

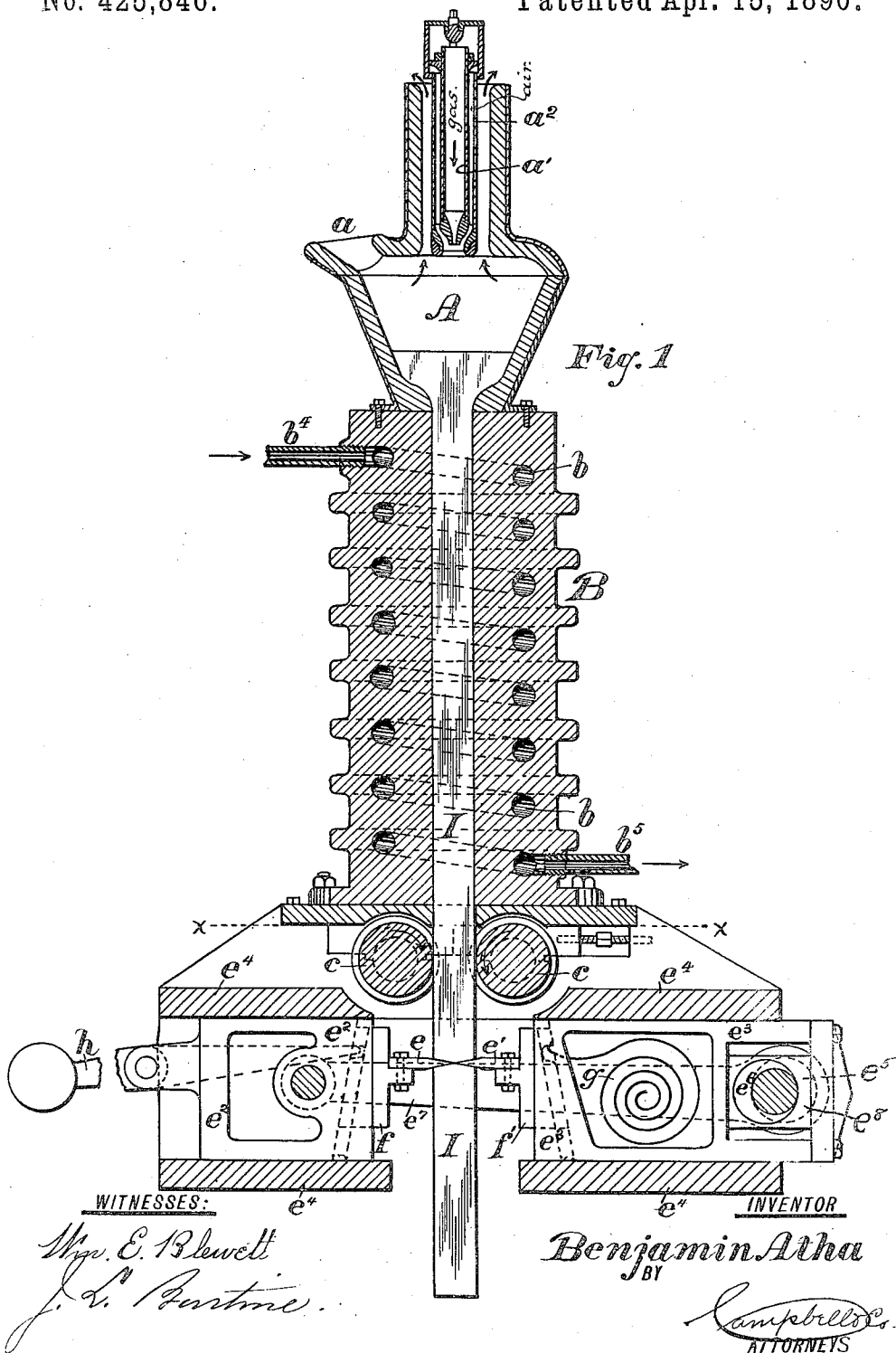
(No Model.)

