June 6, 1933. B. BROWNSTEIN 1,912,966

APPARATUS FOR PRODUCING TUBULAR INGOTS

Original Filed Oct. 21, 1930 3 Sheets-Sheet 1

Fig. 1.

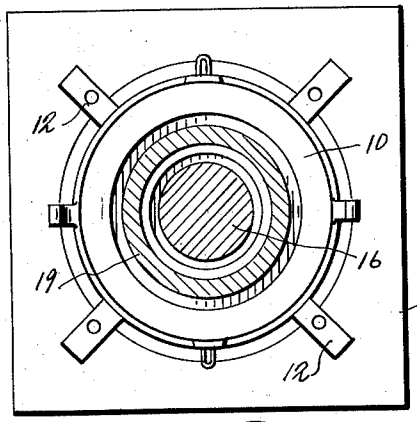


Fig. 4.

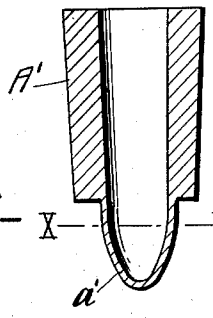


Fig. 5.

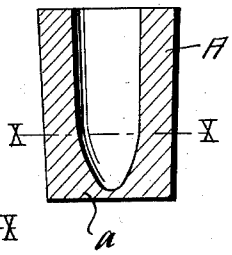


Fig. 2.

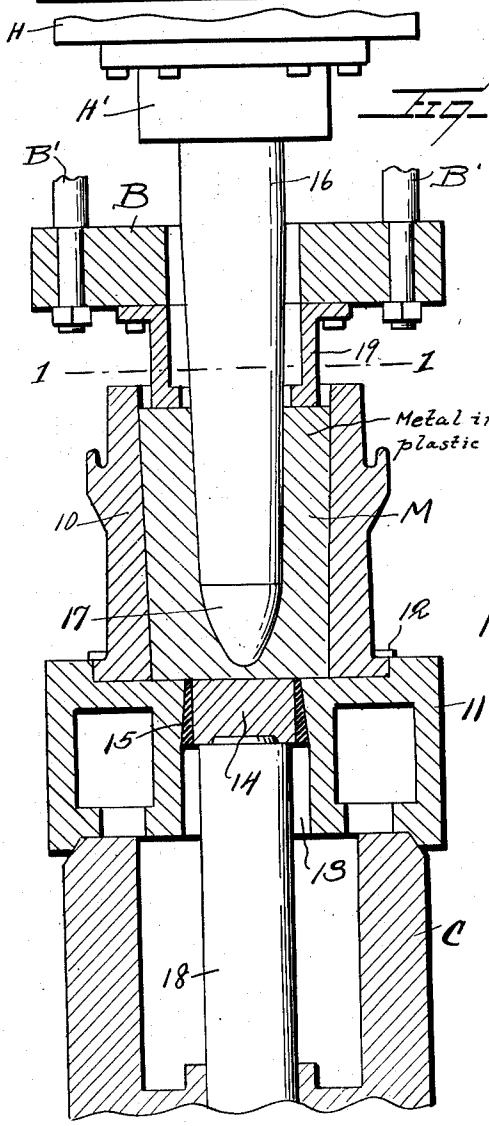
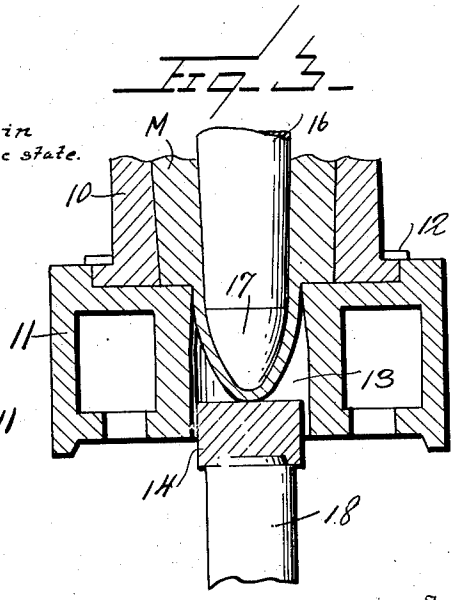


Fig. 3.



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APPARATUS FOR PRODUCING TUBULAR INGOTS

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Fig. 6.

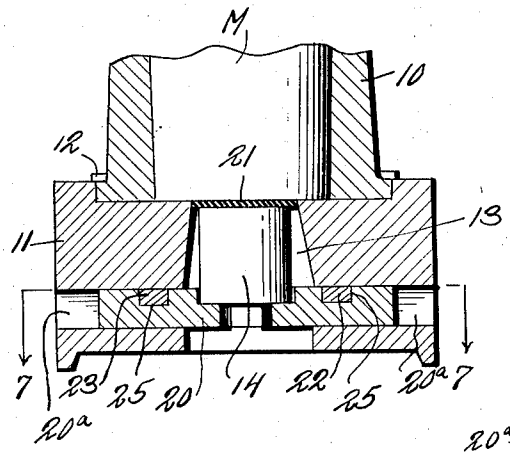


Fig. 8.

