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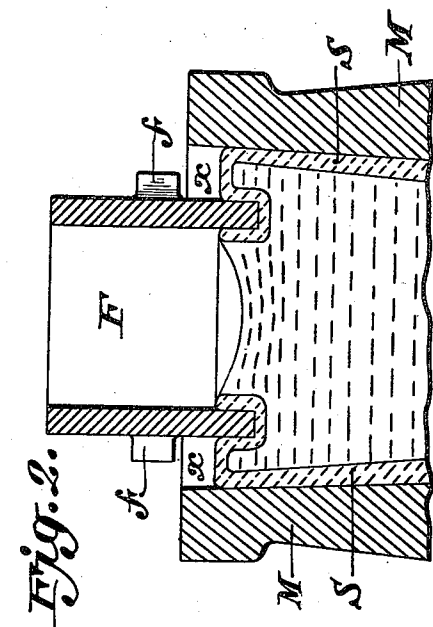
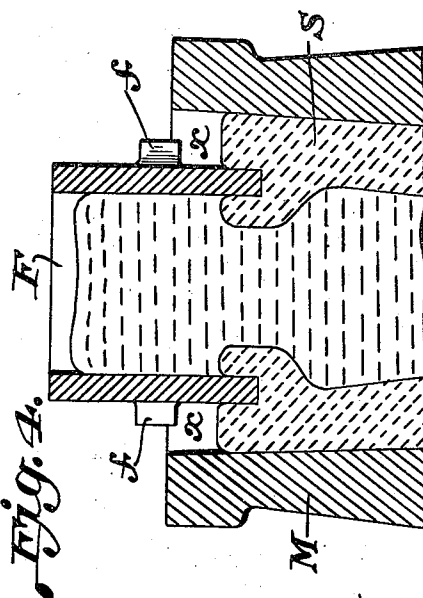
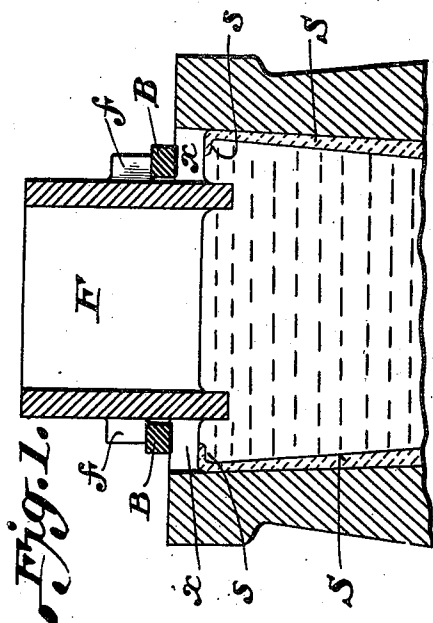
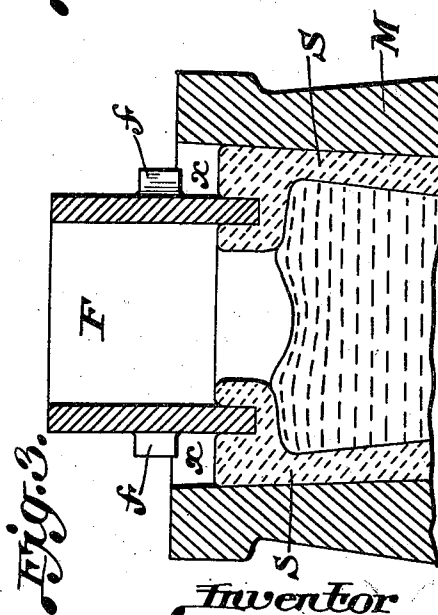
E. GATHMANN

