June 6, 1933. B. BROWNSTEIN 1,912,965

METHOD OF PRODUCING TUBULAR INGOTS

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Fig. 1.

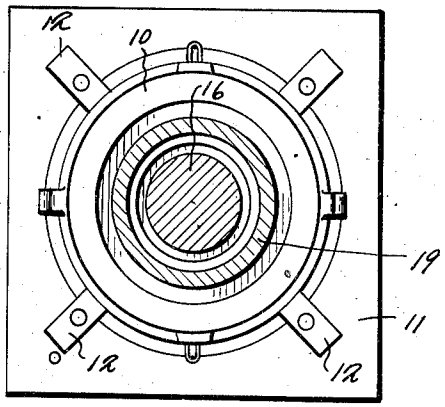


Fig. 3.

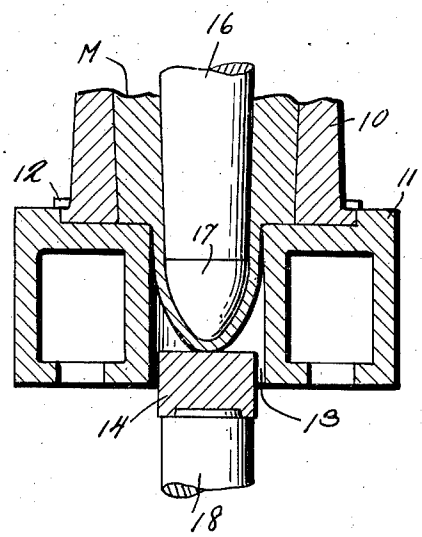


Fig. 2.

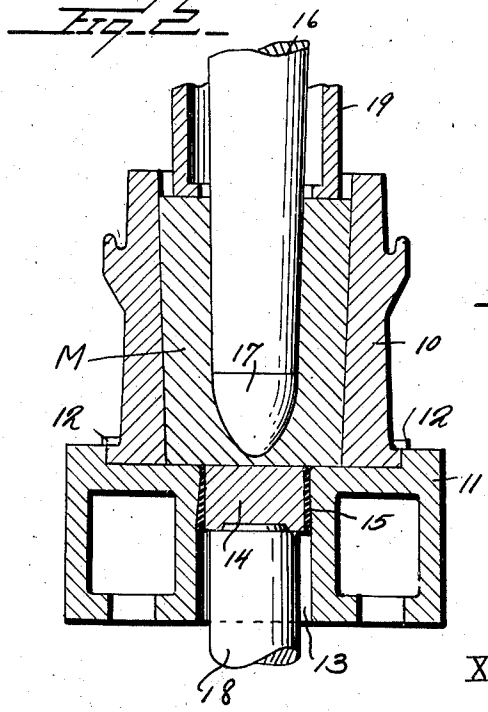


Fig. 4.

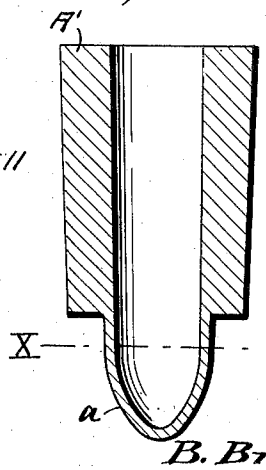
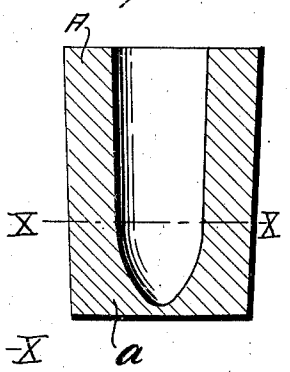


Fig. 5.



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METHOD OF PRODUCING TUBULAR INGOTS

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Fig. 8.

