W. H. CONNELL.

MANUFACTURE OF INGOTS.

APPLICATION FILED JULY 10, 1912.

1,074,248. Patented Sept. 30, 1913.

FIG. 1.

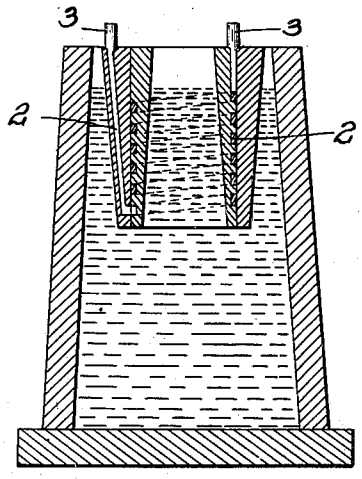


FIG. 2.

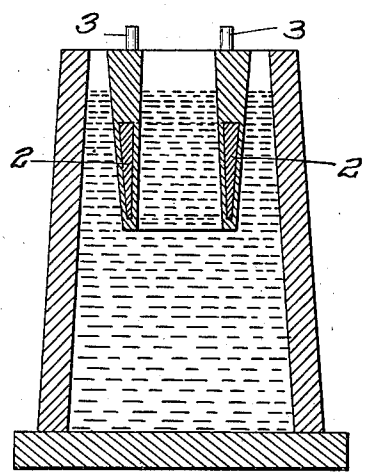


FIG. 3.

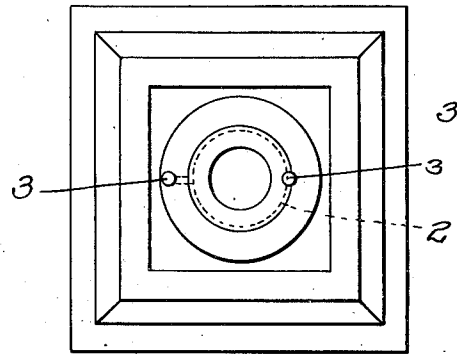


FIG. 4.

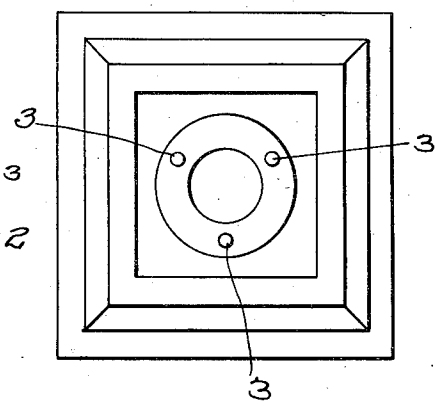
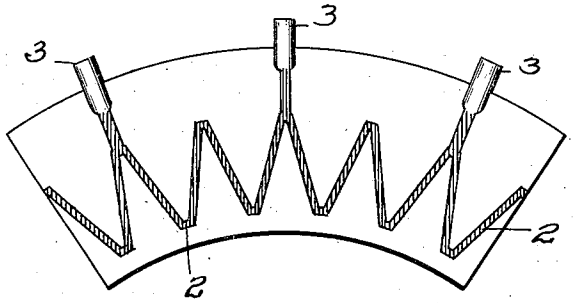


FIG. 5.



WITNESSES:

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MANUFACTURE OF INGOTS.

1,074,248. Specification of Letters Patent. Patented Sept. 30, 1913.

Application filed July 10, 1912. Serial No. 708,712.

To all whom it may concern:

Be it known that I, WILLIAM H. CONNELL, residing at Pittsburgh, in the county of Allegheny and State of Pennsylvania, a citizen of the United States, have invented or discovered certain new and useful Improvements in the Manufacture of Ingots, of which improvements the following is a specification.

As is well known in the art, the piping in the upper portions of ingots is a source of considerable loss. This piping is due, to a very great extent, to the solidification of the outsides and the upper end of the ingot while a large interior portion remains molten or plastic and insufficient in volume when solid to fill the ingot outlined by the earlier solidification of the outside and top. It has been attempted to prevent this piping by the application of heat to the upper surface of the metal in the mold. But it has been found that the heat so applied is effective to keep the metal in a molten condition for a very inconsiderable depth and that a bridge of metal will form across the ingot a short distance below the shallow body of molten metal. It has also been proposed to place an electrically heated sleeve on the end of the mold adapted to contain sufficient metal to fill the cavities formed during the solidification of the metal in the mold proper. This compensating body of metal is maintained for a suitable time in a liquid condition to fill in the cavities, and such portion of metal as remains in the sleeve or sinker-head after the metal in the mold has solidified, is removed from the ingot or other article. Although in this instance the sleeve is heated sufficiently to maintain the metal inclosed in a molten condition, its effect does not extend to any greater depth than where the heat is applied to the surface of the metal in the mold.

It is well known that during the solidification of the metal in a mold, changes are taking place due to segregation, and hence those portions of the ingot which are first cooled by reason of contact with the wall of the mold will differ materially from the inner portions which solidify more slowly. As for example it is well known that during solidification uncombined carbon is squeezed out into the still fluid metal, and will rise to the upper portions of the ingot or other article. As the carbon content of metal influences to a very considerable degree the rate of cooling, the movement of carbon to the upper portions of the ingots, will tend to hasten the cooling of such portions, and *pari-passu* will render the portions from which the carbon has moved less sensitive, and hence there will be such a reduction of plasticity or partial solidification of portions adjacent to the upper part of the ingot while lower interior portions are still fluid, that the gases generated in or escaping from the fluid portions, will be trapped by the same plastic bridge formed as stated near the top of the ingot. And further it is believed that the presence of this bridge near the upper end, prevents the metal kept fluid by the methods heretofore employed, from flowing down into blow holes due to trapped gases or cavities due to shrinkage below the bridge.