3 Sheets—Sheet 1.

B. ATHA.
CASTING INGOTS.

No. 425,846.

Patented Apr. 15, 1890.



(No Model.)

3 Sheets—Sheet 3.

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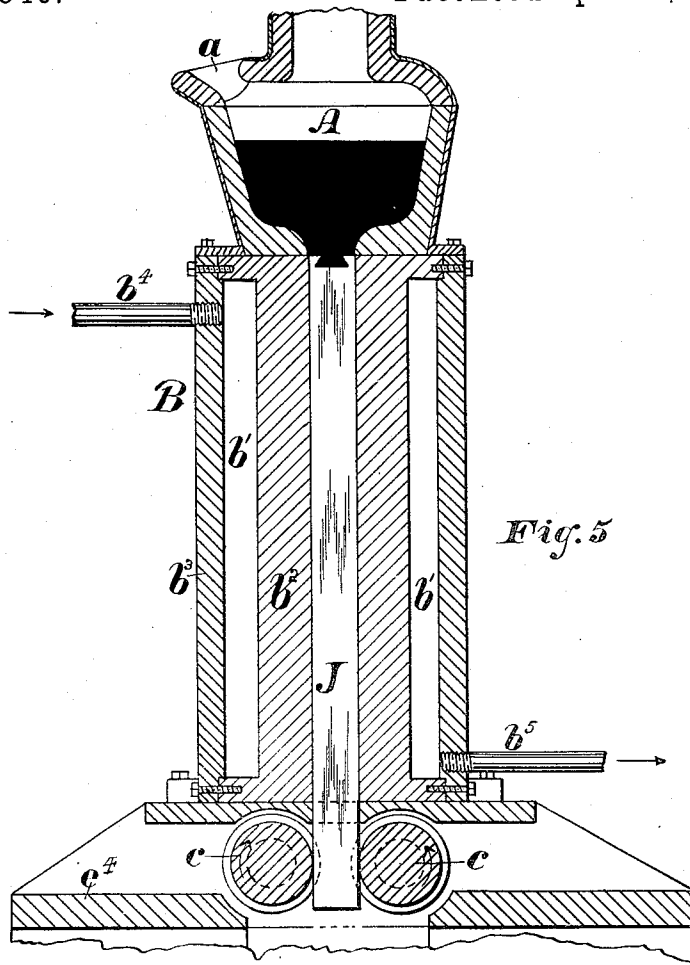


Fig. 5

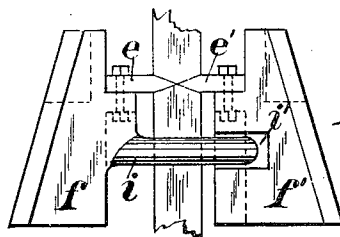


Fig. 6

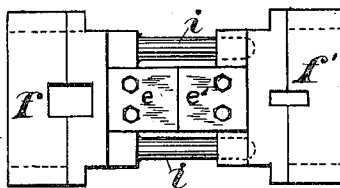


Fig. 7

WITNESSES:

Wm. E. Bluwett
J. L. Amstrong

INVENTOR

Benjamin Atha
BY

Lampbell & Co.
ATTORNEYS

UNITED STATES PATENT OFFICE.

BENJAMIN ATHA, OF NEWARK, NEW JERSEY.

CASTING INGOTS.

SPECIFICATION forming part of Letters Patent No. 425,846, dated April 15, 1890.

Application filed August 23, 1886. Serial No. 211,582. (No model.)

To all whom it may concern:

Be it known that I, BENJAMIN ATHA, a citizen of the United States, residing at Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Casting Ingots; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to letters of reference marked thereon, which form a part of this specification.

In casting steel according to the methods heretofore commonly employed a mold of a given size and capacity has been used, into which one or more ladles of metal have been poured, depending upon the capacity of the matrix, and the filled mold has been permitted to stand until the metal has "set," when the mold was removed from the chilled mass of metal.