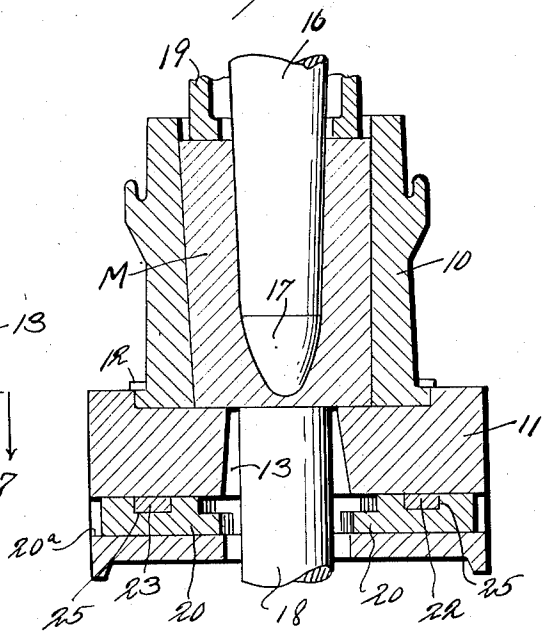


Fig. 7.

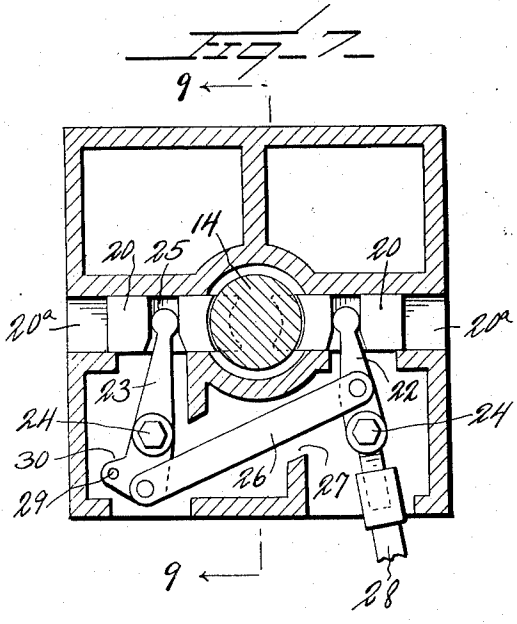
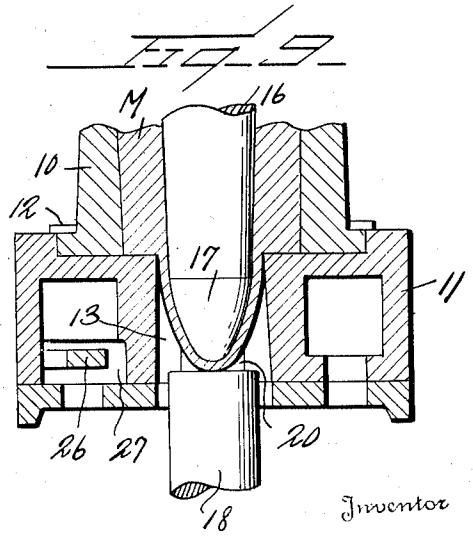


Fig. 9.



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APPARATUS FOR PRODUCING TUBULAR INGOTS

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Fig. 10.

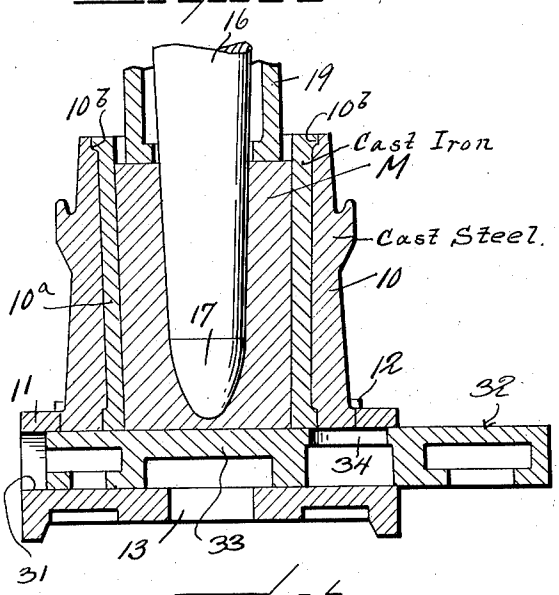


Fig. 11.

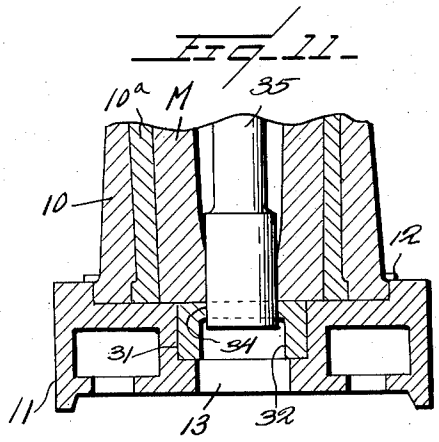


Fig. 13.

