No. 894,410. PATENTED JULY 28, 1908.

J. O. E. TROTZ.

APPARATUS FOR CASTING INGOTS.

APPLICATION FILED JULY 23, 1904.

2 SHEETS—SHEET 1.

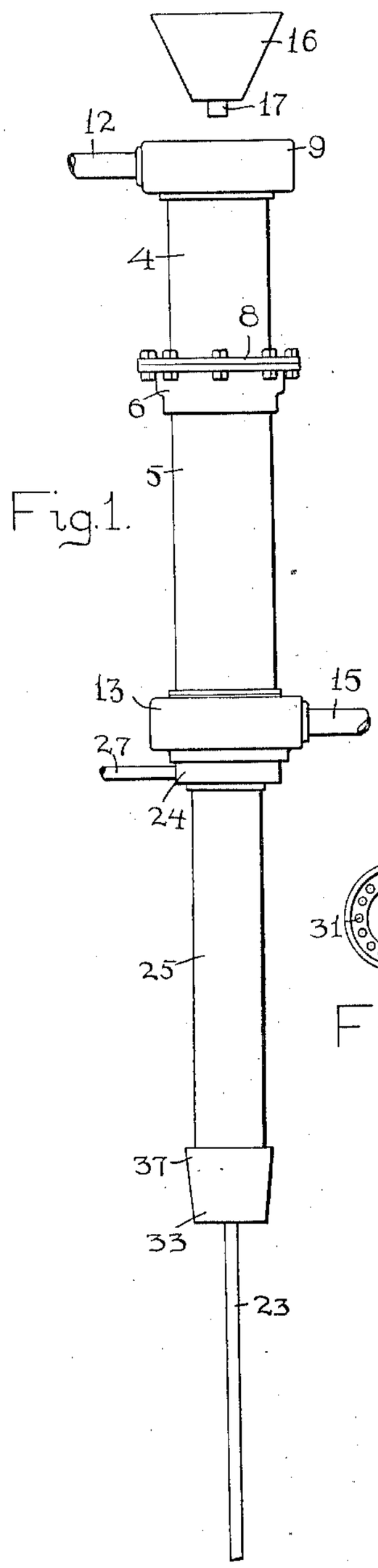

Fig. 1.

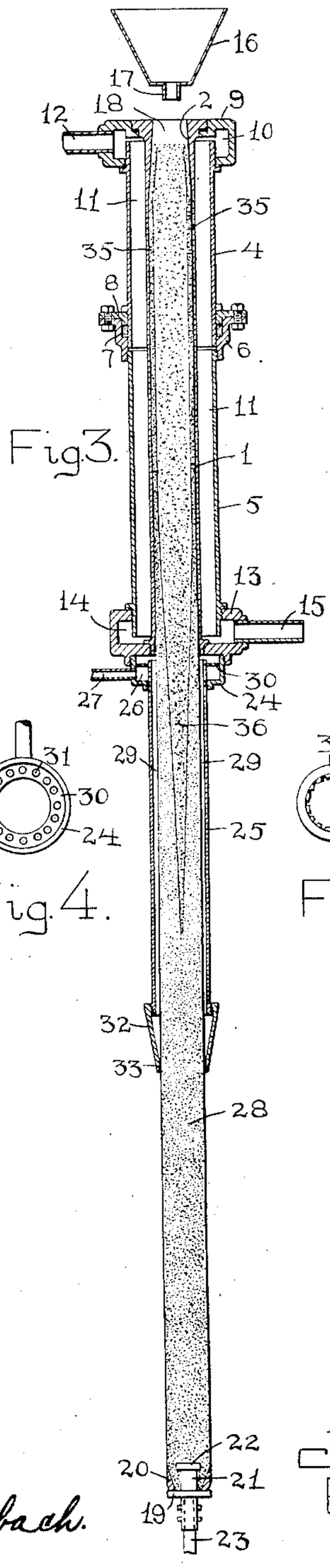

Fig. 3.

Fig. 4.

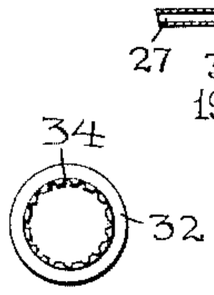

Fig. 5.

Fig. 2.