The product of a single filling of the mold is known as an "ingot," and varies in cross-section according to the diameter of the matrix and in length within certain defined limits from three to five feet, according to whether the ingot is composed of steel treated by the Bessemer, crucible, or open-hearth processes. It is obvious, therefore, that what has been commercially known as an "ingot" is a mass of metal conforming to and limited by the size and shape of the matrix in the mold in which the cast is made.

In casting steel in my improved apparatus and by my improved processes the metal is so treated that the product of the cast is not limited to the capacity—i. e., the length—of the matrix in the mold, exceeding the same many times, according to the quantity of metal poured.

To conform to the recognized phraseology and avoid confusion of terms, the completed product of a casting by my improved process is designated as an "ingot," without regard to its length, whether it is the result of a series of pourings forming an elongated homogeneous mass of metal containing all of the metal cast or whether the said product is obtained by dividing said elongated mass of metal into sections of the same or different lengths, as is more particularly described hereinafter.

The elongated continuous mass of cast metal during the formation thereof, and before it is completed or divided, is designated as the "ingot-bar." The invention is therefore designed to form an ingot-bar of steel of indefinite and unlimited length varying in cross-section according to the cross-section of the matrix in the mold, the length of the ingot-bar being restricted only by the supply of molten metal and not by the length of the mold. From said continuous ingot-bar may be cut sections of any desired length, according to the purpose to which the metal is to be applied, or the ingot-bar may be extended in a continuous unbroken ingot integral and unseamed throughout its whole extent.

One of the most important advantages attained by my improved operation is the effectual prevention of the formation of the "piping" in the top of the ingot. When ingots are cast singly in the ordinary mold and the metal allowed to chill in the mold, the molten metal, when poured, being of sufficient quantity to completely fill the mold, by the contraction which necessarily follows, the cooling of the metal occupies much less space. This contraction is not uniform in all directions and in all parts of the cooling ingot, but takes place first in the ingot at the point of contact of the metal with the inclosing mold, and results in the formation, primarily, of a surrounding film of chilled metal inclosing the still molten interior of the ingot. This inclosing film is formed immediately upon the contact of the molten metal with the mold and extends from the bottom of the mold up to the top thereof. Consequently there is no opportunity afforded for any further contraction of the inclosing sides of the ingot that is appreciable, and what contraction occurs must take place in the interior of the ingot. The result of this contraction and of the gravitation and settling of the cooling metal is the formation of a funnel-shaped opening in the top of the ingot constituting the "pipe," which oftentimes extends into the ingot one-third of its length and renders such proportion of the ingot useless. The obviation of this formation has been desired by all steel-makers and is essential to produce a perfect ingot.

In making a continuous ingot-bar by my improved process no opportunity is afforded

for the formation of the pipe, as the supply of metal is maintained and the space made by the contraction of the cooling metal is constantly being filled by the inflowing metal, resulting in a solid homogeneous ingot-bar, which may be subdivided as desired.

The mechanism illustrated in the drawings is adapted to carry out my invention, and is described specifically hereinafter.

In the accompanying three sheets of drawings, in which similar letters of reference indicate like parts, Figure 1 is a vertical section of one form of the improved mechanism. Fig. 2 is a top view of the mold, the reservoir being removed. Fig. 3 is a section through line *x*; Fig. 1; Fig. 4, a side elevation of the intermittent feed-gearing. Fig. 5 is a vertical section of the mold, illustrating the initial step in the process. Fig. 6 is a side elevation of the sliding blocks, and Fig. 7 is a top view of the same.