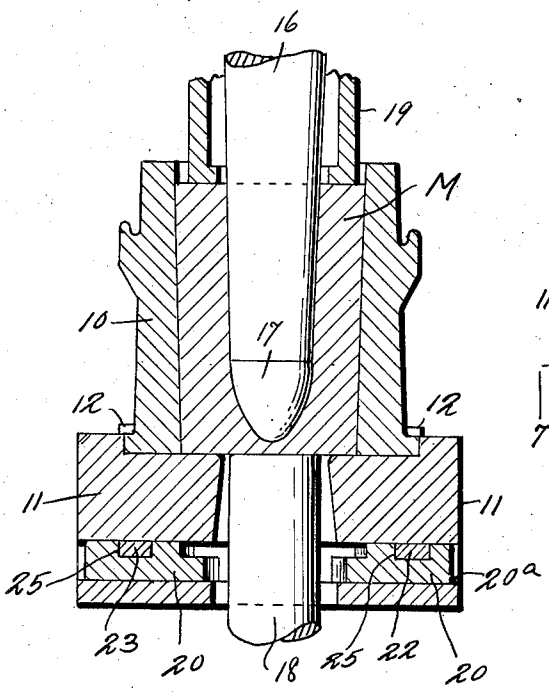


Fig. 6.

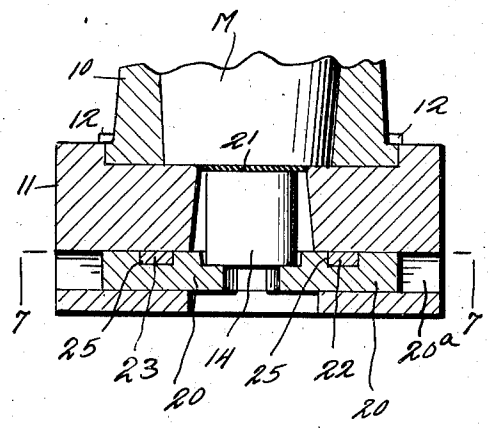


Fig. 9.

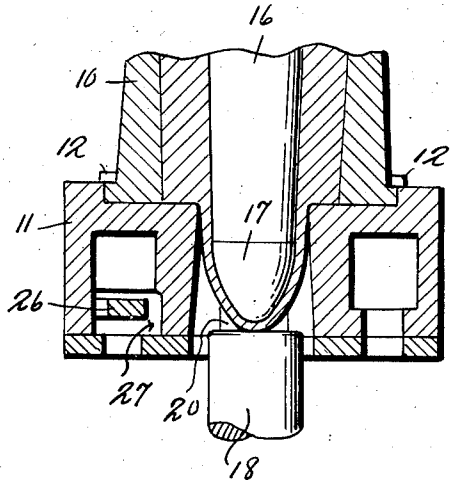
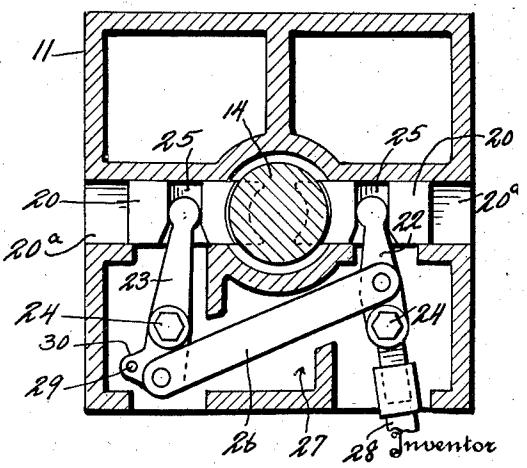


Fig. 7.



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METHOD OF PRODUCING TUBULAR INGOTS

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Fig. 10.

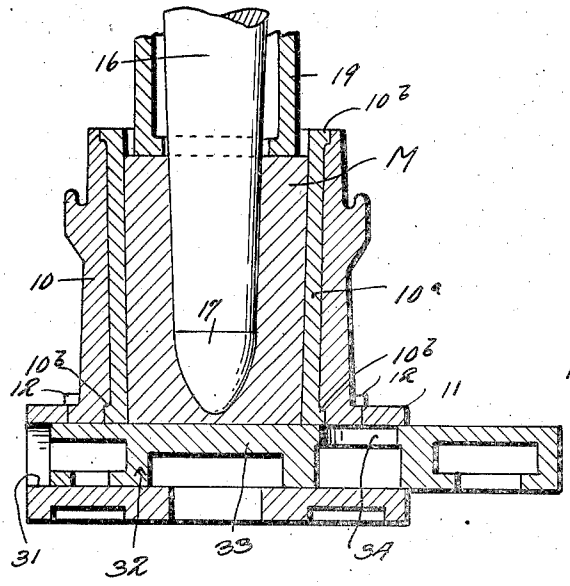


Fig. 11.