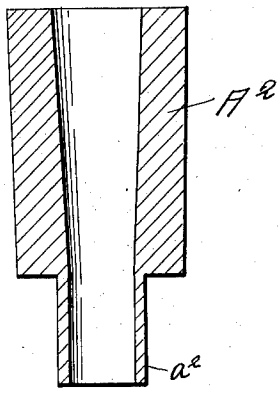


Fig. 12.

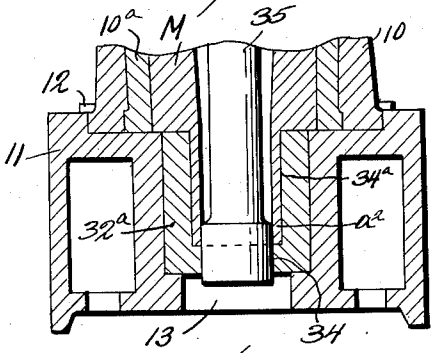


Fig. 15.

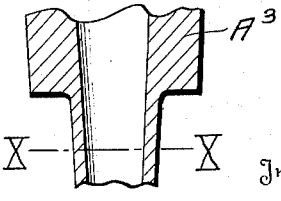
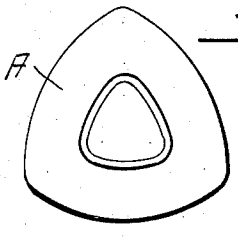


Fig. 14.



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Patented June 6, 1933 1,912,966

UNITED STATES PATENT OFFICE

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APPARATUS FOR PRODUCING TUBULAR INGOTS

Original application filed October 21, 1930, Serial No. 490,229. Divided and this application filed December 31, 1931. Serial No. 584,234.

This invention relates to the art of making hollow ingots as a preparatory step to forming seamless tubes, pipe or hollow shafting and this present invention particularly relates to the apparatus for producing such ingots, the present application being a division of application, Serial No. 490,229, filed October 21, 1930 on Method of and apparatus for producing tubular ingots.

It was proposed a number of years ago to produce hollow ingots by casting the molten metal around a metallic core. This process is practically inoperative because of the fact that molten metal while cooling and solidifying contracts, the force produced by contraction increasing as solidification continues. Now when a core of metal is inserted in the mold and when molten metal is poured around it, the metal "freezes" around the core, while at the same time heating the core to a high temperature, which softens the core and causes it to become distorted in shape. This softening and distorted condition of the core, together with the contractive force of the metal cast around the core, makes it practically impossible to extract the core from the ingot, particularly so when the molten metal is in a large mass.

Another method proposed which is exemplified by the patent to James 442,895 of December 16, 1890, consists in piercing the ingot with a piercing bar while the metal is in a molten state. When piercing molten metal, the piercing bar must be kept in the molten metal long enough to allow the metal to set or solidify, and hence when that state arrives, the same conditions are present as previously referred to.

If the piercing bar is withdrawn too soon, the molten metal will flow out from the bottom and the result of this outflow can be readily conceived. In this patent, the molten metal is pierced from the bottom and thus the molten metal is caused to leak out from the bottom, freezing around the piercing bar and gripping it so that the piercing bar cannot be returned without sticking in the gland. This tends also to burn out the packing in the stuffing box when the gland gets excessively hot from the molten metal, but the process is particularly impractical in that the piercing bar must be kept in the molten metal until it becomes solidified, causing the piercing bar to soften, become distorted and preventing the extraction of the piercing bar from the ingot.

The making of an ingot with a hole cast in it as an ordinary casting has been tried many times, but without success, due to the great difficulty in removing the core if made of any kind of metal. Sand cores offer the same difficulties in removing them from the ingots. Hence the cost is very high, production is low and these two factors are enough to prevent the process from being adopted.

Hollow ingots produced directly in the ingot mold after the molten metal is poured into the mold have never been made as far as I am aware, at least by any practical process.

It has also been proposed to make shells, pipe and like articles by using a piercing press to produce the shell but such articles are invariably made from short billets heated at a high temperature, pierced, drawn out in a hot draw bench and the crop ends cut off. The pipe resulting from this process are short in length and expensive. If long lengths are required, they must be reheated and rolled in a rolling mill and sized to the proper diameter. These operations add greatly to the production cost and hence are not used for regular pipe production.

In the last named process, the blanks, from which the shell or short section of pipe is to be made by a piercing bar are in the form of billets. A billet is the result of many rolling passes after the ingot is cast in the mold and hence in operating upon a billet,

the operation is to be preceded by the following operations, namely, (1) the ingot is cast; (2) stripped from the mold; (3) heated in a soaking pit; (4) rolled in a blooming mill into blooms; (5) cut into short lengths; (6) heated and rolled into billets and cut into short lengths for making pipe. These operations, added to the operations for making pipe from the billet itself, make ten operations for making a length of pipe.

My improved method of making ingots is based upon the fact that when an ingot is cast, the metal cools from without, that is, the exterior cools first and the interior cools last and by my process, broadly speaking, when the metal in the interior has cooled to a completely solidified but plastic condition, and is beyond, therefore, a molten condition, I then pierce the ingot, which at this time offers the least resistance to the piercing bar. Furthermore, inasmuch as the metal is in a plastic condition, the piercing of the ingot causes all cracks and flaws to fill up under pressure and hence produces a sounder ingot. Now when a billet is heated or an ingot is reheated, after it is cooled, even though it is still in a hot state but solidified, the exterior heats first and the interior heats last.

