E. GATHMANN.

METHOD OF MANUFACTURING STEEL INGOTS.

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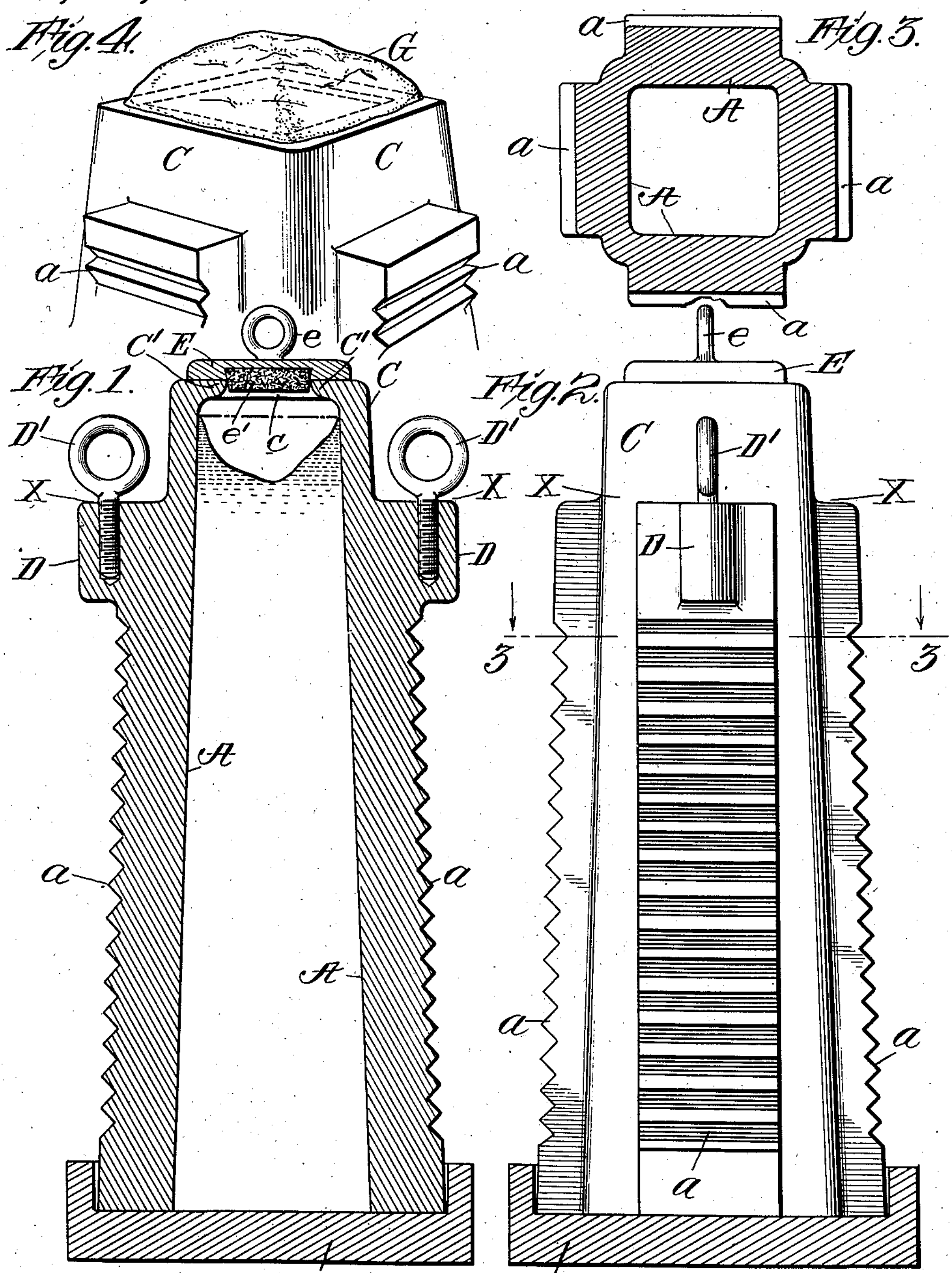
1,049,573. Patented Jan. 7, 1913.



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UNITED STATES PATENT OFFICE.

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METHOD OF MANUFACTURING STEEL INGOTS.

1,049,573. Specification of Letters Patent. Patented Jan. 7, 1913.

Original application filed November 27, 1908, Serial No. 464,546. Divided and this application filed March 8, 1909. Serial No. 481,886.