As piping is due to the outward movement of metal to the shell formed against the wall of the mold, it is obvious that by preventing the solidification of the outer portions of the ingot in advance of that of the interior portion the formation of cavities from such cause will be prevented. But in none of the methods heretofore proposed has there been any attempt to prevent the formation of piping but only to fill them in after they are formed.

The invention described herein has for its object the provision of means whereby the rate of cooling and solidification of any desired portion, may be retarded and regulated that the resulting ingot may be solid throughout without pipes or vacuities.

The invention is hereinafter more fully described and claimed.

In the accompanying drawing forming a part of this specification, Figure 1 is a sectional elevation showing ingot molds having my improved heat generator in position; Fig. 2 is a similar view showing a modification of the heater; Fig. 3 is a top plan view of the form shown in Fig. 1; Fig. 4 is a top plan view of a mold and heater, the latter adapted for use with a three phase electric supply; Fig. 5 is a plane development of the heater shown in Fig. 4.

In the practice of my invention I employ an annular heater formed of some suitable refractory material as fire-clay, magnesite, etc. Within the walls of this annular heater is embedded an electric conductor capable of being heated to a high

temperature, *i. e.*, above that of molten steel without being destroyed or injuriously affected. In the heater shown in Fig. 1, the conductor 2 is of a helical form, having its opposite ends connected to terminals 3, which are adapted to be connected to a supply of electrical energy. This form of heater can be conveniently formed in two parts fitting one into the other as shown in Fig. 1. The outer face of the inner section is grooved for the reception of the conductor 2, and after the latter has been placed in position the two sections are fitted together.

In the heater shown in Fig. 2 the resistor is in such form as to be easily adaptable for use with single phase or poly phase electrical supply. Fig. 5 shows the arrangement for a 3-phase supply.

When casting ingots the mold will be filled up to the desired level and before the upper surface has materially chilled, the heater which has external dimensions less than the internal dimensions of the mold is placed in position. If the weight of the heater is not sufficient to submerge it to the desired depth weights may be placed thereon, or it may be forced down by any other suitable means. As a heater is annular it may be placed in the mold prior to or at any time during the teeming of the metal and the entire charge or any portion of the metal poured in through the heater which will be moved up as the metal rises, such movement being preferably due to the buoyancy of the heater. It is preferred that the heater should be raised to high temperature before being placed in the mold, in order to prevent a chilling of the metal in contact therewith. It will be understood that the heater can be raised to a temperature higher than the melting point of the metal and consequently the metal for a considerable distance from it will be affected. By gradually reducing the current the temperature will be lowered and solidification will progress toward the heater, and at the same time the heater will be gradually raised from the metal. This removal of the heater is facilitated by making the wall of the heater wedge shape in cross-section.

It will be observed that the heater is substantially smaller than the mold so that there will be a considerable body of metal between the heater and the inner surface of the mold and that this body of metal will be subject to the heat radiated from the heater. The temperature of the heater can be so regulated that the chilling effect of the wall of the mold can be modified to such an extent that the outer portions of the metal will have more or less plasticity. As before stated the heater can be placed in the mold at any time and at any desired height and then by regulating its upward movement, the solidification will occur progressively upward across the entire mass. As the cooling will be approximately uniform across the ingot, the shrinkage will be the same at all points and there will be no material movement of the metal outwardly.

It will be understood that provision should be made, as by regulating the heating effect of the heater or otherwise to prevent the metal from adhering to the wall of the mold. It is probable that the metal immediately in contact with the mold may become somewhat harder than the interior portions, but the heater can be so regulated that the metal in contact with the mold will be at least plastic.

As set forth in the English Patent No. 3501 of 1884 to Ellis, it has been proposed to form solid ingots by arranging a refractory sleeve in the upper end of the ingot mold and fill not only the mold but the sleeve with the molten metal. Heat is then applied externally to this refractory sleeve so as to maintain the metal therein in a molten condition, until after the metal in the ingot mold proper has solidified. The mold with the refractory sleeve charged with molten metal is then removed and the metal in the sleeve allowed to solidify. During this solidification the surface metal at the upper end of the sleeve becomes hardened and there will be formed a pipe as in the usual casting method. The mold and sleeve are then removed and the metal in the sinker-head cut off from the ingot.

In the invention described herein the mold is charged with only sufficient metal to form an ingot of the desired size. Heat is then applied to the molten metal in such manner as to keep the metal in contact with the mold from complete solidification until after the interior portions of the ingot have attained approximately the same temperature. It is also characteristic of the invention described herein that the surface metal at the upper end of the ingot is maintained in a molten condition until after the lower portion of the ingot has solidified.

I claim herein as my invention:

1. As an improvement in the method of forming solid ingots, the method herein described, which consists in teeming into the mold only the amount of metal desired in the finished ingot, applying sufficient heat to the metal in the upper portion of the ingot in such manner that it will maintain such upper portion including the metal in contact with the inner surface of the mold in a plastic condition, during the solidification of the lower portion of the ingot.

2. The improvement in the art of forming ingots, etc., the method herein described which consists in teeming metal into a mold, bringing such metal to an approximately even temperature transversely of the mold,

and permitting the progressive solidification upwardly while maintaining the transverse uniformity of temperature.

3. The improvement in the art of forming ingots, the method herein described which consists in maintaining a substantial portion of the upper part of an ingot at a temperature not less than the melting point of the metal during the solidification of the lower portions of the ingot and permitting of the progressive upward cooling and solidification of such upper portion.

In testimony whereof, I have hereunto set my hand.

WILLIAM H. CONNELL.

Witnesses:

M. K. COSTER,

F. E. WILEY.