Hence to heat a billet so that the interior will be in the same plastic state as the ingot after it is cast, will cause the exterior to melt away as it is heated first. Therefore, piercing cannot be utilized as it can with the ingot. To pierce a short billet from which, for instance, a six inch shell is made takes 1,500,000 pounds of pressure whereas if the metal be in a plastic state, it would take one third or less of this pressure to pierce the billet, that is, a small billet from which a three inch pipe is made. My invention contemplates casting the ingot in a mold, piercing the ingot in the mold, while the metal is in a plastic state and offering the least resistance to the piercing bar, stripping the ingot from the mold with no crop end loss, or with a small crop end loss and cutting off the crop end if a crop-end ingot is made.

Since ingots used in my process will weigh from 2,000 to 20,000 pounds, each, and the pipe lengths will weight from 50 to 2,500 pounds each, it will be seen that many lengths of pipe may be made from each ingot by my process as against one or two pipes made by piercing a billet. Furthermore, by my invention, less machinery and equipment is required, thus meaning a cheaper production cost per pipe and a small investment for plant.

With these facts in view, the general object of the present invention is to provide an apparatus of a relatively simple character whereby an ingot may be cast, pierced and stripped in accordance with the method above outlined with the fewest possible steps.

Other objects will appear in the course of the following description.

My invention is illustrated in the accompanying drawings, wherein:—

Figure 1 is a section on the line 1—1 of Figure 2;

Figure 2 is a vertical section of one form of my apparatus, the piercing bar and the cross head being in elevation;

Figure 3 is a fragmentary vertical section on the same plane as Figure 2, but showing the piercing bar at the end of its piercing movement;

Figure 4 is a longitudinal sectional view of an ingot after being cast and pierced and before being cropped;

Figure 5 is a like view to Figure 4 but showing another form of ingot;

Figure 6 is a fragmentary section of the lower portion of the ingot mold and a modified form of stool therefor;

Figure 7 is a section on the line 7—7 of Figure 6;

Figure 8 is a section on the same line as Figure 6 but showing the slides withdrawn and the ram in place;

Figure 9 is a section on the line 9—9 of Figure 7;

Figure 10 is a section on the same plane as Figures 2 and 8 but showing a modified form of stool and slide;

Figure 11 is a fragmentary section at right angles to Figure 10;

Figure 12 is a like view to Figure 11 but showing a modified form of slide;

Figure 13 is a longitudinal sectional view of an ingot made by the mechanism illustrated in Figure 12;

Figure 14 is a top plan view of any one of the ingots to show that the ingot may have rounded sides;

Figure 15 is a fragmentary longitudinal sectional view through an ingot pierced or ruptured by a piercing bar.

Referring to Figure 2, 10 designates an ingot mold such as is used for the production of the ingot A in Figure 5. This ingot mold 10 is placed upon a metal stool 11, and clamped to the stool by clamps 12 engaging the mold or by any other suitable means. The stool is annular in form to provide a central passage 13 and prior to the casting of the ingot a bottom plug 14 is disposed in this opening and cemented in place by fire clay 15. The molten metal M is then poured into the mold and allowed to cool until it is in a plastic state. The mold and the stool are then disposed in a press and a piercing bar 16 is driven downward through the top of the mold, that is, through the plastic metal within the ingot mold while the plug is supported by a ram 18 from below. It will be seen from the drawings that the body of the piercing bar

tapers upward from the piercing nose 17 and the piercing nose tapers downward from the body of the piercing bar, terminating in a rounded point. This construction of the piercing bar and nose enables the piercing and stripping operations to be done with a minimum of wear and tear on the piercing bar and nose and hence prolongs the life of the piercing bar and nose which means less delay in mill operation and greater and more economical daily production. The force holding the supporting ram is greater than the force operating the piercing bar, hence allowing the piercing bar to pierce the ingot to within a predetermined distance from the bottom of the ingot as shown in Figures 2 and 5. The force holding the supporting ram is then released and the piercing bar continues to move downward as shown in Figure 3, beyond the upper face of the stool producing the cylinder shown in Figure 4. It is to be noted that the opening in the stool 11 has downwardly diverging walls and is larger than the piercing bar so that the crop end a' is formed as shown in Figure 3 when the piercing bar is forced beyond the upper face of the stool.

The piercing bar is surrounded by the stripper 19 so that when the piercing bar is moved upward, the ingot is held in the mold and stripped from the piercing bar by the stripper. The stool with the mold and ingot is then removed from the press, clamps released, and the ingot mold removed from the stool. The ingot is then stripped from the mold and the crop end a of the ingot A or a' of ingot A′ is then cut off by a saw or torch, producing a complete hollow ingot from which any size pipe, tube or hollow shafting within the range of the ingot can be rolled. The plug is removed from the supporting ram for use in the next mold. In Figure 2 I have illustrated generally speaking the means whereby the piercing bar, the stripper and the cross head are carried, it being understood, however, that any suitable means may be provided for this purpose. In this figure, H designates the cross head carrying the piercing bar and H′ the holder for the piercing bar. B designates the stripper cross head which carries the stripper 19, this being connected to the piston rods B′. The stool 11 is supported upon the cross head C through which the supporting ram 18 operates. The piercing bar, the stripper, cross head and the supporting ram may be operated by hydraulic means, by compressed air or by any other suitable medium.

