No. 648,091. Patented Apr. 24, 1900.

J. O. E. TROTZ.

APPARATUS FOR CASTING INGOTS IN CONTINUOUS LONG LENGTHS.

(Application filed Dec. 17, 1898.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 1.

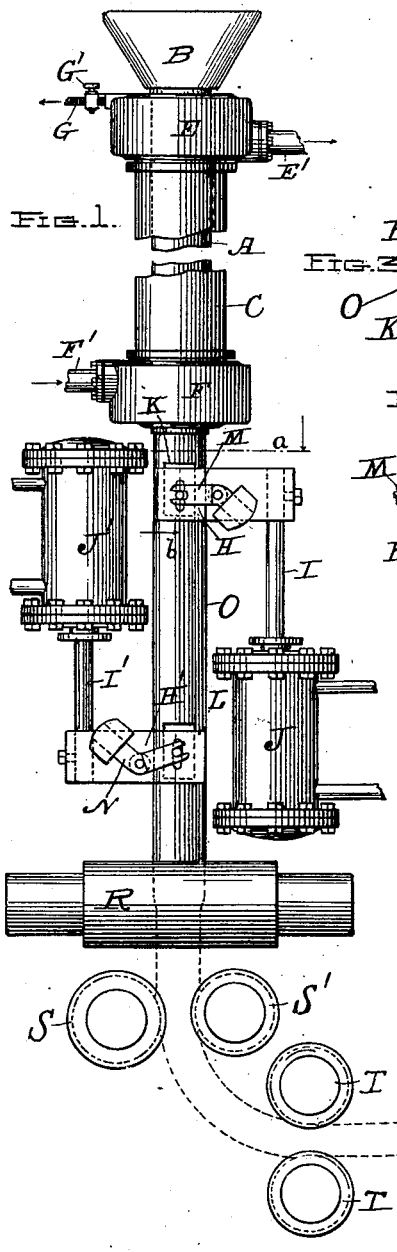

Fig. 3.

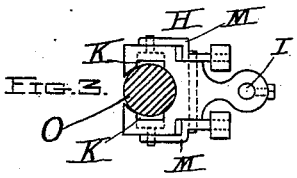

Fig. 4.

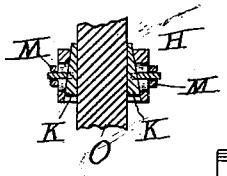

Fig. 5.

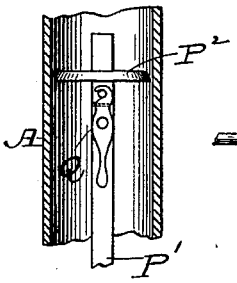

Fig. 2.

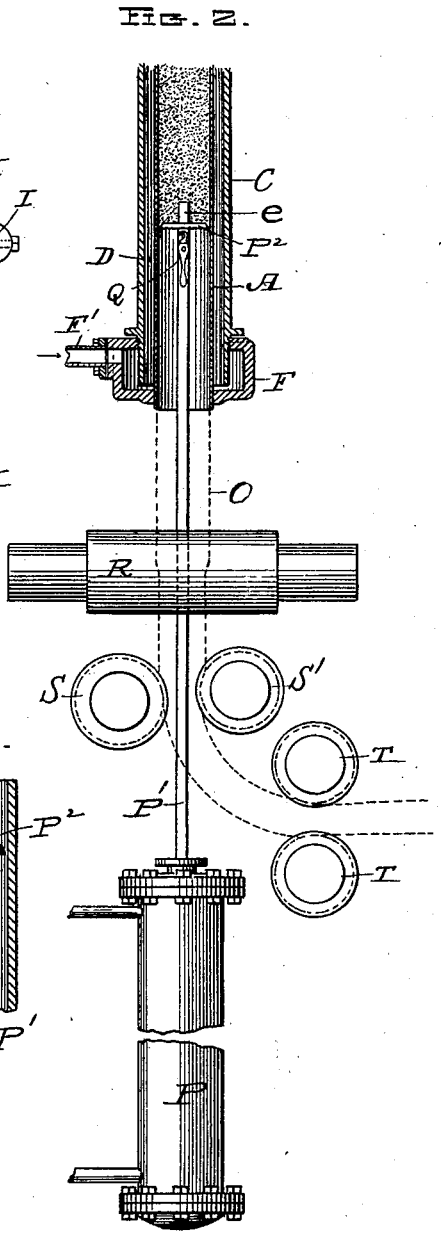

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Fig. 6.