As above stated, the primary object of the invention is to form an ingot or ingot-bar of indefinite or unlimited length, which may be done by either continual or successive additions of molten metal at the top, while the ingot-bar, as it is formed by the cooling of the metal, is drawn from beneath and either cut into short sections or ingots of the usual or any desired length or is drawn through the mold as an extended bar of considerable length. To effect this result it is necessary that no obstacle shall interfere with the downward passage of the newly-formed ingot-bar after it leaves the mold, particularly in making bars of extended length, the length of the bar being limited only by the supply of metal at the top, and as such supply may be kept up for an indefinite length of time, so the length of the ingot may be practically unlimited. This indefinite formation and extension of the ingot-bar is accomplished by maintaining the supply and melting temperature of the steel in a suitable vessel or reservoir and conducting the molten metal into a mold, which is preferably constructed so as to artificially cool the said metal, from which it is drawn by suitable mechanism when sufficiently set or solidified, and is cut or divided into sections or lengths of the desired length, the flow of the metal from the reservoir into the mold being simultaneous with the withdrawal of the solidified bar from the mold.

While the employment of a heated reservoir is considered preferable, as thereby a constant supply of metal is secured, which flows into the mold as fast as is permitted by drawing down the growing ingot-bar, still I may pour directly into the mold itself upon the fluid metal therein should it be considered desirable. The mechanism shown in the drawings for effecting this result consists of a reservoir A, opening into the interior of the mold B, around which a stream of water is caused to circulate to facilitate the hardening of the metal.

To provide a water-jacket around or in the

mold, various constructions may be followed. In Fig. 1 the water-channel *b* is cored out in the solid mold, as shown. In Fig. 5 a water-space *b'* is provided between the inner part of the mold *b²* and the outer casing *b³*, or in said water-space a coil of pipe may be arranged, as will be understood. The water enters the channel or space at *b⁴* and flows out at *b⁵*.

The reservoir is provided with a pouring-duct *a*, through which the molten metal is poured or flows into the reservoir, and is intended to be heated or is provided with heating mechanism to maintain the fluidity or molten state of the metal.

The device for heating the metal shown in the drawings consists of an inner tube *a'*, through which hydrogen or other gas is admitted into the reservoir, and an outer tube *a²*, through which atmospheric air flows, and mixing with the hydrogen ignites at the mouth of said tubes and produces a flame of intense heat, which comes directly in contact with the mass of molten metal and keeps it constantly in a fluid condition. The gas and air are conducted to said tubes by suitable pipes, as will be understood.

In lieu of this method of heating the metal, I may surround the reservoir with a coke or other furnace, and by thus heating the reservoir keep the metal at the proper temperature, or by any known or suitable device produce the desired result, it being my intention not to limit the carrying out of this feature of the invention to the specific apparatus shown.

Beneath the lower end of the mold is arranged the mechanism for drawing the bar of metal after it has been set sufficiently downward from the mold and delivering it to the dividing or severing mechanism, which is preferably arranged beneath the drawing mechanism. In order that sufficient length of time may be allowed to sever the bar without causing any binding or interference of the parts, the said bar is preferably fed to the severing mechanism intermittently, as will be understood. Said feeding mechanism, as shown in the drawings, consists of the rolls *c*, arranged on opposite sides of the ingot-bar *I*, which grip said bar, and when operated, moving in the direction indicated by the arrows, draw the bar downward as far as may be desired to form the ingot, the extent of movement of the rolls determining the length of the ingot or portion separated from the continuous bar. The intermittent action of said rolls is so timed as to allow sufficient time for the metal in the mold to set before the drawing movement of the rolls begins, and also to permit the severing of the ingot from the bar.

In Fig. 4 is illustrated one form of mechanism adapted to produce an intermittent movement of said rolls, consisting of spur gear-wheels *c²*, keyed on the rolls, and a spur gear-wheel *c³*, having a blank *c⁴* on the periphery

thereof, the relative length of the toothed and blank portions of said gear-wheel, which may be varied, determining the time of movement and rest of the continuous bar. It will be understood that this mechanism for producing the intermittent movement is but one of many devices adapted to produce the desired operation.