In Figures 6 to 9 I have illustrated another ingot mold for producing such an ingot as that shown at A′ in Figure 4. The same reference numerals have been used for the stool, the ingot mold, the piercing bar and the stripper. In this case, however, the bottom plug 14 is supported by two oppositely disposed slides 20 located in slideways 20^a formed in the stool. The top of the bottom plug is greased or oiled with heavy oil and fire clay 21 is applied to close the hole in the stool and cover the plug, the oil or grease acting to prevent the plug from sticking to the clay when it is hardened. The molten metal is then poured into the mold and when cooled to a completely solidified but plastic state, the supporting slides 20 are withdrawn by means of the slide operating levers 22 and 23 shown in Figure 7. These slide operating levers are pivoted at 24 within the stool by fulcrum pins and the inner ends of the levers are rounded and fit within openings 25 formed in the slides 20. The lever 22 is pivoted upon a fulcrum pin 24 and between the inner end of the lever 22 and this fulcrum pin 24, is pivoted one end of a link 26 extending through the passage 27 formed in the stool and pivoted to the lever 23 at a point outward of its fulcrum pin so that the levers will operate in opposite directions.

A wrench bar or handle 28 is applied to the extremity of the lever 22 to move this lever. Thus by shifting the wrench handle in one direction, both slides will be shifted inward, that is, into a position to support the plug 14 or shifted outward to release the plug. When the slides are closed and the plug is placed on the slides, a lock pin 29 is inserted through the stool and through an aperture formed in the lug 30 projecting through the lever 23 to thus lock the operating slide levers and prevent the supporting slides from moving, thus keeping the plug in its proper location on the stool. When the metal is cooled to a completely solidified but plastic state, the supporting slides are moved by the handle 28 and the plug drops out from the bottom of the stool. The ingot mold is then placed in a press having a piercing bar and a supporting ram as shown in Figures 8 and 9, and is then operated on in the same manner as the ingot mold previously described. In this case also the wall of the opening 13 is downwardly flared and has a diameter greater than that of the piercing bar whereby the piercing bar may pass into said opening in the stool as shown in Figure 9 and produce a projecting hollow crop end a.

In Figures 10 and 11 I have shown an ingot mold for forming an ingot A and A^2. The mold 10 is formed of a steel casting and provided with a cast iron inner mold shell 10^a. Stool 11 has an opening 13 and has a slideway 31 in its base in which the slide 32 is movable. This slide may be shifted by any suitable means. The slide is formed with an imperforate portion 33 closing the bottom of the mold when the ingot is poured and while the piercing bar is operated and with an aperture 34 extending entirely through the slide and designed to be brought beneath the center of the ingot, after the piercing bar has

been withdrawn, to permit a punch bar to punch out the bottom of the ingot. The aperture 34 is less in diameter than the diameter of the piercing bar above its tapered lower end and the wall defining the upper end of this aperture 34 constitutes a cutting die plate coacting with the punch 35 to enable the punch to cut out the bottom of the pierced ingot.

The metal is poured and when in a state where the metal has completely solidified but is still plastic, the piercing bar 16 is moved downward to a predetermined distance from the top of the slide. The movement of the piercing bar is then reversed and the piercing bar withdrawn while the ingot is held in the mold and stripped from the piercing bar by the stripper 19. The mold is then moved beneath a punch bar 35 and the slide 32 is shifted to bring the center line of hole 34 in alinement with the center line of the mold. The punch bar is then forced down and the bottom of the pierced ingot is punched out as shown in Figure 5, waste dropping out through the hole in the bottom of the stool, as shown in Figure 11.

The punch bar has a head at its lower end smaller than the diameter of the piercing bar and this head has, of course, a sharp cutting edge at its lower end with which the sharp cutting edges of the slide opening secure a proper action for the punch in punching out the lower end of the ingot as shown in Figures 11 and 12. The slide shown in Figure 12 is provided with a relatively deep cylindrical opening to permit the piercing bar to produce a cylindrical extension and at the lower end of this opening 34^a, there is a smaller opening 34 provided with a cutting edge for the purpose of punching out the bottom of the cylindrical extension. Therefore, it will be seen that the slides 32 anud 32^a shown in Figures 11 and 12 not only act as the bottom for the mold but principally for the purpose of providing a cutting die plate to enable the punching bar to cut out the bottom of the pierced ingot.

In Figure 12 there is shown the same general structure as in Figure 11 but with slide 32^a having a deeper section with a recess 34^a, above the opening 34, which is greater in diameter than the piercing bar, thus forming the ingot shown in Figure 13 with the elongated end a^2.