To all whom it may concern:

Be it known that I, EMIL GATHMANN, a citizen of the United States, residing in Bethlehem, in the county of Northampton and State of Pennsylvania, have invented certain new and useful Improvements in Methods of Manufacturing Steel Ingots, of which the following is a specification.

My invention relates primarily to the casting of steel ingots or alloy ingots which contract in their freezing or solidification from the hot liquid casting and which are subsequently pressed, rolled or hammered into various commercial structural shapes and forgings.

The primary object of my invention is to manufacture steel ingots in such manner that the so-called pipe or cavity which forms in the upper middle portion of the ingot manufactured by the usual methods is greatly reduced or practically eliminated.

Another object of my invention is to so mold such ingots that ingotism or the formation of large crystals in the structure of the ingot is greatly reduced and a further object of my invention is to provide a cleaner and more homogeneous steel casting.

By my improvements I effect a saving and make fit for structural or forging purposes a large percentage of the ingots usually cropped or scrapped on account of piping and other imperfections incident to the present manufacturing practices.

In my application for Patent No. 464,546, filed November 27, 1908, I have described and claimed certain novel molds for practising the method herein described and claimed. I herein claim the method of casting ingots by the molds shown in my application above referred to and the mold herein shown.

In the accompanying drawings I have shown a mold adapted to operate in the manner above stated, but molds of other constructions within the limits hereinafter specified may be employed.

Figure 1 shows a vertical central section through an ingot mold which may be employed in carrying out my invention. Fig. 2 shows a side elevation of the mold shown in Fig. 1, the stool or base being in section. Fig. 3 shows a horizontal section on the line 3—3 of Fig. 2 looking in the direction of the arrows, Fig. 4 is a perspective view showing a modified way of closing the top of the mold.

An essential characteristic of the mold is that its construction is such that all that part of the molten mass below a relatively small part thereof at the upper end of the mold is cooled more rapidly than the remainder of the metal in order that the upper portion of the molten mass may feed molten metal to the pipe or cavity formed in the lower portion of the mass while the latter is freezing or contracting and until the solidification of the ingot is completed. This may be accomplished in various ways as set forth in my application for patent above mentioned. In the mold shown, the lower part below the letters X—X is relatively thick, while the upper part of the mold above the letters X—X is relatively thin. This insures a quicker absorption of heat from the lower part of the molten mass, and the lower part of the mold below the letters X—X is provided with roughened or serrated surfaces, as indicated at *a*. As shown, these surfaces are provided by employing horizontally arranged ribs and intervening grooves, as I find this construction to be well adapted to favor heat radiation.

The mold shown has side walls A which rest on a stool B, of well known construction, and these side walls preferably taper upwardly, as indicated, where they join the four side walls of the upper part C of the mold, which are also preferably tapered. The upper part C is provided with a pouring opening *c* surrounded by a flange C′ which is mainly for the purpose of strengthening the upper part of the mold. The walls of the part C are made thinner than the walls A of the lower part of the mold in order that the lower part of the mold may absorb heat more rapidly from the fluid ingot than the upper part of the mold. Other means than those shown, as set forth in my above mentioned application, may be employed for giving a greater heat absorption, conduction or radiation quality to the lower part of the mold. The parts *a* of the mold are arranged to give an increased radiating surface per superficial foot area of the side walls of the lower part of the mold. The upper portion of the mold may be formed with laterally projecting lugs D provided with devices D′ for convenience in handling or stripping the mold. A mold thus constructed will reduce or practically eliminate piping in the ingot. The freezing or solidifying of the molten mass is progressive from the lower portion of the ingot toward the upper end thereof as is common in all top-cast ingots as the hottest metal lies in progressive layers from the bottom to the top of the ingot. With my method I obtain a far greater differential of this progressive solidifying of the ingot than has heretofore been obtained.

In order to entirely avoid any possibility of piping and to prevent depressed area at the top of the ingot, I cover the mold with a suitable non-conductor of heat, or a very poor conductor, which should be neutral, *i. e.*, it should not have any action on the steel composition.

I may, as shown in Fig. 1, provide a cover E having a handle *e* or a device by means of which the cover may be lifted and lowered and this cover, as shown, carries a mass *e'* of non-conducting material, such as calcined lime, but other substances which are at once non-conductors, or poor conductors of heat, and which have no effect on the material from which the ingot is cast, may be employed. In this way the heat is conserved at the top or upper portion of the fluid ingot.

Instead of employing a cover, such as shown in Fig. 1, I may merely fill the top of the mold with suitable powdered or plastic material, as indicated at G in Fig. 4.