As above stated, the severing or dividing mechanism is preferably arranged beneath the drawing mechanism, and, as shown in the figures of the drawings, consists of oppositely and reciprocally moving cutters $e e'$, which are removably secured to reciprocally-moving heads $e^2 e^3$, sliding between ways e^4 and operated by the oppositely-arranged eccentrics $e^5 e^6$, arranged on a shaft. A rod e^7 communicates the movement of the eccentric e^5 to the head e^2 , the eccentric e^6 turning in a bearing e^8 in the head e^3 , as shown in Fig. 1. The movement of the eccentrics is so timed in relation to the intermittent feed that when the feed has stopped and the continuous ingot-bar I is at rest, then the cutters move forward, sever the bar at the desired point, and return to their normal position. Should the movement of the bar not cease at the proper time when the cutters enter the same, the said cutters may be bolted to sliding blocks $f f'$, which are supported by a weighted lever h or spring g , and if the movement of the said bar continues after the cutters have begun to work the sliding blocks and said cutters move downward with the bar, and thus prevent the breaking of the cutters or the stoppage of the operation. This sliding or yielding action of the cutters is particularly advantageous when the continuous bar I is fed to said cutters continuously instead of intermittently, as previously described, the device shown in Fig. 1 being adapted to be used with either an intermittent or continuous feed.

In lieu of the cross-heads and eccentrics, hydraulic cylinders may be employed, the cutters being secured to the ends of the pistons thereof.

Instead of two cutters, a single cutter and an abutment may be used, the cutter being operated by either of the above-described devices or by any suitable mechanism.

To keep the cutters in a line, a bar i , projecting from one of the sliding blocks f and engaging with a groove i' in the other block f' , as shown in Fig. 6, may be used, or the said cutters may be bolted directly to the cross-heads $e^2 e^3$ to accomplish the same result.

I may employ a saw instead of the cutters to sever or divide the bar, but consider the cutters preferable, the several ways referred to, however, indicating a few of many devices that may be used to divide the bar into sections or ingots.

On Sheet 3; Fig. 5, is illustrated the first step, which is used in casting the metal, which is as follows: A dummy ingot or bar J , the upper end of which is preferably dovetailed,

as shown, is arranged within the mold, the upper dovetailed end extending up to and constituting the bottom of the metal reservoir A , and the lower end of the said dummy ingot extending down between the rolls $c c$.

In the process of casting the molten metal is poured into the reservoir, and as the rolls revolve the dummy ingot is drawn through the mold, the molten metal following the same and filling the mold. During the downward passage of the dummy ingot there may be one or more cessations of its movement, during which period of rest the molten metal has time to crystallize and set, so that when the dummy ingot passes out of the mold down between the cutters and is cut off the metal has formed a continuous bar within the mold of sufficient solidity to be drawn down by the rolls $c c$ and fed to the cutters, as hereinbefore described, and shown in Fig. 1. The dummy ingot acts as a stopper or block to prevent the escape of the molten metal through the bottom of the mold during the first step in the process—i. e., the first pouring—and as soon as the said stopper is drawn from the bottom of the mold or matrix and the rolls have seized the end of the continuous steel ingot-bar the said stopper is of no further service to continue the process and is entirely removed or severed from the end of the newly-formed ingot-bar. It is not considered essential that the stopper should extend through the entire length of the matrix, as shown in Fig. 5, as it may stop at any point therein above the open lower end of the matrix, so that the metal does not run through the bottom of the matrix during the first pouring; but the said stopper should be so placed as to be seized by the drawing mechanism to enable the same to draw the said stopper and the superincumbent ingot-bar down through the mold. As the capacity of the reservoir is several times that of the mold and may be enlarged or reduced as desirable, a constant supply of metal is provided, which flows into the mold as the solidified bar is drawn down from below and cut off. Thus it will be seen that by this apparatus and process a continuous supply of molten metal is provided, which is constantly being turned into a solidified bar in the water-jacketed mold and the solid bar cut off in suitable length as it escapes or is drawn from the lower end of the mold. The opening or duct from the metal reservoir need not necessarily be immediately over the top of the mold, as the said top may be closed and the metal conducted into the interior of the mold through the side thereof by a suitable duct.