In the use of this modification, the piercing bar is moved downward to a predetermined distance from the top of the slide. The slide is then moved until the center line of the hole is in line with the center line of the mold and then the piercing bar is moved a further distance downward to a predetermined amount, producing the cylinder end of the ingot shown in Figure 4. The piercing bar is then withdrawn from the ingot, the stripper 19 preventing the ingot from being lifted from the mold. The ingot mold is brought beneath and in line with the punch bar 35 which is moved down and the bottom of the cylinder end is punched out (see Figures 12 and 13) waste dropping out through the hole in the bottom of the stool. The slide can be operated by any suitable means, as for instance, by hand or motor, through a rack and pinion or screw. This has not been shown inasmuch as many different means may be used for this purpose, all of which are obvious.

It is to be particularly noted here that in my apparatus the punch bar is never used for piercing the ingot but only for punching out the end of the ingot and that in my apparatus, a piercing bar is used for piercing the ingot, this piercing bar being moved nearly to the lower end of the ingot or moved to produce the extension shown in Figure 4 and then the punch is used to punch out this lower end of the ingot as shown in Figure 12. In other words, I pierce the ingot first and after the piercing bar is withdrawn from the ingot, I follow with a cool punch bar which has a sharp cutting edge at its lower end whose diameter is smaller than the diameter of the piercing bar. This is for the reason that a punch bar having an enlarged cutting head when it is forced down through a billet or through even an ingot which is solidified, yet plastic, will become distorted or bend or buckle at its middle when a compressing force is applied to it and hence the distorted punch bar will have its cutting head disposed eccentrically to the central opening through which the punch bar must pass and which it must more or less closely fit. It will be seen that since the punch bar will deviate from the true center of the ingot, the punch bar will not enter the hole in the slide 32, for instance, and hence will not punch or shear the bottom of the ingot.

It will be seen that with my construction, however, the punch bar 35 travels downward through the relatively large opening formed by the piercing bar and that the punch, therefore, only has to act against the lower end of the ingot and for a relatively short distance so that there is no strain tending to distort the punch bar or render it eccentric. To pierce or punch and shear in the same operation requires that the punch bar must be provided with a sharp edge at its lower end and if such an edge is provided, it will be burned off by the hot metal where the punch bar is forced downward through the entire length of an ingot to pierce the ingot and the punch will become pitted and blistered. A punch bar with such an edge cannot shear or punch out any metal even though it is hot.

In Figures 10 to 12 I have illustrated the ingot mold as made in two parts, that is, of an outer shell 10 and an inner shell 10^a.

This inner shell is made of cast iron and heated to a high temperature before it is placed in the mold, the outer shell being made of steel casting, which outer shell is thus cast around the cast iron core 10^a, with both at a high temperature. A good bond is formed when cooled and the inner shell will not separate from the outer shell under heating and cooling. The inner shell of cast iron possesses high heating quality while the steel casting outer shell possesses high tensile strength, thus making a strong and durable mold. The inner shell is made with a flange 10^b at top and bottom overlapping the outer shell so as to form a positive connection between the shells and prevent the shells from being stripped apart when stripping the ingot from the mold.

The stripper 19 which strips the ingot from the piercing bar is attached to the press and operated by it. The ingot A shown in Figure 5 can be made in any one of the molds described. The ingot A′ shown in Figure 4 can be made in the ingot molds shown in Figures 2, 3, 8, 9 and 12. Ingot A^3, Figure 15, can be made in the molds Figures 3 and 9 by allowing the piercing bar to continue in its stroke until the cylinder end is ruptured, and opened to the full size of the piercing bar, making a hollow ingot with a hole from end to end. The ingots in Figures 4, 5 and 15 may all be cropped along the lines X—X indicated in the several figures. The irregular metal at end of cylinder produced by rupture may be cropped after the ingot is stripped from the mold or left until ingot is rolled into tubes or pipe and then cropped.

It is to be understood that in Figure 5 an ingot is shown in which the piercing bar is stopped in its movement before reaching the extremity of the ingot and that under these circumstances, the ingot will be cut off on the line X—X, the crop end *a* being thrown away or remelted. In Figure 15, the ingot is shown as having its crop end formed by forcing the piercing bar entirely through the ingot mold, the crop end being cut off on the line X—X. The ingot shown in Figure 13 is made by forcing the piercing bar through the ingot mold forming the ingot shown in Figure 4 and then followed by forcing the punching bar 35 into the ingot and punching the bottom out from the cylinder. The ingot shown in Figure 11 is made by forcing the punching bar through the closed end and punching the end out. In all forms of my apparatus and in all the steps of the processes described by me, an ingot is formed which after its end is cropped is tubular and which may be thereafter rolled to form tubes, pipes, hollow shafts or other like tubular objects.

The reason for producing a cylinder end at the bottom of the ingot instead of forcing the piercing bar to the end of the ingot is as follows:—

The metal as it is poured into the ingot mold solidifies as it comes in contact with the ingot mold, hence though it is plastic, this metal is harder than the mass of metal in the center of the ingot. Therefore, it cannot be pierced so easily, as the inward and upward flow of the metal is very slow due to the hardness of the metal and also due to the great resistance of the large mass of metal at the bottom of the ingot and more firmly held to the bottom and sides of the mold than the metal within the mass of the ingot. Second, in Figures 5 and 10 a large part of the ingot is left as a crop end which is expensive waste. Third, it is far easier to draw out the bottom of the pierced ingot into a small cylinder than to cause the metal to flow inward and upward in a confined space as the case happens to be in the bottom of the ingot mold. Fourth, the crop end produced by the cylinder end shown in Figures 13, 15 and 4 is the least expensive crop end waste.