1,508,931

METHOD OF FORMING INGOTS

Filed Feb. 12, 1924

2 Sheets-Sheet 1



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Sept. 16 , 1924

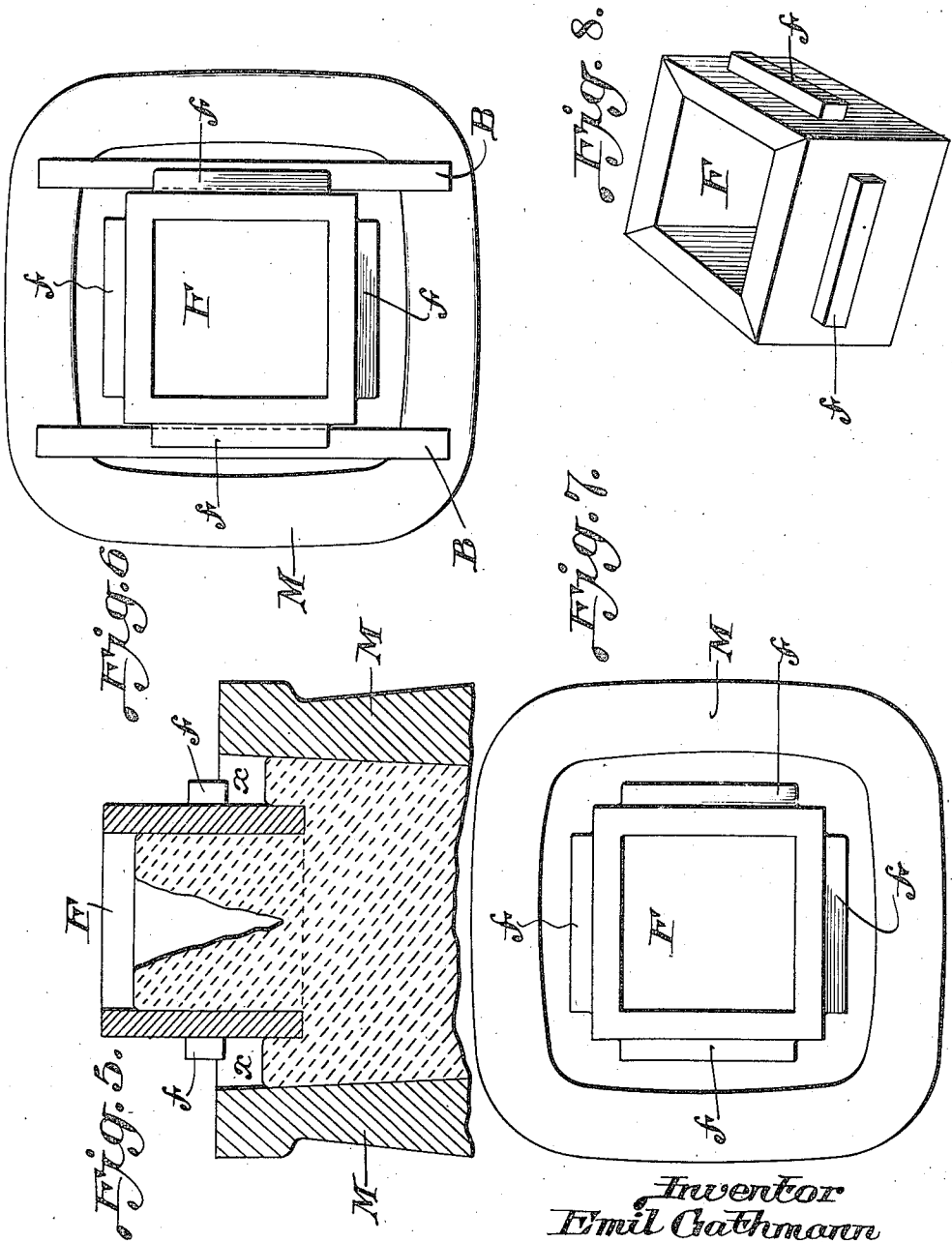
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METHOD OF FORMING INGOTS

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE.

EMIL GATHMANN, OF BALTIMORE, MARYLAND.

METHOD OF FORMING INGOTS.

Application filed February 12, 1924. Serial No. 692,317.

To all whom it may concern:

Be it known that I, EMIL GATHMANN, a citizen of the United States, residing in Baltimore, Maryland, have invented certain new and useful Improvements in Methods of Forming Ingots, of which the following is a specification.