The matrix in the mold may vary in cross-section according to the use to which the product is to be applied, the drawings showing the form commonly used; but the matrix has a straight axial or center line whether the cross-section is circular or polygonal in form, and its sides are parallel or approximately parallel

diverging slightly at the bottom to readily permit the downward movement of the ingot-bar.

In my improved apparatus there is nothing 5 beneath the mold to interfere with the indefinite projection or extension of the ingot-bar, as the clamps or rollers *c* grasp or seize the sides of the ingot-bar, the space made in the mold by the drawing down of the ingot-bar 10 being filled with metal either by continuous or successive additions, so that as fast as the bar is drawn down it grows in length by the accretion of metal at the top.

The employment of an upright mold permits the utilization of the gravity of the metal 15 in retaining the fluid metal in the mold, whereas any other than a vertical position or approximately vertical position of the mold would necessitate the use of a plunger or piston to force the metal into and from the matrix, which, from the nature of steel and the care requisite in handling it, would be extremely impracticable, although it might be 20 attended with considerable success with tin or some of the metals having a low fusing-point.

The upright open-top mold permits the unlimited addition of molten metal to the top of the descending ingot-bar, and may be continued indefinitely, being limited only by the 30 supply of metal and not by the mechanism.

To allow the fluid metal to become sufficiently set or solidified to be handled, it must remain within the mold a certain length of 35 time, or else, while the lower end of the ingot-bar is in the proper condition to be drawn from the mold, the overlying metal is in a fluid state and would run out from the mold when the solidified lower end had been drawn from the 40 mold.

In forming the ingot-bar by a continuous and gradual lowering of the bar the metal is preferably poured into the bottom of the mold upon the stopper and chills from below upward. 45 as the pouring continues. This tendency of the metal to run out may be obviated by pouring, as above stated, and drawing the metal gradually and continuously down through a mold of extended length, so that the fluid metal is chilled by the time it 50 reaches the lower open end of the mold.

In lieu of a mold of great length, a mold of the usual length may be used, and instead of drawing the metal down or allowing it to descend gradually and continuously the ingot-bar 55 is held stationary within the mold for a given length of time, then drawn down a short distance, then permitted to stand again, and so on until the process of casting is completed. 60 By this intermittent action (moving downward and stopping alternately and repeatedly and by accretions of metal on the top) the formation of the ingot-bar may be continued indefinitely.

65 One advantage of the short mold and the intermittent process is that the mechanism may be made much smaller and more com-

pact and not require the room necessary for the extended mold; but whether the long or short mold is employed, and irrespective of 70 the manner of pouring the metal, the process of the formation or growth of the ingot-bar is the same—viz., by drawing the same downward through the bottom of the mold and adding molten metal to the top thereof. 75

The method most common in casting ingots, as has hereinbefore been mentioned, is to pour the molten metal into the mold, filling the same from the bottom upward, the metal remaining stationary in relation to the 80 mold until set, when the mold is lifted from the ingot or the ingot from the mold. This method has been worked practically, but is found to necessitate the utmost care in pouring the metal into the mold, it being absolutely essential in order to form a perfect ingot that the inflowing stream of metal shall strike the center of the bottom of the mold, spreading out toward the sides thereof and the sides of the mold, and also strike the center 90 of the gradually-rising surface of the fluid metal until the mold is full. Any contact of the molten metal with the sides of the mold will score and groove the same, rendering the mold unfit for use in subsequent 95 castings and also injuring the surface of the ingot in process of formation, which must conform to the shape and surface of the matrix. Thus it will be apparent that any incompetency on the part of the workman resulting from want of skill or care or any accident will render useless the mold and many tons of castings. This has been obviated by employing a movable bottom or plunger moving down through the mold from the top to the 105 lower end thereof and by starting the pouring when the bottom or plunger is at the top of the mold, and, drawing the same down as the pouring continues, the surface of the metal is maintained on a level with the top of the mold, and the sides thereof are thereby protected from the impingement of the stream. This operation is very effective in preventing the scoring of the sides of the mold, as they are not exposed to the stream, being always covered 115 with metal; but, owing to the peculiar action and distribution of the metal in cooling in this process, it is quite essential that the plunger be drawn down in such a manner as to most effectively meet the necessary conditions of the cooling metal. The action of the 120 metal in cooling to form the ingot by this process during a continuous and gradual lowering of the plunger or stopper, which is the manner heretofore used in lowering the plunger, is as follows: Immediately upon the 125 contact of the molten metal with the top of the plunger a thin film or layer of cooled or set metal is formed, and upon the commencement of the continuous downward movement of the plunger the metal flows out against the sides of the mold, also forming a layer of cooled metal upon the contact thereof with said sides, the inclosed interior being still in a fluid 130