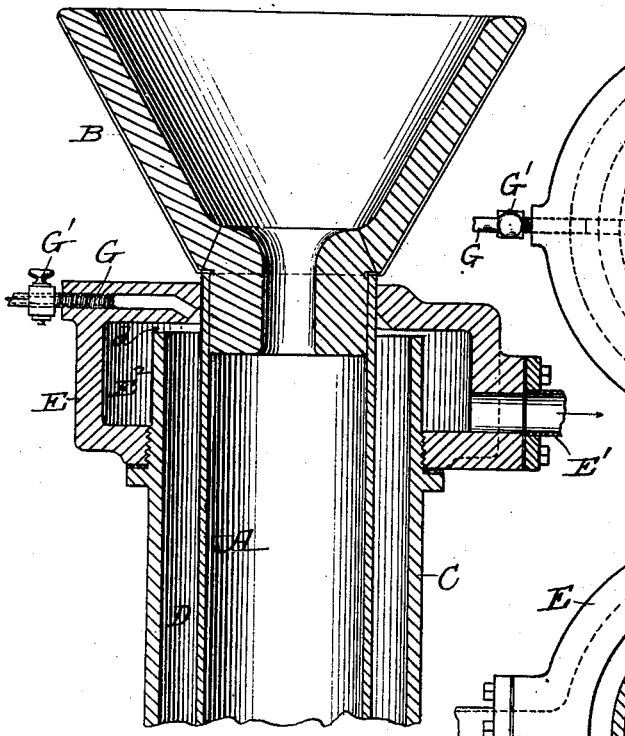


Fig. 7.

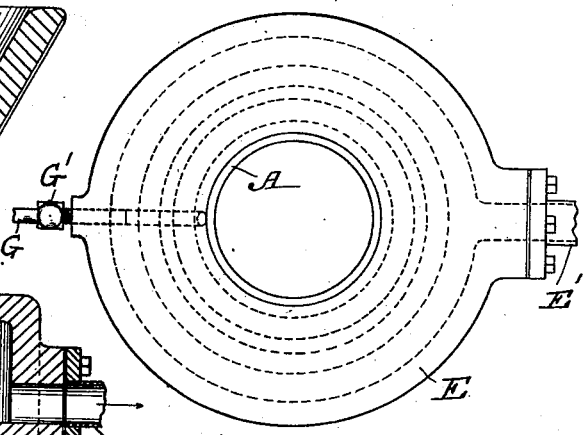
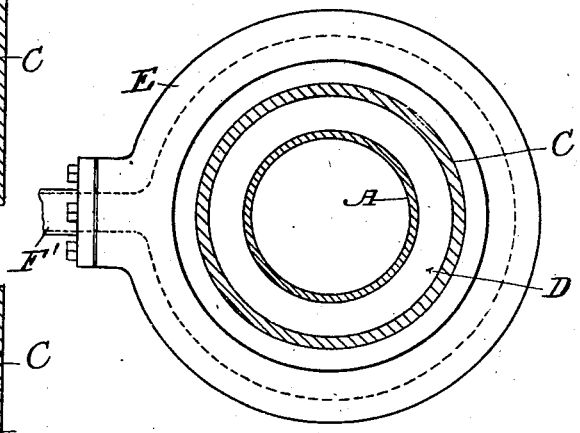


Fig. 8.



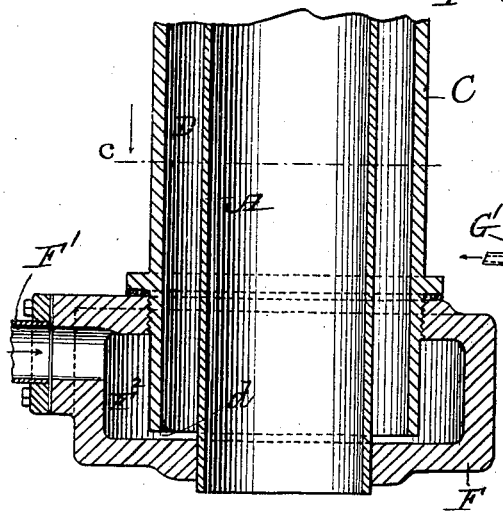
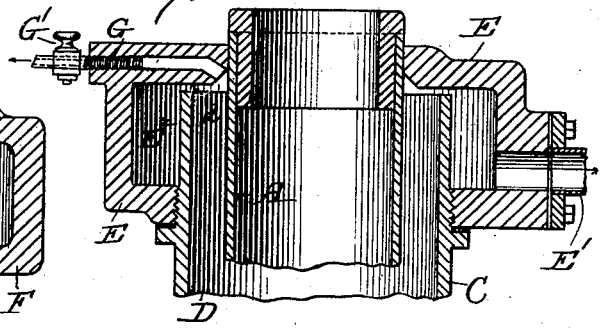


Fig. 9.