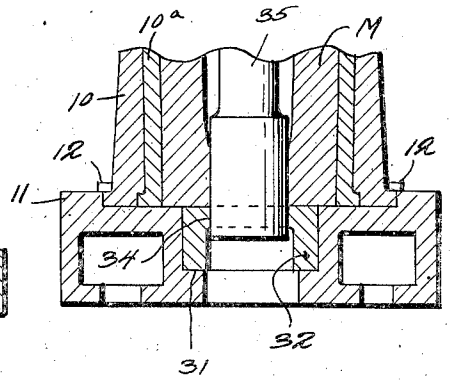


Fig. 14.

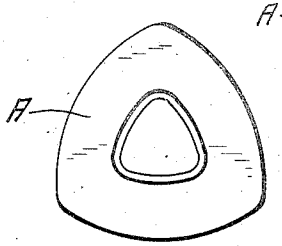


Fig. 15.

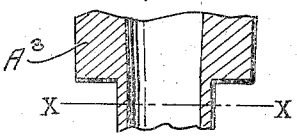
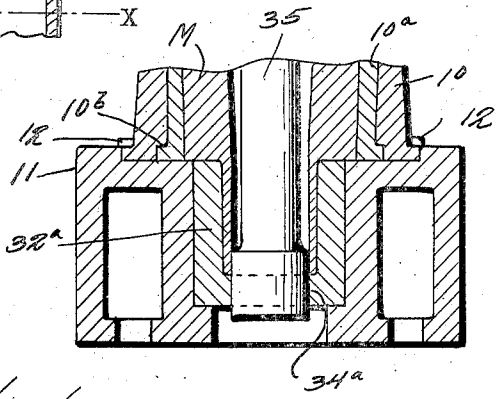


Fig. 12.



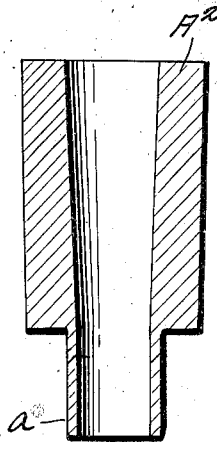


Fig. 13.

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Patented June 6, 1933 1,912,965

UNITED STATES PATENT OFFICE

BENJAMIN BROWNSTEIN, OF ELLWOOD CITY, PENNSYLVANIA

METHOD OF PRODUCING TUBULAR INGOTS

Application filed October 21, 1930. Serial No. 490,229.

This invention relates to the art of making hollow ingots as a preparatory step to making seamless tubes, pipe and hollow shafting. 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 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 in the mold have never been made so 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 one to two lengths 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 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.

It is to be noted that in the above statement, I have referred to the metal of the ingot as being in a plastic condition. "Plasticity", as defined in the Hand Book of the Bureau of Instruction, Carnegie Steel Company, page 5, "is a physical property of matter which is opposite to elasticity. A plastic body once distorted will not regain its original shape." Steel though hard and in a cold state becomes plastic when heat is applied and when this heat is continued, it finally becomes liquid. Steel begins to become plastic or soft at about a temperature of 1,250° F. and continues to increase in plasticity until it reaches the melting point which is between 2,050° and 2,732° F. The variation in the melting point, of course, is due to the carbon content and to the constitution of different alloys. Steel while in a solid state is highly plastic due to the high heat which it contains and that is the condition of my ingot when I pierce it. The steel in this condition has the greatest plasticity at the interior of the ingot and the least plasticity at the exterior or surface due to the lower temperature of the ingot mold and the natural heat radiation from the surface of the exposed metal. I pierce my ingot at from 50 to 100° below the temperature of complete solidification for at these temperatures, the ingot possesses the greatest plasticity, hence offers the least resistance to the piercing bar during the piercing operation.