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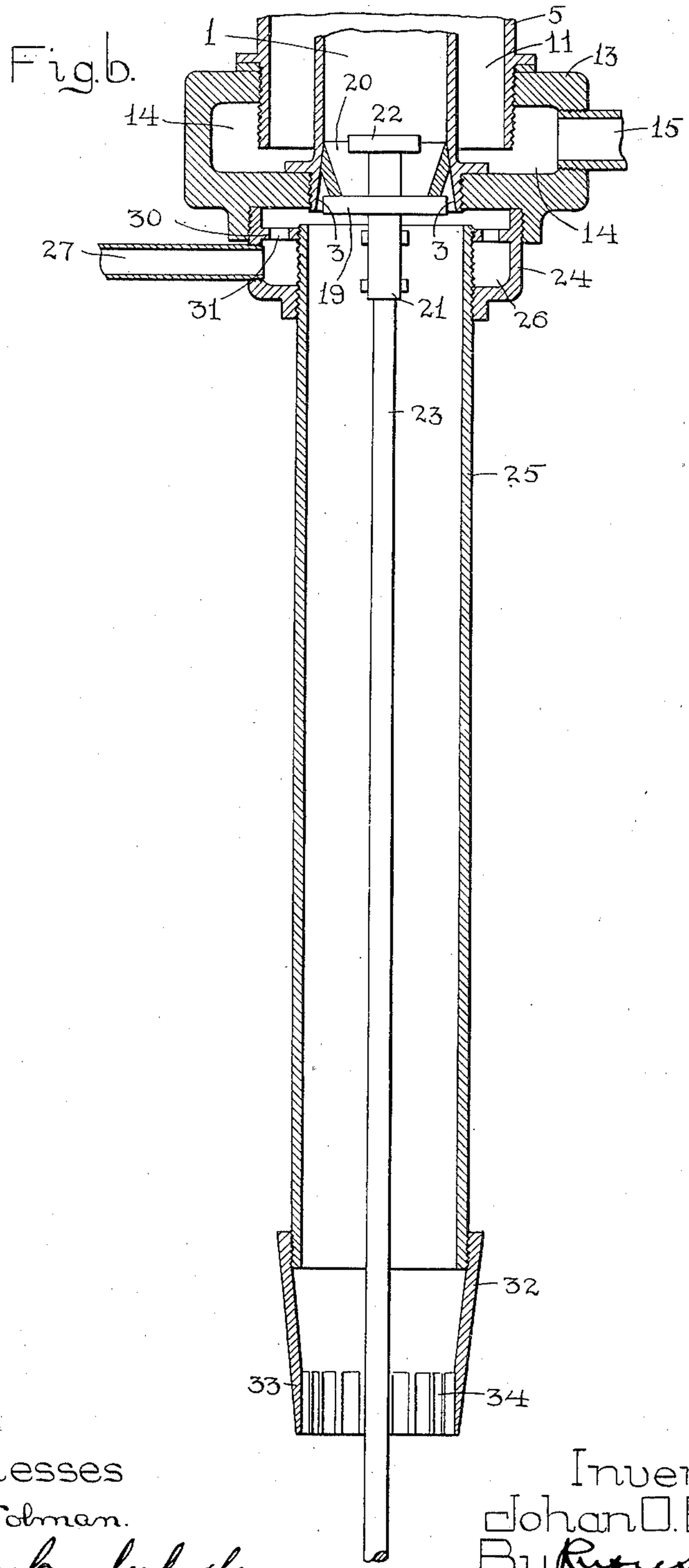
2 SHEETS—SHEET 2.

Fig. 6.



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APPARATUS FOR CASTING INGOTS.

No. 894,410. Specification of Letters Patent. Patented July 28, 1908.

Application filed July 23, 1904. Serial No. 217,783.

To all whom it may concern:

Be it known that I, JOHAN O. E. TROTZ, a citizen of Sweden, residing at Worcester, in the county of Worcester and Commonwealth of Massachusetts, have invented a new and useful Improvement in Apparatus for Casting Ingots, of which the following is a specification, accompanied by drawings forming a part of the same, in which—

Figure 1 represents a side elevation of an ingot mold embodying my invention. Fig. 2 is a central vertical sectional view of the same. Fig. 3 is a vertical central sectional view of my improved mold with an ingot inclosed therein. Fig. 4 is a detached view of the perforated steam distributing plate. Fig. 5 is a bottom and detached view of the conical tip forming the lower end of the apparatus and showing the annular series of openings for the escape of steam, and Fig. 6 is a vertical sectional view of the lower end of the ingot mold and of the tempering chamber, shown on a larger scale.

Similar reference letters and figures refer to similar parts in the different views.

My present invention relates to an apparatus for continuously casting an ingot in length greatly in excess of the length of the forming mold by which a supply of molten metal may be continuously fed to one end of the mold and a cast ingot be gradually withdrawn from the opposite end of the mold without interrupting the continuity of the ingot during the entire process, thereby enabling ingots of indefinite length to be cast, and it consists in certain additions and improvements to the apparatus shown and described in Letters Patent of the United States, No. 648,091, issued to me April 24, 1900 and No. 705,721, issued to me July 29, 1902, as hereinafter described, the novel features being pointed out in the annexed claims.