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UNITED STATES PATENT OFFICE.

JOHAN OTTO EMANUEL TROTZ, OF WORCESTER, MASSACHUSETTS.

APPARATUS FOR CASTING INGOTS IN CONTINUOUS LONG LENGTHS.

SPECIFICATION forming part of Letters Patent No. 648,091, dated April 24, 1900.

Application filed December 17, 1898. Serial No. 699,525. (No model.)

To all whom it may concern:

Be it known that I, JOHAN OTTO EMANUEL TROTZ, of the city and county of Worcester, in the State of Massachusetts, have invented certain new and useful Improvements in Apparatus for Casting Ingots in Continuous Long Lengths; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, forming a part of this specification, and in which—

Figure 1 represents a side view of so much of an apparatus for casting said ingots as is necessary to illustrate my improvements, the central part of the mold and casing or jacket thereof being shown broken away and several pairs of reducing-rolls also being shown in connection therewith, as will be hereinafter described. Fig. 2 represents part of the apparatus shown in Fig. 1, showing a modification in the means employed for drawing forward the ingot as it is continuously formed and delivered from the mold, the lower end of said mold and its casing or jacket being shown in section longitudinally. Fig. 3 is a transverse section on line *a*, Fig. 1, through the cast ingot after it leaves the mold, looking down, and showing a plan of one of the grip devices hereinafter described for drawing forward said ingot, as aforesaid. Fig. 4 is a longitudinal section through part of the ingot and a transverse section through said grip device, taken on line *b*, Fig. 1. Fig. 5 shows an enlarged view of part of the mold and upper end of the device for supporting the forward end of the ingot until it cools and hardens and for drawing said ingot from the mold, as aforesaid. Fig. 6 represents, upon a still larger scale, a central longitudinal section through the ingot-mold, its longitudinal casing or jacket, the end, water-chambers, and the top tunnel into which the molten metal is poured prior to entering the mold, the central part of said mold and casing or jacket being broken away to admit of the end parts being shown upon a large scale. All the following figures are shown upon the same enlarged scale as Fig. 6. Fig. 7 is a top end view of the parts shown in Fig. 1 with the top tunnel removed. Fig. 8 is a transverse section taken at the point indicated by line *c* in Fig. 6, looking down, as shown by the arrow; and Fig. 9 shows a modification in the construction of the upper part of that portion of the apparatus shown in Fig. 6, which will be hereinafter described.

The object of my invention is to provide an apparatus whereby ingots may be cast in continuous long lengths and drawn forward as fast as delivered in a partially-hardened state from the mold and then rolled down to smaller sizes direct from the mold or cut into desired lengths before rolling, all by a continuous and automatic operation.

The main or essential feature of the invention relates to the part of the apparatus for casting the ingots; and it consists of a thin metal mold having its inner face polished perfectly smooth, an outer casing or jacket of larger diameter than the mold arranged over and forming an annular chamber around said mold, a hollow head at each end of the mold of larger diameter than the outer casing or jacket and attached to said outer casing or jacket to form annular chambers outside of the ends of the casing or jacket and also to form an annular opening at each end of the mold for connecting said annular chambers in the hollow heads with the annular chamber between the mold and outer casing or jacket, and suitable inlet and discharge pipes connected with the aforesaid hollow heads for supplying cold water thereto and discharging the same into the chamber surrounding the mold, entirely around said mold, at an even temperature.

Said invention also consists of suitable mechanism, combined with the above casting part of the apparatus, whereby the metal may be drawn forward continuously in long lengths as fast as it is sufficiently cooled, as will be hereinafter more fully set forth.