It is to be understood that the ingot and the corresponding mold may have any desired cross section, that is, approximately round, elliptical, triangular or rectangular. In Figure 14, the ingot is shown as many-sided with the sides curved instead of straight. This is because curved sides are less apt to sag or collapse. Hence the mandrel bar with the plug will enter the hole of the ingot more easily and there will be less trouble from that source during the rolling in the first pass. Of course, the shape of the ingots and the opening extending through the same, will depend entirely upon the shape of the mold and the shape of the piercing bar.

It will be seen that with my apparatus, an ingot of the character described may be formed by piercing the ingot nearly to its lower end, removing the ingot from the mold and cutting off the crop end of the ingot or the ingot may be formed by forcing the piercing bar through the ingot to a point beyond the stool to thus form a hollow outwardly projecting crop end which may be cut off or the piercing bar may be forced entirely through an ingot and into a stool having an aperture larger than the diameter of the piercing bar, forcing the piercing bar entirely through the ingot to form the ingot shown in Figure 15 or the piercing bar may be forced into the ingot to form the ingot shown in Figures 13 or 14.

I claim:—

1. An apparatus for forming tubular ingots comprising a mold open at both ends, a stool upon which the mold is supported, the stool having a central opening, a member disposed in position to close said central opening but removable therefrom, a piercing bar adapted to be forced through the center of the ingot toward the stool, and a stripper engaging the end of the ingot opposite the stool and holding the ingot in place when

the piercing bar is removed, the lower end of the piercing bar having a rounded conical tip and being downwardly tapered above the tip.

2. Apparatus for producing hollow ingots comprising a mold open at both ends, a stool upon which the mold is mounted having a central opening smaller than the diameter of the mold, the stool being formed with slideways, means carried in said slideways and movable through said slideways into position across the opening in the stool or into position to unclose said opening in the stool, a piercing bar movable through the center of the ingot toward the stool, and a stripper holding the ingot in place against the stool when the piercing bar is withdrawn, the lower end of the piercing bar having a rounded conical tip and a slightly tapered body above the tip.

3. Apparatus for forming hollow ingots comprising a mold open at both ends, a fixedly supported stool upon which one end of the mold is supported and having a central opening, the stool being formed with a slideway, a slide movable in said slideway, the slide having an imperforate portion adapted to entirely close the bottom of the mold and having an opening adapted to be brought into alinement with the central bottom portion of the mold, a piercing bar movable longitudinally through the center of the ingot and having a diameter greater than the diameter of said opening in the slide, a stripper holding the ingot in place while the piercing bar is removed and a punch movable longitudinally through the opening in the ingot formed by the piercing bar and having a head with a diameter approximately equal to the diameter of the opening in the slide and into which the punch is movable.

4. Apparatus for producing hollow ingots including a mold open at opposite ends, a fixedly supported stool upon which the mold is disposed and having an opening less in diameter than the diameter of the mold, the stool being formed with slide-members movable into position across the opening in the stool, a bottom plug supported by the slide member, and means for simultaneously moving said slide members inwardly to support or outwardly to release the bottom plug, a piercing bar movable longitudinally through the ingot toward the stool and movable through said opening in the stool, and a stripper holding the ingot in place while the piercing bar is removed.

5. Apparatus for forming tubular ingots comprising a mold open at its opposite ends and formed of an outer shell of cast steel and an inner shell of cast iron, the shells being interlocked with each other against relative longitudinal motion, a stool upon which the mold is supported, the stool having a central opening smaller in diameter than the diameter of the mold, a piercing bar movable through the hollow interior of the ingot toward the stool, and means for supporting the central portion of the ingot while the piercing bar is being forced into the interior of the ingot, said means being movable to permit the piercing bar to pass through the ingot and into the opening of the stool.

6. Apparatus for producing ingots including an ingot mold and a piercing bar, the ingot mold and the piercing bar both being formed with many sided walls each side being outwardly curved.

7. An apparatus for making hollow ingots comprising an ingot mold open at opposite ends, a stool supporting the mold against downward movement and having a central opening, a bottom plug insertable therein, a refractory element to close the space between the plug and stool, clamping means for locking the ingot mold to the stool a piercing bar movable longitudinally through the center of the ingot and through said opening in the stool, and withdrawable means for supporting said plug in the central opening in the stool.

8. Apparatus for forming hollow ingots comprising a mold open at both ends, a stool upon which one end of the mold is supported and having a central opening, the stool being formed with a slideway, a slide movable in said slideway, the slide having an imperforate portion adapted to entirely close the bottom of the mold and having an opening adapted to be brought into alinement with the central portion of the mold, a piercing bar movable longitudinally through the center of the ingot toward said opening in the slide, a punch bar movable through the central opening in the slide to punch out the end of the cylinder formed by the piercing bar and having a punching head and a stripper holding the ingot in place when the piercing bar is removed the opening in the slide being of approximately the same diameter as the punch head to permit the passage of the punching head.