This invention relates to the casting of steel ingots in metallic molds to which the molten metal is delivered through sink heads or feeders of refractory heat insulating material.

The ideal way to make sound ingots would be to pour the molten metal through the sink heads slowly and at intervals, i. e. to first pour a relatively small amount of the metal to fill the mold chamber to a small extent, then wait a suitable time (the length of which depends on the cross section of the ingot), and then pour again, wait a short time, and then continue these operations until the mold chamber is filled to the desired extent and until the ingot has solidified. In this way pipe or cavity due to shrinkage would be practically eliminated. As this method would take from one to two and a half hours additional time in forming an ingot of say 20" cross section and as the surface of the ingot would show a scabby formation where pouring was stopped and recommenced, such practice has been found to be impractical.

According to my invention I pour the molten metal through a sink head into the mold chamber until the mold is nearly filled and the sink head partially filled, allow the metal to partially solidify or form a skin on the surface of the ingot, allow the fluid steel in the sink head to lower or descend to a short extent due to solidification and shrinkage of the body of the ingot and then fill the sink head with the molten metal. After the mold chamber and the sink head are thus filled, the metal in the mold and sink head is allowed to cool and solidify and the ingot with the sink head thereon may be removed from the mold in well known ways. In this process the pipe is formed wholly in that part of the ingot within the sink head and this end of the ingot may be cropped or rolled out or forged and cropped in the usual way.

My invention involves the use of sink

heads or feeders of smaller size than those commonly used, that is to say, the sink head is made of considerably smaller cross section or diameter than the upper end of the mold chamber and when the mold is first poured, the feeder is supported on the top of the mold by suitable devices which suspend the feeder in the mold. After the mold chamber and the sink head are filled to the desired extent, and the sink head is partially filled, the supporting devices are withdrawn and the feeder is supported on the partially solidified metal. After this the metal is allowed to gradually cool and solidify from its outer sides and bottom inwardly and upwardly from the mold walls until thick walls are formed around the central molten metal mass. At this time additional hot molten metal is poured into the feeder and the pouring is continued until the feeder is filled to the desired extent. When the metal has completely solidified in the mold chamber and in the feeder the pipe or shrinkage cavity is eliminated from the mold chamber and the pipe is contained wholly within the feeder. The ingot with the feeder may then be stripped from the mold in well known ways.

One-fourth to one-half of the entire shrinkage of the liquid steel occurs in an ingot of twenty inches cross section in approximately eight to ten minutes and by my invention I am able to use a sink head chamber of approximately one-half the volume ordinarily used in direct pouring of ingots.

In the accompanying drawings I have indicated the steps of the process of casting an ingot performed in accordance with my invention.

Figure 1 shows the first step where the mold chamber, which is defined by metal chill walls, is filled through the refractory feeder or sink head to a short distance below its upper end, the feeder being supported on the top of the mold.

Figure 2 shows the next step where the feeder supports are withdrawn and the feeder rests on the upper skin of the body of the ingot which through cooling has partially solidified.

Figure 3 indicates the position of the feeder after the ingot has solidified to a greater extent.

Figure 4 indicates the position of the feeder and the thickness of the ingot skin after the ingot has solidified still more and the feeder has been filled with molten metal.

5 Figure 5 shows how the ingot has completely solidified and the pipe is located wholly within the feeder.

Figure 6 is a plan view of the mold and feeder shown in Figure 1.

10 Figure 7 is a plan view of the feeder shown in Figure 2.

Figure 8 is a perspective view of a feeder showing the lugs or ribs which as shown in Figure 1 rest on the feeder supports.

15 The metallic mold indicated at M is preferably of the Gathmann type, the lower portion of the side walls being thicker than the upper portions thereof and being of the big-end-up type. The feeder F is of refractory material of good heat insulating quality and may be either formed in one piece or may be made of sections. It is provided with 20 lugs or ribs *f* located preferably mid-way between its upper and lower ends so that it is reversible, i. e. either end of the feeder may be inserted in the mold chamber.