It is a well-known fact that ingots made in the common way are seldom, if ever, perfect. The surface is generally rough and frequently crackly. The inside or parts thereof are always to a certain extent unsound on account of the presence of what is commonly termed a "pipe" or "blow-holes," or both, depending on the nature or composition of the metal and the temperature at which it is poured. The formation of the pipe is due to the contraction of the metal in connection with the top metal in the mold solidifying earlier than the inner part of the ingot below and may extend almost through the whole length of the ingot, according to the shape of the mold, and when found is always largest in

the upper end of the ingot. The cracks are caused by either the unevenness of the inside of the mold on account of parts of the ingot sticking and adhering to the surface during a certain part of the contraction period, or by the ingot adhering to the bottom of the mold and also to the sides or the top, where it occasionally splashes or boils over or up from under the cover which is sometimes put on to stay the boiling. In both cases this causes it to adhere and prevents a free contraction when the surface is cooling. These cracks will frequently when the ingot is worked cause surface defects on the finished material. Like the pipe, the cracks or blow-holes are always found in the largest number in the top of the ingot. The blow-holes are, as is well known, due to the gases which molten metal absorbs and in the moment of or just before solidification discharges. The reason for their being found in larger numbers in the top of the ingot is undoubtedly due partly to the higher pressure to which the lower part is subjected when the metal solidifies and partly to the upper layers or the larger part thereof being in full fusion when said lower part solidifies, thus permitting the gases discharged by the latter to pass up and escape through the former. Both the pipe and blow-holes necessitate what is termed "cropping" or cutting away a large percentage of the upper part of the ingot before or after being worked down or used, thus causing a large loss and expense, as do also the presence of surface cracks, all of which disadvantages are well known to those skilled in the art to which my invention appertains. To overcome or at least reduce said defects to a minimum is the purpose of my improved apparatus, which will now be described, with reference to the accompanying drawings.

In said drawings, A represents a thin metal tube which in practice is made as thin as is practicable for holding the molten metal until sufficiently cooled to sustain itself and be drawn therefrom. Said thin tube is preferably cylindrical in shape and serves as the mold of the apparatus. The inside thereof is planed and polished or otherwise mechanically worked to a perfectly straight, smooth, and even surface without any bunches, depressions, or other unevenness whatever. The upper end of said tube or mold is preferably provided with a close-fitting head or tunnel B, made of metal lined with graphite or other refractory material or made wholly of said graphite or refractory material, as desired, and which may be of any desired shape—as, for instance, in the form of the flaring tunnel shown in Figs. 1 and 6 or straight, as shown in Fig. 9.

Outside of the aforesaid cylindrical tube A is arranged a larger cylindrical casing or jacket C, thereby forming an annular chamber D around said inner tube. The ends of said outer case or jacket C are provided with hollow cast heads E F, each in turn having a pipe E′ and F′ connected therewith for effecting a circulation of water or other cooling medium around the annular chambers E^2 and F^2 of said heads and around the tube or mold A, as aforesaid. Water is preferably used as the cooling medium and is also preferably introduced through the bottom pipe F′ into the bottom chamber F^2, thence around the lower end of the outer case or jacket C, up through the same, around the mold A, and out through the top chamber E^2 and pipe E′, a constant even circulation of cold water being maintained while the apparatus is in use, which, if desired, may in practice be artificially cooled below the usual or normal temperature of the city supply in any suitable manner in order to expedite and more effectually cool the molten metal as it is poured and drawn from the mold, as hereinafter described.

It is very essential to have the inside tube or mold A as thin as possible in order to keep it well cooled off, and thus not allow it to become heated to such an extent as to cause it to lose its shape, and also in order that it may permit the molten metal to be cooled off as quickly as possible. It is also essential that the water or other cooling medium shall be distributed evenly around the mold, so that it will cool the metal inside of the mold exactly alike all around, or it is liable to bend out of shape, and thus impair the parts and retard the forward movement of the ingot. Although only two points of supply and discharge of the cooling medium are shown in the drawings, I do not limit myself thereto, as several others at different points might be used, if desired.

The upper head E is provided with a vent-opening and pipe G, provided with a shut-off cock G′ for the purpose also hereinafter described. The heads E F are fitted over the outer case or jacket C to bring the ends of said case or jacket within a short distance *d* of the inside of the outer ends of said heads, and the supply and discharge pipes F′ E′ are connected with their respective heads near the inner ends thereof. Therefore when the water is discharged from the supply-pipe into the chamber of the head it first impinges against the side surface of the end of said outer case or jacket C and flows around the same prior to passing over its end into the chamber D, between it and the inner tube or mold A, thus insuring a constant and even flow of water around all sides of said mold to cool it in a correspondingly even and uniform manner. This feature of employing the hollow heads E F and forming the annular openings or spaces *d* between the ends of the thin tube A and the inside of the outer ends of said hollow heads E F is very important for the reason that by first discharging the water into what may be termed the "primary" chambers E^2 F^2, so that it may flow around the ends of the outer casing before entering the annular chamber surrounding the mold, said

water is permitted to flow in evenly at all points around the mold, and thereby causes the molten metal poured therein to be cooled uniformly on all sides and also prevents the tube which serves as the mold from bending out of shape from uneven heating.