state. As the plunger continues its downward movement, the inclosing-shell of cool metal adheres to the sides of the mold at the top and the molten metal flows down through the same and spreads out against the sides of the mold below the metal already set and forms a thin film of cooled metal, and so on during the entire downward continuous movement of the plunger, the ingot cooling around the edges thereof and forming a solidified inclosing-shell in contact with the sides of the mold, which grows from the top downward, the interior of the ingot being kept in a fluid state, as it is only therethrough that the inflowing metal can fill up the space made by the lowering of the plunger. Hence it will be seen that at some point during the entire downward movement of the plunger, just above the top of the plunger or above the top of the layer of cooled metal, which adheres to the top of the plunger and is drawn down with it, there must be a place extending entirely around the four sides of the matrix where the molten interior of the ingot has last come in contact with the sides of the mold, and which is relatively to the top of the plunger about the same distance therefrom—that is to say, owing to the plunger moving continuously and unintermittently downward, the solidification and attachment of the metal upon the top of the plunger are retarded, the quantity on the top of the plunger increasing but very little during the downward movement thereof and after the first impact of the metal upon the plunger. So long as this point of contact of the outwardly-spreading metal is within the mold the formation of the bar goes on; but when the top of the plunger reaches the bottom of the mold and passes therethrough the outwardly-spreading metal from the interior, not being confined by the sides of the mold, runs out between the top of the said plunger and the bottom of the mold, and the entire molten mass of metal in the interior of the ingot escapes through the opening thus made, leaving a shell of cooled metal adhering to the sides of the matrix and a small quantity of metal adhering to the top of the plunger. This must inevitably occur whenever the plunger starts from the top of the mold and is caused to move continuously and gradually down through the mold, because no opportunity is afforded for the metal to anchor itself firmly to the top of the plunger, and the formation of the ingot is not from below upward, but from above downward. Consequently there is not the slightest downward movement of the cooled metal, but downward accretions of metal only. To avoid the possibility of this occurring, and also to secure the advantages resulting from starting the plunger from the top of the mold—viz., prevention of the scoring of the mold—instead of causing the plunger to move continuously and gradually down through the mold, the said plunger is caused to move intermittently downward, dropping

a given distance, then stopping a sufficient length of time, then dropping still farther and stopping, and continuing in this manner indefinitely, each period of rest permitting the metal to chill and solidify sufficiently to anchor itself to the plunger and the substratum of metal, so that the metal is drawn down with the plunger instead of adhering to the sides of the mold. In this manner by the time any portion of the bar reaches the bottom of the mold it is in the proper condition to be drawn therefrom and to be subdivided, if desirable. The growth of the bar from below upward may be attained by arranging the plunger at the bottom of the mold, pouring in a sufficient quantity of metal upon the top thereof, and allowing the same to stand until chilled, and then draw down the plunger and the superincumbent metal continuously instead of intermittently, the metal being added to the top of the downward-moving bar being poured so as to chill and adhere thereto. The intermittent method is, however, considered to possess some advantage over the continuous operation, particularly when the ingot-bar is to be subdivided, as the periods of rest may be utilized in separating the same into the required lengths, thereby simplifying the severing mechanism in addition to those advantages already mentioned.