9. Apparatus for producing hollow ingots including a mold open at opposite ends, a stool upon which the mold is disposed and having an opening less in diameter than the exterior diameter of the mold, the stool being formed with slideways, oppositely disposed slides mounted in said slideways and movable into position across the opening in the stool, a bottom plug and supported on said slides when the latter are moved across the opening in the stool, means for locking the ingot mold to the stool, means for moving said slides simultaneously inwardly to support or outwardly to release the bottom plug, means for locking the slides in their inward or outward position, and a piercing bar movable longitudinally through the ingot toward the stool.

10. Apparatus for producing hollow ingots including an ingot mold open at both ends, an ingot piercing bar rectilinearly movable through the mold axially thereof in opposite directions, means for initially supporting the central portion of the ingot while the piercing bar is moving into the mold, said means being shiftable to permit the piercing bar to move inward beyond the inner end of the mold, and a punch movable axially through the mold and beyond the inner end of the mold to punch out the bottom of the pierced ingot, and means holding the ingot from retraction from the mold as the piercing bar or punch are withdrawn.

11. An apparatus for forming tubular ingots comprising a mold open at its opposite ends, an ingot piercing bar rectilinearly movable into and out of the mold axially thereof in opposite directions, a stool upon which the mold is supported, the stool having an opening smaller in diameter than the interior diameter of the ingot mold, a member associated with the stool and movable to close the central opening therein or to provide an opening immediately in advance of the piercing bar and larger in diameter than the diameter of the piercing bar at its inner end whereby to form an elongated crop end on the ingot when the piercing bar moves beyond the inner end of the mold, and a punch movable into the ingot after the piercing bar has been withdrawn to punch out the crop end formed upon the ingot.

12. An apparatus for making hollow ingots including an ingot mold open at its opposite ends, a stool upon which one end of the ingot mold is supported, the central portion of the stool below the end of the ingot mold being open, an element temporarily disposed in position to close the opening in the stool while the metal is being poured into the mold but removable therefrom, a piercing bar adapted to be forced through the center of the ingot toward the stool, and means for holding the ingot in place upon the stool while the piercing bar is being withdrawn, the piercing bar tapering downwardly slightly from its upper end toward the nose and the lower end of the piercing bar tapering downward at a greater angle than the taper of the body of the bar and terminating in a rounded nose.

13. An apparatus for making hollow ingots including an ingot mold open at its opposite ends, a stool upon which one end of the ingot mold is supported, the central portion of the stool below the end of the ingot mold being open, the opening being defined by a downwardly flaring wall, an element temporarily disposable into position to close the opening in the stool to thereby permit the mold to be filled with molten metal, said element being removable from such position, and a piercing bar adapted to be forced through the center of the ingot toward and into the opening in the stool.

14. An apparatus for making hollow ingots including an ingot mold open at its opposite ends, a stool upon which one end of the mold is supported, the central portion of the stool below the end of the mold being open, a removable element temporarily disposable into position to close the opening into the stool and thereby permit the retention of the molten metal in the mold while hardening and being pierced, said element being removable from this position, a retractible ram movable into the opening in the stool to support said element and the central portion of the ingot, and a piercing bar adapted to be forced through the center of the ingot toward the stool and ram.

15. Apparatus for making hollow ingots including an ingot mold open at its opposite ends, a stool upon which one end of the ingot mold is supported, a slide operating in the stool below the ingot mold, a portion of the slide being imperforate to close the ingot mold and permit the material of the ingot to be poured, another portion of the slide having a recessed portion extending downward from the upper face of the slide, the lower wall of the recess being formed with an opening alining with the axial center of the mold, a piercing bar adapted to be forced downward toward the mold through the center of the ingot and into the recess of the slide, a punch bar movable downward through the opening formed through the ingot by the piercing bar and having a head movable into the recess in the slide and through the opening at the bottom of said recess, the slide recess being larger in diameter than the head of the punch bar and the opening at the bottom of said recess being approximately the same diameter as the diameter of the punch bar head.

16. An apparatus for forming tubular ingots comprising a mold open at both ends, a stool upon which the mold is supported, the stool having a central opening, a member disposed in position to close said central opening, a piercing bar adapted to be forced through the center of the ingot toward the stool, and a stripper holding the ingot in place when the piercing bar is removed, the piercing bar having a piercing nose and the body of said bar slightly tapering downward to the piercing nose and the piercing nose tapering downward from the body of the piercing bar at a greater angle than the taper of the body of the bar and terminating in a rounded point.

17. Apparatus for producing hollow ingots comprising a mold open at both ends, a stool upon which the mold is supported having a central opening smaller than the diameter of the mold, the stool being formed with slideways, means carried in said slideways

and movable through said slideways into a position across the opening in the stool or into a position to unclose said opening in the stool, a piercing bar movable through the center of the ingot toward the stool and a stripper holding the ingot in place against the stool when the piercing bar is withdrawn, the piercing bar having a nose and tapering downward toward the nose, the piercing nose tapering downward from the body of the piercing bar at a steeper angle and terminating in a rounded point.

In testimony whereof I hereunto affix my signature.

BENJAMIN BROWNSTEIN.