In the use of my invention the mold is preferably pre-heated to the desired degree in order to avoid sudden strains. The liquid steel is then teemed or poured into the mold from a ladle or the like in any suitable way until the mold is filled, preferably, up to, or near its upper end. The heat from the liquid steel is then rapidly conveyed through the side walls A of the lower part of the mold by conduction to the outer surfaces of said side walls upward to the upper part of the mold and downward through the stool or platform D. The heat from the liquid steel having thus passed by conduction or absorption to the outer surface of the mold is further transmitted by radiation and convection into the surrounding atmosphere. As the speed of heat radiation from any similar body is directly proportional to the exposed surface and as it is also governed by the character of the surface, the heat will radiate far more rapidly from the rough surface *a* than from the smoother surface C. It thus follows that the upper portion of the ingot will retain its heat for a much longer period of time than the lower portion thereof, or rather, the lower or body portion of the ingot will be cooled far more rapidly than the upper portion thereof. The upper portion of the molten metal thus being the last to cool, will feed liquid steel to the lower portion of the molten metal as the latter freezes and contracts. This contraction takes place, as is well understood, from a neutral longitudinal axis and usually forms the so-called pipe, but by my improvements this pipe or cavity is automatically filled by the liquid metal fed to it from above and so the pipe or cavity in the cast ingot is, by my improvement, reduced.

The entire time of freezing for a given size of ingot is considerably reduced by my improvements as the radiation of heat is greatly enhanced from the major portion of the outer surface of the mold.

The exact location of the line at which the radiation favoring and non-favoring surfaces of the mold meet cannot be definitely determined except by experiment for specific sizes and depths of molds, but for the best results I have found that the line of rapid cooling of the ingot should extend to at least 85% of the vertical mass of the ingot when in the molten or liquid state. This does not necessarily mean 85% of the actual height of the mold but relates to the volume of the same. If the mold were made very wide or of large cross section at the bottom, the line referred to would be lower than where the mold is made relatively narrow at the bottom or is of the same width at the bottom as at the top.

It is well known that liquid steel when practically deoxidized weighs approximately .256 lbs. per cubic inch while the like cold solid steel weighs approximately .284 lbs. per cubic inch. This is a contraction of approximately 10% in volume. The contraction from said liquid to solid (at white heat) at 1870° F. is approximately 6% and it will thus be understood how the liquid steel floats on the top of the ingot and how as the ingot solidifies a gradually decreasing quantity of liquid steel will still remain on the top until the solidification is completed, and how this liquid steel at the top of the mold can be fed to and made to fill the cavity or pipe tending to form in the lower part thereof, as the steel contracts and increases in specific gravity.

The covering of the top of the mold in the manner before described, not only serves to prevent heat radiation, but it insures the uniform shrinking of the molten mass and thus prevents the formation of a depressed area at the top of the ingot.

In the use of the mold shown and in practising my process the metal in the lower portion of the mold below a relatively small part thereof at the top is frozen in a sidewise direction, while the relatively small portion of the molten metal at the top of the mold is frozen upwardly. This is done by conserving the heat of the ingot at the top of the molten mass and in the relatively small upper portion thereof in order to cause the upper portion of the ingot to freeze last. The solidification at the upper portion progresses upwardly, there being always liquid steel on the top of the ingot until the solidification is completed.

I have hereinbefore stated that the line of rapid cooling of the ingot should extend to at least 85% of the vertical mass of the ingot when in the molten or liquid state. By so doing the upper part of the mold represents in extent approximately twice the extent of the vertical shrinkage of the metal during solidification and by conserving the heat to the extent just specified, I have found that central piping is practically eliminated from the ingot and the depressed portion is so far reduced as to be inconsiderable as compared with the present practice.

I claim as my invention:

The herein described method of casting steel ingots, whereby piping is reduced which consists in retarding the radiation of the heat of the ingot from the upper portion thereof and in progressively accelerating the radiation of heat from the lower portion of the ingot toward the top to an extent approximately 85% of the mass of the molten metal to cause the upper portion of the mass to feed molten metal to the pipe or cavity tending to form in the upper central portion thereof while the metal is freezing or contracting and to thus cause the pipe to rise toward the top of the ingot and disappear in the upper portion of the ingot where the radiation of the heat is retarded.

In testimony whereof, I have hereunto subscribed my name.

EMIL GATHMANN.

Witnesses:

ISABEL GATHMANN,

WILMUTH GARY.