The processes herein set forth of casting and forming ingots of steel will form the subject of a separate application, and are described herein to more fully explain the effect produced in the various operations of the mechanism which is illustrated to carry out the invention.

Having thus described my invention, I desire to claim the following:

1. The combination, with an open-bottom ingot-mold, of a clamp or grasping device constructed and arranged to grasp the sides of an ingot below the bottom of the mold and mechanism for causing said grasping device to draw the ingot downward, for the purpose set forth.

2. The combination, with a vertically-arranged ingot-mold for casting steel, provided with an elongated matrix having a straight axial or center line and sides which are non-contracting toward the lower end and extending through the bottom of said mold, and mechanism other than the mold itself constructed and operating to draw the steel ingot-bar from the matrix through the bottom of the mold, of mechanism for dividing or separating the ingot-bar into ingots or sections of the desired length, for the purpose set forth.

3. In a machine for forming ingots from a continuous steel ingot-bar, the combination of a vertically-arranged ingot-mold provided with an elongated matrix having a straight axial or center line and sides which are non-contracting toward the lower end and extending entirely through said mold, a metal-reser-

- voir opening into said matrix at the top thereof, means for maintaining the fluidity of the metal in said reservoir, mechanism other than the mold itself constructed and operating to draw the continuous steel ingot-bar through the bottom of the matrix, and mechanism for dividing or separating the continuous steel ingot-bar into ingots or sections of the desired length, for the purpose set forth.
4. The combination, with an ingot-mold, of mechanism other than the mold itself constructed and operating to draw the ingot intermittently from said mold, for the purpose specified.
5. The combination, with an ingot-mold, of means constructed and arranged to draw the ingot intermittently from the mold and means for separating a portion of the ingot from the ingot, for the purpose set forth.
6. In a machine for forming ingots from a continuous steel ingot-bar, the combination of a vertically-arranged ingot-mold provided with an elongated matrix having a straight axial or center line and sides which are non-contracting toward the lower end and extending through the bottom thereof, drawing-rolls arranged beneath and adjacent to the lower open end of said matrix and constructed to operate to draw the continuous ingot-bar intermittently from said lower end of said matrix, and means for producing said intermittent movement of the drawing-rolls, for the purpose set forth.
7. In a machine for forming ingots from a continuous steel ingot-bar, the combination of a vertically-arranged ingot-mold provided with an elongated matrix having a straight axial or center line and sides which are non-contracting toward the lower end and extending through the bottom thereof, a removable stopper or dummy ingot arranged in said matrix and projecting through the bottom thereof, and means constructed and arranged to seize the projecting end of said stopper and to draw the same and the superincumbent ingot-bar down through the bottom of said matrix and to continue to seize and draw down the said superincumbent ingot-bar after the withdrawal and removal of said stopper, for the purpose set forth.
8. In a machine for forming ingots from a continuous steel ingot-bar, the combination of a vertically-arranged ingot-mold provided with an elongated matrix having a straight axial or center line and sides which are non-contracting toward the lower end and extending through the bottom thereof, drawing-rolls arranged beneath and adjacent to the lower open end of said matrix and operating intermittently to draw the continuous ingot-bar from said end of the matrix, means for producing said intermittent movement of the drawing-rolls, reciprocally-moving cutters arranged beneath and adjacent to said rolls, and means for producing the reciprocating motion of said cutters during the period of rest of said rolls, substantially as and for the purpose set forth.
- In testimony that I claim the invention set forth above I have hereunto set my hand this 20th day of August, 1886.
- BENJAMIN ATHA.
- Witnesses:
 FREDK. F. CAMPBELL,
 FREDK. C. FRAENTZEL.