In order that the metal may not adhere to the inner surface of the mold A in passing through, the inside thereof is in practice made with a perfectly straight and smooth polished surface, as aforesaid. This feature is important, as I have fully demonstrated in practice that by making the inside of the mold in connection with the method of cooling the objections hereinbefore mentioned are practically removed and ingots of any desired length produced of a uniformly-smooth surface and texture.

In first pouring the molten metal into the mold some means must of course be provided to stop it from flowing in its molten state down through and out of the bottom of the mold. This object may be attained in various ways, and I therefore do not limit myself to any special way or to the way of drawing the metal as it becomes hardened by cooling from the bottom of the mold.

In Fig. 1 I have shown the ingot as being drawn from the bottom of the mold by means of two grip devices H H′, connected with pistons I I′, operated by the hydraulic or steam cylinders J J′. Said grip devices are so constructed that by the use of loose wedges K K and L L, connected with forked weighted levers M M and N N when the pistons are operated to move the grip devices toward the mold A, the grip devices will slip along freely over the surface of the ingot O; but, on the other hand, when the return movements are made said devices grip said ingot firmly and draw it forward out of the mold with, of course, a slow and gradual movement conforming to the speed of the pouring and hardening process of said ingot, or, in other words, it is drawn forward continuously with just sufficient speed to remove it from the mold as fast as hardened by cooling sufficient to retain the transverse shape imparted thereto by the mold. In connection therewith it may be stated that the mold may be made cylindrical in shape, as shown, or of any other form that it is desired to impart to the ingots cast therefrom. In practice the grip devices are designed to be operated alternately, one moving forward gripped to and drawing the ingot, while the other is returning preparatory to the next grip and forward draft, the operation being similar to pulling upon a rope hand over hand. By this construction it is obvious that the ingot may be drawn forward continuously, as aforesaid, at such speed as may be admitted of by the casting and cooling operation.

In casting an ingot the molten metal forming the same is held in suspension in the mold until hardened sufficiently to retain its shape by means of a piece of ingot bar or tubing with a solid head extending up a short way into said mold and projecting out long enough for the gripping devices to act upon it, the upper end thereof being preferably provided with a short spur or stud, as *e* in Fig. 2, for the metal to surround and obtain a grip upon, so that when the said section of ingot or bar is drawn upon the ingot may also be pulled forward with it. After the forward end of the ingot is once hardened by cooling, as aforesaid, said ingot itself, it is obvious, will form its own support for the inflowing molten metal, being cooled by the time it reaches the bottom of the mold and is slowly drawn forward therefrom.

If preferred, instead of using gripping devices, as above described, and shown in Fig. 1, for drawing the ingot forward a single long cylinder P, piston-rod P′, and head P^2, as is shown in Fig. 2, may be used in lieu thereof, said piston-rod thus forming a movable bottom for said mold, the piston and its head being preferably in this case made separable and adapted to be attached together by means of a suitable hook device Q, as is shown in Figs. 2 and 5. In either case it will of course be understood that the pulling device is employed only in starting the ingot forward until its forward end has been inserted between the first set of rolls, as R, of a series of reducing-rolls—that is, if the ingot is to be continuously rolled down or reduced direct from the casting apparatus. If not, it must then be drawn or pulled forward until the end is connected with a reel or other means for disposing of it after having been cast. I reserve the right to cast the ingots in continuous long lengths and cut to the desired lengths to be worked at some future time or to connect the same with reducing-rolls for immediate reduction by a continuous operation, as aforesaid. In this case the rolls R are of course arranged to take up the ingots as fast as delivered and from them are passed onto other rolls S S′ in the form of what may now be called a "bloom," when, owing to one roll S being larger than the other, S′, it is bent a quarter-circle and delivered to another pair of rolls T T, through which it passes. This pair of rolls may now deliver the bloom either to a pair of shears or to a rolling-mill.

