.

My invention relates to the art of casting metal ingots and particularly to the art of casting steel ingots and ingots of steel alloys.

Heretofore ingots have been cast in cast iron or steel molds or castings, the metal either being poured into the top of the mold or forced thereinto from the bottom thereof, the latter requiring relatively expensive apparatus compared with top poured ingots. When the metal is poured in at the top, occluded bubbles formed, when the stream of molten metal strikes the surface of the molten metal sometimes disposed five or more feet below the pouring spout of the ladle, depending upon the depth of the mold, are carried toward the side walls of the mold and are there entrapped in the chilled metal adjacent to the mold walls which are usually three or four inches in thickness.

The zone of the ingot adjacent to the surface and commonly known as the skin usually contains countless bubbles or blow holes which zone extends inward from the surface about an inch. When the ingot is rolled to form a bloom or slab, the bubbles remain near the surface of the bloom or slab and cause seams on or near the surface which remain in the bar or sheet rolled from the bloom or slab respectively, with the result that the surface thereof is rough and of weakened structure.

Gases released from the molten metal at the time of pouring or later are also entrapped and produce bubbles which also are carried to the side walls by the flowing metal and there permanently entrapped in the chilled metal adjacent to the surface of the ingot.

The metalloids such as carbon, manganese, sulphur, etc. have a tendency to move toward the center of the ingot, the central portion being the last to cool, and therefore are concentrated near the central zones of the ingot. This segregation of the metalloids causes a non-uniform distribution of the metalloids and consequently the steel of the ingot is not uniform in structure or strength.

An object of my invention is to produce a method of casting ingots wherein the occluded air bubbles and the released gases are prevented from coming in contact with the side walls of the mold or accumulating in the vicinity of the side walls thereof.

Another object of my invention is to produce a process of casting ingots wherein segregation of the metalloids is arrested, if not entirely prevented and wherein the distribution of the metalloids is substantially uniform throughout the mass of the ingot from top to bottom and from side to side.

Another object of my invention is to produce an ingot mold that may be poured from the top and which will produce an ingot practically free of bubbles and in which the metalloids are uniformly distributed.

Another object of my invention is to provide an ingot mold for producing an ingot having the above noted characteristics that may be adapted to existing ingot mold castings, thereby eliminating the necessity of using special mold casings.

Another object of my invention is to produce an ingot mold wherein the yield of usable steel is increased and wherein the quality thereof is superior to that produced in the usually employed mold by the present practice of casting.

These and other objects that will be made apparent throughout the further description of my invention are attained by means of the process and apparatus hereinafter described and illustrated in the accompanying drawings, wherein—

Figure 1 is a vertical section through an ingot cast in the usual mold and by the present practice of casting;

Fig. 2 is a similar view of an ingot cast in my improved mold and by my improved process of casting;

Fig. 3 is a vertical section through a mold embodying features of my invention;

Fig. 4 is a plan view of the mold shown in Fig. 3;

Fig. 5 is a vertical section through the mold shown in Fig. 3, illustrating the phenomena incident to casting an ingot by my improved process;

Fig. 6 is a vertical section through a modified form of mold construction;

Fig. 7 is a transverse section taken on the line VII—VII of Fig. 6;

Fig. 8 is a vertical section of a further modification of an ingot mold;

Fig. 9 is a transverse section taken on the line IX—IX of Fig. 8; and

Fig. 10 is a transverse section through a further modification of an ingot mold.

Referring to the drawings, Figs. 1 and 2 represent respectively, an ingot cast in the usual mold by the present process and an ingot cast in my improved mold by my im-

proved process. The ingot 11 shows in exaggerated form the bubbles and blowholes 12 that are entrapped near the surface of the ingot and the segregation of the metalloids 13 near the center is represented by the dots, the concentration being greatest near the center of the ingot and near the upper end. In Fig. 2, the ingot made with the improved mold and process shows the substantial elimination of the blowholes and bubbles and a substantially uniform distribution of the metalloids. Referring to Figs. 3, 4, and 5, an improved mold is illustrated wherein the usual mold casing 14 is provided with a frusto-conical partition 15 of rectangular cross section, and which is made of four metal plates riveted at the corners as shown in Fig. 4. The mold casing is supported on a base plate 16 and the partition 15 extends from the top to the bottom of the mold and is provided at its lower edges with notches 17, the purpose of which will hereinafter appear.

The walls of mold casings are usually three or four inches in thickness and consequently are not fused by the molten metal poured into the mold. The partition 15 is preferably of the same metal composition as that to be poured in the mold and the thickness of the partition walls is such that the partition will fuse after it has been immersed in the molten metal a predetermined time, the time being determined by the thickness of the plates and the temperature of the metal.