It is, therefore, to be particularly understood that the ingot when it is pierced in accordance with my process is not in a weldable or pasty condition, the weldable point of low carbon steel being that condition in which the steel is in a pasty state close to the melting point, or, in other words, at the point where the scale begins to melt or the liquor begins to flow as stated on page 1055 of the Hand Book of the Carnegie Steel Company, Bureau of Instruction on the "Making, Shaping and Treating of Steel."

Another reason and a particularly practical reason for piercing the ingot when it is in its solidified or plastic condition is that steel in its liquid or pasty state cools very suddenly when brought in contact with a cooler body such, for instance, as the piercing bar which is forced into the ingot, and while cooling shrinks considerably, gripping this cooler body with enormous force and holding it so that it cannot be extracted without either disrupting the press or the ingot mold. By piercing the ingot when it is in a plastic condition as opposed to a pasty condition, I eliminate this "freezing" of the metal on the piercing bar. If the metal of the ingot were at a welding heat, then the interior or core of the ingot would freeze on the piercing bar and a "cobble" would result or else the frozen metal with the piercing bar would be ripped from the outer shell of the pierced ingot, leaving a badly ripped up and creviced interior from which a finished tube could not be made. When piercing a steel ingot, however, that is completely solidified but still in a plastic state, the flow of metal as the piercing bar enters is laterally and upwardly and hence the metal does not grip the piercing bar with much force. This has been proven from actual practice by piercing billets with a piercing bar which is not tapered and it has been found that the stripping speed is not less than the piercing speed but that it takes less power to strip the piercing bar from the billet than it does to pierce it. Steel which is in a pasty or weldable state, however, does not flow away from the piercing bar but sticks to it with tenacious force, and cannot be extracted from it. 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 weigh from 50 to 2,500 pounds each, it will be seen that many pipes may be made from each ingot by my process as against one or two pipes made by pierc-

ing 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.

A further object of my invention is to provide means of a relatively simple character whereby an ingot may be cast, pierced and stripped 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 top plan view of an ingot mold, the stripper and piercing bar being shown in section;

Figure 2 is a vertical sectional view through the ingot mold shown in Figure 1;

Figure 3 is a like view to Figure 2 but showing the piercing bar depressed through the stool to form a crop end on an ingot;

Figure 4 is an ingot formed with a protruding crop end;

Figure 5 is an ingot in which the piercing bar has not been moved through the end of the ingot;

Figure 6 is a vertical sectional view of an ingot mold having a modified form of stool and sliding means for holding a plug beneath the mold;

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

Figure 8 is a like view to Figure 6 but showing the plug supporting slides open and a ram supporting the center of the ingot while piercing is being accomplished;

Figure 9 is a like view to Figures 6 and 8 but showing the piercing bar as forcing the crop end of the ingot out;

Figure 10 is a like view to Figures 1 and 8 but showing a modification in the sliding means for supporting the ingot while being poured and pressed;

Figure 11 is a fragmentary section as in Figure 10 showing the manner in which a punching bar is used to punch out the bottom of the ingot;

Figure 12 is a like view to Figure 11, but showing a deeper slide and showing the operation of the punching bar to produce a cylindrical crop end;

Figure 13 is a vertical sectional view of an ingot having a cylindrical crop end;

Figure 14 is a top plan view of an ingot showing the manner in which the sides will be curved to facilitate the later operations of rolling.

Figure 15 is a longitudinal fragmentary sectional view through a modified form of ingot.

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 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 whose lower end is tapered to a rounded point to form a nose 17 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. 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. The force holding the supporting ram is then released and if the piercing bar continues to move downward, producing the cylinder end shown in Figure 4.

The piercing bar is surrounded by the stripper 19 so that when the piercing bar is moved upward, the ingot is 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′ 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 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 supporting 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 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 between the inner end of the lever 22 and this fulcrum pin 24 is pivoted to one end of a link 26 extending through a 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 or shifted outward to release the plug. When the metal is cooled to a 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, and is then operated on in the same manner as the ingot mold previously described. 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 in the stool.