By the use of my improved apparatus I am enabled to obtain an ingot or bar of any desired length (being limited only by the supply of molten metal poured into the mold) with a smooth perfect surface without any cracks and comparatively free from blowholes. This results from the moving ingot being poured without having the jet of metal fall any considerable height and also from fresh metal being continuously fed in, thus allowing the gases which the steel emits at the moment of or just prior to solidification to escape through the upper quick-flowing metal of a higher temperature. What is commonly termed the "pipe" is also entirely done away with, except in the very last part

of the ingot, as are also the surface defects so commonly seen on ordinary ingots or blooms. Therefore the percentage of what is termed "cropping" is reduced to a minimum. These results are due mainly to the fact of the mold being made perfectly smooth upon the inside, as previously stated, in connection with the continuous process of pouring and feeding forward the ingot as fast as it is cooled.

It will be clear from the foregoing description that the expense of casting ingots or bars in this way is much less than by the common way, as less expense, aside from the saving in croppings, is incurred for the molds, also less labor, and if the ingots are rolled direct from the mold the cost of fuel is also reduced.

I do not limit myself to the use of one mold when pouring a heat, as I may prefer to have two or more nozzles in the same ladle, from which the molten metal may be poured into as many molds. I have also in some instances found it preferable to use two or more molds for each nozzle, in which case the ingot is started in each mold, as hereinbefore described; but when the supporting movable head has reached the lower end of the mold it is stopped and the ladle moved over to the next mold, which is filled in the same way. When this is filled, the ladle is moved back to the first mold, and the ingot which occupies it is slowly lowered during the time the metal is poured until the top of the first ingot reaches the bottom of the mold, when it is stopped and the ladle again moved over to the second mold, where the same process is repeated, and so on, the ladle being moved from one to the other until all the metal is poured into ingots.

If preferred, the metal may be poured direct from the furnace into the molds instead of using a separate ladle, as above described. This way is of especial advantage in making ingots or bars of copper, aluminium, brass, and similar metals.

If desired, the apparatus may be arranged upon an incline instead of vertically, as shown.

It will be understood that I make no claim, broadly, to casting ingots in long continuous lengths, this having been done before, but by pouring and cooling portions of the molten metal while held stationary and then drawing forward the cooled sections intermittently instead of by pouring, cooling, and drawing the metal forward simultaneously and continuously, as herein described. The purpose of the construction hereinbefore described, and shown in the drawings, is to attain this particular result and which result I am not aware has heretofore been accomplished.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an apparatus for casting ingots or bars in continuous long lengths from molten metal, the central mold, comprising a thin metal tube whose interior is worked and polished to a straight and uniformly-smooth surface, and having means for conducting the molten metal thereto, said tube being secured at its upper end; in combination with the outer case or jacket, of larger diameter than the central tube, arranged over said tube to form an annular chamber surrounding the tube; the hollow heads arranged at each end of said central tube and its jacket, and of larger diameter than said jacket to form annular chambers around the ends thereof, the inside of the outer ends of said hollow heads being arranged to come a short distance from the ends of the central tube to form an annular opening between the two, and suitable inlet and discharge pipes, connected with said hollow heads, substantially as and for the purpose set forth.

2. In an apparatus for casting ingots or bars in continuous long lengths from molten metal, the central mold, comprising a thin metal tube whose interior is worked and polished to a straight and uniformly-smooth surface, and having means for conducting the molten metal thereto, said tube being secured at its upper end, in combination with a movable support, fitted to slide vertically in said tube, for holding the first pouring of molten metal while cooling, and having means connected therewith for drawing said metal down as fast as it is properly cooled; the outer case or jacket, of larger diameter than the central tube, arranged over said tube to form an annular chamber surrounding the tube; the hollow heads, arranged at each end of said central tube and its jacket, and of larger diameter than said jacket to form annular chambers around the ends thereof, the inside of the outer ends of said hollow heads being arranged to come a short distance from the ends of the central tube to form annular openings between the two, and suitable inlet and discharge pipes, connected with said hollow heads, substantially as and for the purpose set forth.

3. In an apparatus for casting ingots or bars in continuous long lengths from molten metal, the central mold, comprising a thin metal tube whose interior is worked and polished to a straight and uniformly-smooth surface and having means for conducting the molten metal thereto, said tube being secured at its upper end, in combination with a movable support fitted to slide vertically in said tube for holding the first pouring of molten metal while cooling; means for drawing said movable support and metal down to and between the first pair of rolls of a rolling-mill and said rolls for drawing the ingot or bar forward continuously from the mold and reducing the same to the desired size and shape all by a continuous and automatic operation substantially as and for the purpose set forth.

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