By my invention I am able to use refractory feeders of much smaller size than those commonly employed for an ingot of given 30 cross section and weight. Its cross section or diameter is much smaller than that of the upper end of the mold chamber with which it is used. Thus economy in the expense of the feeder which, as is well known is used 35 for only one pour, or ingot, is obtained.

When starting the operation the feeder is so supported on the top of the mold that it extends a considerable distance into the mold chamber. For instance, in a mold having a 40 chamber of twenty inches cross section, the feeder should extend into the mold chamber a distance of from four or six inches and the cross section for a feeder of the size referred to should be about fourteen inches to sixteen 45 inches thus leaving a clear space within the top of the mold chamber around the lower end of the feeder of from two to three inches, this space being in the form of a ring bounded by the inner mold walls and the outer 50 walls of that portion of the feeder within the mold chamber.

Preferably the feeder is suspended on the mold by horizontally arranged bars B which bridge the mold chamber and rest on the 55 top of the mold, but other forms of supports may be used. The feeder is preferably suspended in such manner that its central vertical axis is substantially in line with the central vertical axis of the mold chamber. 60 This is indicated in Figure 1 where it will be seen the bars B rest on the top of the mold and extend under the lugs or ribs *f* which are preferably formed integrally with the side walls of the feeder. When the feeder is 65 thus suspended, molten metal is poured

through the feeder into the mold chamber until it is filled to the desired extent as indicated in Figure 1. It will be observed that the mold chamber is filled until the molten metal enters the lower portion of the 70 feeder and a space *a* surrounding it. Figure 1 also indicates how the metal quickly solidifies through crystallization upon lowering of its temperature to form a skin S next the side walls of the mold and also to a 75 slight extent on the top of the metal as indicated at *s*.

In making steel ingots a series of molds are usually fitted with sink heads. For instance if thirty-two ingots are made in one 80 heat, each mold is fitted with a sink head and the metal is poured through the sink head until the metal rises to about the line indicated in Figure 1. Then other molds in the series may be filled in the same way to the same extent until, say, eight or ten 85 molds are thus filled, the feeders or sink heads of all these molds being supported by the bars B or similar devices. By that time the skin S in the first mold poured is increased in thickness and the partially 90 formed ingot has shrunk, leaving a depressed portion within the feeder or sink head as indicated in Figure 2 where it will be observed a portion of the skin while surrounding the lower part of the sink head 95 does not extend across the top of the molten metal within the sink head. The supporting bars B may then be removed from the first mold, allowing the feeder or sink head to descend with the shrinking ingot and to be supported thereby in the manner indicated in 100 Figures 2 and 3. Then the sink head may be filled with molten metal in the manner indicated in Figure 4, the molten metal breaking 105 through any slight crust that may be formed on the top of the molten metal in the mold chamber. The first mold may then be left in this condition and the feeder or sink head of the second mold filled in like manner. 110 The first mold is then allowed to stand for a proper length of time until the metal has completely solidified when it will appear as shown in Figure 5, the pipe being entirely contained in the sink head as illustrated. In 115 this way the pipe is formed within a relatively small crop end and thus much metal is saved and expense reduced and as before stated inasmuch as the sink head is relatively small, there is considerable saving in the 120 cost of the sink head.

Shrinkage of a steel ingot commences with the formation of a skin in contact with the mold walls. This solidification progresses 125 rapidly by dendritic crystallization during the initial stages of the cooling of the ingot and after an interval of a half minute the *s*' in thickness materially increases and extends to the surface of the ingot, and into the ring *a* surrounding the feeder and a small 130

thickness of skin is formed around the lower end of the feeder as shown in Figure 2 and, as shown in Figure 3, as the freezing continues the thickness of the skin outside the feeder is made somewhat greater than that within it. Ingot solidification progresses from the exterior portion in contact with the mold walls and with the open air and also in contact with the feeder. As the solidification progresses the volume of the ingot becomes less in view of shrinkage and the metal initially in the lower part of the feeder sinks downwardly to compensate for the decreased volume due to shrinkage upon the formation of solidified steel. A cavity or recess is thus formed in the sink head chamber, the depth of which increases in ratio to the time elapsed from the completion of the initial pouring.