The partition is preferably spaced about three inches from the side walls of the mold and is centered and supported within the mold by spacers 18 and 19, the latter extending over the upper edges of the mold walls and preventing downward movement of the partition when the lower edges of the partition fuses.

Upward displacement of the partition is prevented by the inclined side walls of the mold casing.

The operation of the process is illustrated in Fig. 5 wherein the mold 14 is shown about half full of molten metal which is being poured from the spout of a ladle 21. When the first molten metal was poured into the mold it flowed under the edges of the partition through the notches 17, and thereafter the metal flowing to the side walls of the mold casing was caused first to descend under the lower edges of the partition and thence upward between the partition and the side walls of the mold casing.

The occluded bubbles 12 which are caused by the column of molten metal striking the surface of the molten metal within the mold, rise rapidly and the relatively slow downward movement of the metal within the partition as it flows beneath the under edges thereof, permits the bubbles to rise clear of the mass before the metal flows under the partition. Therefore the occluded bubbles are released and cannot come in contact with the side walls of the mold where the metal is first chilled and solidified.

Because the lower edges of the partition come first in contact with the molten metal, they are the first to fuse, and the thickness thereof is such that they withstand the heat sufficient time without fusing to maintain a portion of the partition always below the surface of the molten metal as indicated in Fig. 5, and well below the zone of the bubbles.

The metal therefore must flow downward before it can rise between the partition and the mold walls, thus clearing it of occluded bubbles due to pouring of the metal. Molten steel, at the temperature at which it is taken from the furnace, contains gases in solution such as carbonic acid, nitrogen, hydrogen and other elements. When the metal cools, these gases are separated or released in the form of minute bubbles. When metal is poured into the usual ingot mold, gases are released in the metal while the latter is in a molten state due to reduction in temperature and form bubbles which tend to rise so long as the metal remains in the molten condition.

These bubbles differ from the occluded bubbles due to pouring, in that they are gases released from the molten metal instead of entrapped air. The usual ingot, at the time of pouring, contains a definite quantity of such gases which are separated in the form of bubbles as the metal cools. If their formation is not facilitated, immediately after the metal enters the mold, they remain entrapped throughout the ingot with a concentration thereof adjacent the side walls of the mold, where cooling at this point causes more rapid release or separation. However, due to the excessive chilling of the metal adjacent the walls, the metal at this point solidifies before the bubbles have had opportunity to rise to the surface. It is an object of my invention to cause uniform cooling of the metal to the temperature at which the gases are separated or released as the metal is being poured into the mold and to provide sufficient time for them to rise to the surface before they actually come into the vicinity of the side walls of the mold. By causing the metal poured into the mold to descend along and under the partition or gate where they are cooled thereby, its temperature is reduced to the point where gas bubbles are formed and before the metal reaches the side walls of the mold the gases are separated and permitted to rise before flowing to the space between the partition and the mold walls or other cooled zones.

The partition, however, may be made of such thickness that it will not fuse until the entire ingot has been cast, and in that event, all the metal flowing to the side walls

of the mold must flow downward under the partition.

The partition also reduces the temperature of the molten metal in its immediate vicinity and this action tends to impede segregation of the metalloids.

An ingot cools first at the sides in contact with the mold walls, the center being the last to solidify.

Such metalloids that have a lower fusion point than the iron, stay in a molten condition after the iron molecule has become plastic and the contraction of the iron molecule tends to squeeze the metalloids towards its hottest side which is in the direction of the center of the ingot. As the metal solidifies the metalloids move toward the center of the ingot, and ingots cast under present conditions are found to contain a greater density of metalloids near the center.

The cooling action of the partition within the mass causes the ingot to be cooled more uniformly, and consequently the tendency to move the metalloids to the center is minimized, with the result that they are more uniformly distributed throughout the mass of the ingot.

Uniform cooling of the metal also causes uniform shrinkage of the metal and thereby reduces the piping usually occurring at the upper end of the ingot and correspondingly increases the yield of steel of good quality in each ingot.

In Fig. 6 I illustrate a modified form of mold wherein three partitions 15 are disposed in concentric spaced relation within the mold casing 14 and centered by spacers 18 and 19. The lower edges are notched to permit initial flow of molten metal under the lower edges, the metal being poured into the inner partition and permitted to flow upward between the partitions and between the outer partition and the side wall. In this form, there is an increased refining or bubble eliminating action, and a more uniformly distributed cooling medium tending to arrest segregation of the metalloids. It will be seen that by proper distribution of the partitions and the mass of the partitions, substantially uniform cooling can be accomplished and segregation substantially arrested.