In Figures 10 to 11 I have shown an ingot mold for forming an ingot A^2. In these figures I have illustrated an ingot mold 10 which is formed of a steel casting and is provided with a cast iron inner mold shell 10^a. The stool 11 is formed with a slideway 31 in its base in which the slide designated generally 32 is movable. This slide may be shifted by any suitable means. The slide is formed with an imperforate portion 33 designed to close the bottom of the mold when the ingot is poured and while the piercing bar is operated and with a hole or aperture 34 extending entirely through the slide and which is designed to be brought beneath the center of the ingot, after the piercing bar has been withdrawn to permit a punch bar to be operated to punch out the bottom of the ingot. In using the construction shown in Figures 10 and 11 initially the slide 32 is so located that the bottom of the mold is closed.

The metal is then poured and when it is in a plastic state, 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 is withdrawn while the ingot is stripped from the piercing bar by the stripper 19. The ingot mold is then moved along the press base and brought in line with a punch bar 35 as shown in Figure 11 and then the slide 32 is shifted until the center line of the hole 34 is in alinement with the center line of the hole and the punch bar is then forced down and the bottom of the pierced ingot shown in Figure 5 is punched out, waste dropping out through the hole in the bottom of the stool, as shown in Figure 11. In Figure 12 I show the same construction as is illustrated in Figures 10 to 11 but having a deeper section. The slide 32^a in this case has a hole 34^a.

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 then moved along the press base and brought in line with the punch bar 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 and screw. This has not been shown inasmuch as many different means may be used for this purpose, all of which are obvious.

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 3, 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.

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 it is far harder than the mass of metal in the center of the ingot after it has cooled to a plastic state. 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 Fig. 5, 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 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, or the crop end punched out by punch bar as shown in Figure 11, the crop end *a* being thrown away or remelted. In Figure 4, 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 15 is made by forcing the piercing bar through the closed cylindrical portion and the crop end X—X is cut off. 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.

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 sides of the ingot are shown as 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.

Seamless tubes or pipe are at present made by indirect process as follows:—

1. The ingots are poured, cooled and stripped.
2. The ingots are reheated in a soaking pit or furnace.
3. The ingots are rolled in a blooming mill and cut into proper length blooms.
4. The blooms are examined for surface cracks or seams and the cracks or seams are chipped out, sand blasted or the surfaces are machined by a special planer. The reason for this operation is due to spiral or angular twisting of the material by the piercing rolls during piercing and defects in the surface of the billet are opened up by the angular twisting which results in defective tubes or pipe.
5. The blooms are heated in a continuous or other type of furnace.
6. The blooms are rolled in a billet or bar mill and cut into proper length billets.
7. The billets are reheated in a continuous furnace.
8. The reheated billets are pierced in a disc or roll piercing mill thus producing outer rough walled tubes. When two piercing mills are used, the second piercing mill is used for expanding the pierced tube to larger diameter.
9. The pierced tubes are rolled in a rolling mill equipped with stripper rolls for returning the tube after each rolling.
10. The rolled tubes are reeled in a reeling machine which smooths out the wrinkles which the rolling mill failed to smooth out. These wrinkles or rough spirals are produced by the piercing mill during piercing whether disc or roll piercing mill is used.
11. The reeled tubes are sized in a sizing machine and is the last mill operation, bringing the tube or pipe to proper diameter, producing a finished hot tube or pipe. They are then cooled.
12. The hot finished tubes are cut to proper length, straightened, inspected, tested and oiled for shipping or stocked. Pipe are cut to random lengths, straightened, threaded, inspected, tested and oiled. In some mill layouts the straightening is done right after the pipe leave the cooling table after which follow the cutting off and threading operations, each billet producing but one tube or pipe.

My direct process for making seamless tubes or pipe is as follows:—

1. The ingots are poured and partly cooled.
2. The partly cooled ingots are pierced and stripped.
3. The crop ends are cut off from the pierced ingots.
4. The pierced ingots are reheated in a soaking pit furnace.
5. The reheated ingots are rolled in a con-

tinuous rolling mill and sized in the last passes to the proper diameter;

6. The long length of tube or pipe after leaving the rolling mill is cut into many standard or other length tubes or pipe and cooled. The length of tubes coming from the rolling mill will vary between 100′ and 350′ or more. One ingot produces many tubes or pipe.

7. Hot finished tubes or pipe are finished in the same order as in the present indirect process.

It will be seen from the above comparison that my direct process produces more tubes or pipe with less operations than the present indirect process. Hence it is, therefore, cheaper in cost of plan machinery and operating costs per tube or pipe produced. By direct process any size of tube, pipe or hollow shaft in any length can be produced.