As shown in Figure 3 of the drawing, the shrinkage at this period has absorbed substantially the greater part of the liquid steel in the sink head casing. When shrinkage has progressed to this point which would take approximately from eight to ten minutes for an ingot of twenty inches in cross section, repouring of the sink head is necessary to supply the additional hot liquid steel required to compensate for further shrinkage and to fill the sink head where the final pipe is formed or confined.

The pouring just referred to should be rapidly accomplished as otherwise an objectionable thick skin or crust would occur, closing up the body of the ingot from the sink head casing. Sometimes a very thin skin is formed separating the sink head chamber from the ingot body, but the addition of hot metal removes this thin skin and the filling of the body of the ingot is not interfered with.

As the cost of a sink head is proportional to its size and weight, it will be readily understood that a decrease in size of the sink head and when used according to my method, greatly lowers the cost thereof.

Briefly stated my method consists of a preliminary pouring of ingot molds, using sink heads of relatively small size suspended in the upper part of the mold chambers, a time interval being allowed to elapse which should be sufficiently long to allow the molten metal which has only partially entered the sink heads to shrink downwardly to compensate for the initial body shrinkage of the ingot structure. During this period no true pipe is formed, but a depressed area of saucer like shape occurs within the molten steel entering and adjacent to the sink head chamber as indicated in Figure 3.

An ingot thus formed may remain in the condition shown in Figures 2 and 3 for a period of from five to ten minutes while other molds are being similarly poured. Before this the supporting bars should be removed

within a period of from one-half to two minutes after the steel has risen to the level shown in Figure 1 in order to allow the sink head to descend with the contracting ingot. After a period of five to ten minutes the first ingot poured is repoured so that the sink head is filled to approximately its top as shown in Figure 4. Repouring should be in the order of the pourings initially used in forming the ingots in the series of molds. By my method it is desirable but not essential that a crust of material thickness should not be allowed to form over the entire surface of the molten metal. This crust or skin, however, should be allowed to form over the annular outer ring of steel surrounding the sink head casing and under the walls of the sink head so that the feeder may have a solid support and the suspending bars may be removed at an early period. The steel from which the ingots are formed according to my invention should be deoxidized as well as possible so that it is free from gases and will set and solidify quickly.

By my apparatus and by my method substantial clearance between the mold chamber inner walls and the outer sink head walls is obtained. It should be observed that the stream of steel entering the mold and sink head can be stopped off when the sink head is poured to the desired preliminary height which should be below the top of the mold as the ladle-man can see the height of pour in the mold while pouring through the sink head by inspecting the rise of steel around the sink head. This he could not do if there were no substantial clearance or space surrounding the sink head.

In rolling the ingot for reduction to blooms and billets ordinarily a thin outer wall about the sink head rolls out into very thin fins, which is very troublesome in passing between the rolls without overlapping, thus producing scabs on the body of the ingot. By making the clearance space of substantial or considerable amount these fins are not produced. Another advantage of my invention is that a smaller and thus more economical feeder can be used with a larger clearance than with a smaller one or where the feeder fits closely the mold chamber. It is important to observe that in the first pouring the metal is not allowed to rise to the extreme top of the mold chamber or to overflow and the initial pouring is suspended as soon as the metal rises to the point indicated in Figure 1. In a short time, say from one to two minutes in a twenty inch cross section mold, the supports B should be removed. If this were not done the metal would freeze to the sink head and would tend to draw it downwards. If left in this condition too long it would either break the sink head or crack it or cracks would be formed in the upper surface of the solidify-

ing ingot which would be extremely harmful where a smooth finish bloom or billet is desired. The advantage, therefore, of having the sink head first mounted on supports and then removing these supports and allowing the sink head to be supported on the solidifying ingot itself will be apparent.