Fig. 8, shows a further modification wherein in place of the two inner partitions shown in Fig. 6, metal rods 23 are substituted to cause uniform cooling of the mass. The rods are supported on a plate 24 having an opening 25 through which the metal is poured. The number, size and position of the rods may be varied to obtain uniform cooling action, and to insure fusion thereof before the ingot metal solidifies. The partition 15 functions in the manner of the mold illustrated in Figs. 3, 4 and 5, and may be perforated.

The partition walls may be made of sheet metal having openings or perforations or of steel wire gauze as shown in Fig. 10 wherein a cylindrical partition made of steel gauze wire is employed. The main flow of molten metal is beneath the lower edge of the screen, and the cooling action of the screen tends to arrest segregation of the metalloids.

It will be understood, that the screens or partitions are preferably made of metal similar to that being poured and that the temperature of the metal is sufficient to fuse the rods, with the metal of the ingot, the result being an ingot of homogeneous structure throughout, substantially free of blowholes and bubbles and of substantially uniform composition. By reason of this process, more uniform steel is produced and the yield per ingot is materially increased.

To assist in the internal cooling action of the devices above described, pieces of metal scrap may be placed in the mold as the pouring progresses, thereby reducing the temperature of the metal in the interior of the ingot as it is being poured and causing a substantially uniform cooling action and even distribution of the metalloids.

While I have described my process and have shown several modifications of the mold for practicing my invention, it will be understood that many modifications, additions and omissions can be made without departing from the spirit of my invention.

What I claim is:—

1. The process of casting ingots in a mold which consists in placing a partition within the mold for dividing the mold into an inner and outer compartment, and in pouring molten metal into the inner compartment whereby it is caused to flow under a submerged portion of the partition to the outer compartment.

2. The process of casting ingots in a mold which consists in placing a partition within the mold and in pouring molten metal into the mold on one side of the partition and at a temperature capable of melting the partition before the metal solidifies and whereby the metal is caused to flow under the submerged unmelted portion of the partition to the other side thereof.

3. The process of casting ingots in a mold which consists in placing a plurality of screens within the mold for dividing the mold into a plurality of substantially concentric compartments, and in pouring the molten metal into the inner compartment whereby it is caused to flow under the screens to the other compartments.

4. The process of casting ingots in a mold which consists in placing within the mold fusible metal and in distributing it throughout the interior of the mold, and in pouring molten metal into the mold at a tempera-

ture sufficient to fuse the fusible metal before the molten metal solidifies.

5. An ingot mold comprising a mold shell of sufficient mass to prevent fusion by the molten metal poured therein and fusible metal supported within the mold adapted to be fused by the molten metal but constituted to remain intact beneath the surface of the metal during the pouring operation.

6. An ingot mold comprising a relatively non-fusible mold shell and having fusible cooling metal supported therein adapted to be fused by the molten metal poured into the mold but constituted to remain intact beneath the surface of the metal for a predetermined time during the pouring operation.

7. An ingot mold comprising a mold casing and fusible partitions therein adapted to be fused by the molten metal poured therein but constituted to remain intact below the surface of the metal a predetermined distance during the pouring operation.

8. An ingot mold comprising a mold casing and fusible metal directing partitions therein.

9. An ingot mold comprising a mold casing and a fusible partition within the mold for directing molten metal downward to a predetermined point below the surface of the metal before it reaches the side walls of the casing.

10. An ingot mold comprising a mold casing and a fusible partition within the mold adapted to remain intact below the surface of the metal and to eventually fuse for directing the molten metal and for cooling it internally.

11. An ingot mold comprising a mold casing and a fusible cooling agent within the mold adapted to remain intact below the surface of the metal and to eventually fuse for internally cooling the molten metal.

12. An ingot mold comprising a mold casing and a vertical partition dividing the mold into an internal and external chamber, and provided with gates at its lower edge to permit the molten metal to flow from one compartment to the other.

13. An ingot mold comprising a mold casing and a plurality of fusible partitions dividing the mold into a plurality of concentric communicating compartments.

14. An ingot mold comprising a mold casing and a fusible perforate partition dividing the mold into a plurality of communicating compartments.

15. The process of casting metal ingots in a mold which consists in introducing relatively cold unfused fusible metal members therein for quickly cooling the metal and in pouring the metal into the mold and in contact with the fusible metal members.

In testimony whereof, I have hereunto subscribed my name this 21st day of October, 1926.

JOSEPH A. DURFEE.