I claim:—

1. A method of making hollow ingots which consists in filling an ingot mold with molten metal, allowing the metal to cool until it is completely solidified but yet in a plastic condition and then while the metal is in the plastic state, forcing a piercing bar longitudinaly into the center of the ingot and withdrawing the piercing bar.

2. A method of making tubular ingots which consists in filling an ingot mold with molten metal, allowing the metal to cool to such a degree that the metal is entirely solidified but still in a plastic state, forcing a piercing bar longitudinally into the center of the ingot while the metal is still in a plastic state, withdrawing the piercing bar and cropping off the closed end of the ingot.

3. A method of making tubular ingots which consists in filling an ingot mold with molten metal, allowing the metal to cool to a degree where the metal is entirely solidified but yet plastic with the central portion of the ingot in a more plastic state than the outer portion of the ingot, and then while the interior of the metal is still plastic, forcing a piercing bar longitudinally into the center of the ingot.

4. A method of making tubular ingots which consists in filling an ingot mold with molten metal, allowing the metal to cool until the metal is solidified but plastic and forcing a piercing bar longitudinally through the center of the ingot and while the interior of the ingot is still in a plastic state, withdrawing the piercing bar and cropping off that portion of the metal which has been forced out beyond the ingot by the piercing bar.

5. A method of making tubular ingots which consists in filling an ingot mold with molten metal, allowing the metal to cool until the metal of the ingot is entirely solidified but yet in a plastic state, supporting the ingot at the central portion at one end, forcing a piercing bar longitudinally into the center of the ingot, and within a predetermined distance from the supporting means, removing the central supporting means, and forcing the piercing bar through the ingot and beyond the inner end of the body thereof to thus form an open projecting crop end, withdrawing the piercing bar from the ingot and cutting off the projecting crop end.

6. A method of making tubular ingots which consists in using an ingot mold, having one end closed by a stool formed with a central opening and by a member disposed to close said central opening, filling the mold with molten metal, allowing the molten metal to cool until the metal has solidified but is in a plastic condition, forcing a piercing bar into the center of the ingot, and toward the closed end of the mold, removing the central supporting member and forcing the piercing bar through the end of the ingot to thus form a closed projecting crop end, removing the piercing bar, stripping the ingot from the mold, and cutting off the crop end.

7. A method of making tubular ingots which consists in using a mold open at both ends, mounting the mold upon a stool having a central opening, disposing a supporting member to temporarily close the central opening, filling the mold with molten metal, allowing the metal to cool until the ingot is completely solidified but is in a plastic state, forcing a piercing bar through the central portion of the ingot toward the supported end thereof while the metal is still plastic, withdrawing the piercing bar, withdrawing the supporting element from the central part of the stool forcing a punch bar through the interior of the now hollow ingot and punching out the end thereof through the opening in the stool.

8. A method of making tubular ingots which consists in filling an ingot mold with molten metal, allowing the metal to cool until it is completely solidified but in a plastic condition, forcing a piercing bar longitudinally through and beyond the end of the ingot while the interior of the ingot is still in a plastic state, forcing a punch bar through the interior of the now hollow ingot and punching out the end of the ingot by the punch bar and cropping off a portion of the metal which extends beyond the body of the ingot.

9. A method of making tubular ingots which consists in using a mold open at both ends, mounting the mold upon a stool having a central opening, disposing a supporting member in said central opening to close the opening, filling the mold with molten metal, allowing the metal to cool until the metal is completely solidified but is in a plastic state, forcing a piercing bar longitudinally through the center of the ingot for a predetermined distance from the supporting member while the metal is in a plastic state, with-

drawing the supporting member and allowing the piercing bar to continue in its downward movement to another predetermined distance beyond the body of the ingot, forming a projected cylinder, withdrawing the piercing bar from the ingot and moving a punch bar into the now hollow ingot and punching out the end of the projected cylinder of the ingot, waste dropping out through the hole in the bottom of the stool.

In testimony whereof I hereunto affix my signature.

BENJAMIN BROWNSTEIN.