I claim as my invention:

1. The method of forming an ingot, which consists in pouring molten metal through a sink head supported on the top of a mold with its lower portion within the mold chamber until the mold chamber is filled with molten metal to the desired extent and surrounds the lower portion of the sink head and extends within it; allowing the metal to partially solidify and the sink head to descend, then pouring molten metal into the sink head while supported on the partially solidified ingot until the sink head is filled to the desired extent and then allowing the entire mass of metal to completely solidify.
2. The method of forming an ingot, which consists in pouring molten metal into a mold chamber through a sink head of materially smaller cross section than that of the upper portion of the mold chamber, continuing this operation until the mold chamber is nearly filled and the molten metal rises around the sink head and extends within it; allowing the molten metal to partially solidify and causing it to support the sink head and then allowing the entire mass of metal within the mold chamber and within the sink head to completely solidify.
3. The method of forming an ingot, which consists in pouring molten metal into a mold chamber through a sink head of smaller cross section than that of the upper portion of the mold and the lower portion of which extends into the mold chamber, continuing the operation until the mold chamber is nearly but not completely filled with molten metal which surrounds the lower portion of the sink head and enters the lower portion thereof, waiting until a cavity has formed within the sink head on top of the molten metal within the mold chamber, then filling the sink head to the desired extent and allowing the entire mass of metal within the mold chamber and the sink head to completely solidify.
4. The method of forming an ingot in a metal mold, which consists in pouring molten metal into the mold chamber through a suspended sink head of materially smaller cross section than that of the upper portion of the mold until the mold chamber is nearly but not completely filled, allowing the metal to partially solidify within and around the sink head, allowing the sink head to sink with the partially solidified ingot, then pouring metal into the sink head until the latter is filled to the desired extent and

then allowing the entire mass of metal within the mold chamber and the sink head to completely solidify.

5. The method of forming a steel ingot in a metallic mold, which consists in pouring molten metal into the mold chamber through a sink head of relatively small cross section supported on the top of the mold, until the mold chamber is nearly filled and the metal surrounds the lower portion of the sink head, allowing the metal to partially solidify in such manner as to form a skin around the molten metal and beneath the bottom of the sink head, withdrawing the sink head supports and allowing the sink head to lower in the mold chamber while resting on the partially formed ingot, then pouring molten metal into the sink head until it is filled to the desired extent and then allowing the entire mass of metal within the mold chamber and within the sink head to completely solidify.

6. The method of forming an ingot in a metal mold, which consists in pouring molten metal into the mold chamber through a suspended sink head of smaller cross section than that of the upper portion of the mold chamber until the mold chamber is nearly filled and the molten metal enters the lower portion of the sink head and surrounds it, allowing the metal to partially solidify, then withdrawing the supports of the suspended sink head and supporting it on the solidifying ingot until the solidification has somewhat progressed, then filling the sink head to the desired extent and then allowing the entire mass of metal in the mold chamber and in the sink head to completely solidify.

7. The method of forming ingots in a series of metal molds which consists in successively filling the mold chambers with molten metal through suspended sink heads of relatively small cross section until each mold is filled to the desired extent, then allowing the metal in each mold to partially solidify and the sink head to lower in the mold chamber with the shrinking ingot, then after further solidification, filling each sink head to the desired extent with molten metal beginning with the first mold poured, then successively filling the sink heads of the remaining molds in the series and then allowing the metal within the mold chambers and the sink heads to solidify completely both within the mold chambers and within the sink heads.

8. The method of forming an ingot, which consists in pouring molten metal through a refractory sinkhead casing supported on the top of a metallic mold with its lower portion within the mold chamber until the mold chamber is filled with molten metal to the desired extent for forming the

body of the ingot, and surrounds the lower portion of the sinkhead casing and extends within it, allowing the metal to solidify in an annular space surrounding the sinkhead casing and in contact therewith and the sinkhead to descend with the body of the ingot, then pouring molten metal into the sinkhead while supported on the partially solidified ingot until the sinkhead is filled to the desired extent and then allowing the entire mass of metal comprising the ingot to solidify. 10

In testimony whereof, I have hereunto subscribed my name.

EMIL GATHMANN.