Referring to the accompanying drawings 1 denotes the ingot mold consisting preferably of a cylindrical tube having its interior surface smoothly polished to facilitate the withdrawal of the ingot. The diameter of the mold 1 is slightly contracted at its upper end forming the inclined inner wall 2, and at the lower end of the mold 1 its diameter is slightly increased forming a flaring delivery opening 3 at the lower end of the pipe. Surrounding the mold 1 is an outer casing preferably consisting of the two sections of pipe 4 and 5, the opposing ends of the sections 4 and 5 being united by a coupling ring 6 inclosing an annular space to receive a packing 7, which is compressed by a gland 8 to allow for the longitudinal expansion and contraction of the inclosing pipes 4 and 5. The outer casing is provided at its upper end with a hollow head 9 inclosing an annular water space 10 communicating with the annular chamber 11 between the mold 1 and the outer casing. The head 9 is provided with a water pipe 12 communicating with the annular chamber 10. The lower end of the casing is similarly provided with a hollow head 13 inclosing an annular water space 14 which is provided with a water pipe 15, and the annular water space 14 communicates with the annular chamber 11 around the mold.

A circulation of water, or other cooling medium, is maintained around the ingot mold 1 for the purpose of uniformly cooling the molten metal on all sides by connecting either the pipe 12 or 15 with a suitable source of water supply, and allowing the remaining pipe to serve as a discharge pipe. Suitably supported by a framework not shown, at a slight distance above the upper end of the ingot mold 1 is a funnel shaped hopper 16 provided with a restricted tubular opening 17 in its bottom, whose diameter is less than the diameter of the upper end 18 of the ingot mold. The tubular opening 17 of the hopper is elevated a slight distance above the opening 18 of the ingot mold to allow a free space for the escape of gases from the molten metal in the ingot mold. At the beginning of the casting operation the lower end of the ingot mold is closed by a circular disk or bottom 19 of substantially the same diameter as the inside of the ingot mold 1, and consequently slightly smaller than the flared open end 3. Supported upon the bottom 19 with its upper edge bearing against the inner surface of the ingot mold is a wall or dam 20 formed of some plastic refractory material, such as fire clay or plumbago, and thereby entirely closing the lower end of the ingot mold 1, so that the molten metal poured through the open end 18 will gradually fill the mold. The bottom 19 is carried by a head 21, provided with an enlarged upper end 22 extending above the bottom 19 and adapted to be inclosed within the mass of molten metal as the ingot mold is filled. The head 21 is detachably connected to an ingot withdrawing rod 23, preferably connected at its lower end to the piston rod of an hydraulic cylinder, not

shown, by which the bottom 19 and head 21 is supported in position to close the ingot mold 1, and by which the ingot when properly cooled may be withdrawn through the lower end of the mold by the engagement of the end of the ingot with the enlarged end 22 of the head 21, as shown in Fig. 3. Attached to the under side of the lower head 13 is a cup shaped shell 24 from which is suspended a tubular extension 25, with its upper end projecting into the shell 24 to form an annular space 26 which is connected by a pipe 27 with a source of steam supply under pressure. The interior diameter of the pipe 25 is slightly larger than the interior diameter of the ingot mold 1, so that when an ingot 28 is drawn through the pipe 25, an annular space 29 will be formed around the ingot in communication with the interior of the cup shaped shell 24, so that steam entering the annular space 26 in the shell 24 may pass over the upper end of the pipe 25 and downward into the annular space 29 around the ingot 28.

In order to secure a uniform distribution of steam around the ingot I interpose into the path of the steam an annular plate 30 having a series of small holes 31 through which the steam passes from the annular space 26. Attached to the lower end of the pipe 25 is a tip 32 having the diameter of its lower or delivery end 33 contracted to the interior diameter of the ingot mold 1, and around the interior of the delivery end 33 are a series of longitudinal grooves 34 which, when the ingot 28 fills the delivery end of the tip, forms a series of channels through which steam admitted through the upper end of the pipe 25 is allowed to escape.

The operation of my improved apparatus is as follows:—The bottom 19 carried by the end of the withdrawing rod 23 and having mounted thereon a plastic wall or dam 20 made of some refractory material is inserted in the lower end of the ingot mold 1, thereby closing the lower end of the mold to the passage of molten metal. A current of cooling water is made to pass through the annular chamber 11 surrounding the mold 1 and the latter is filled with molten metal from the hopper 16 through the restricted opening 17 in the bottom of the hopper which is elevated some distance above the open upper end of the ingot mold, in order that the metal may give off its neutral or other gases. The employment of water in the annular chamber 11 acting upon the outside of the thin pipe forming the ingot mold begins at once to cool the ingot and form a semi solidified shell 35 as indicated by the heavier shading in Fig. 3. At the proper stage in the process of solidification a longitudinal movement is given to the withdrawing rod 23 either by a hydraulic cylinder, not shown, or by other suitable means, thereby drawing the ingot from the lower end of the ingot mold 1 into and through the extension tube 25, while at the same time a fresh supply of molten metal is fed to the upper end of the ingot mold to fill the space caused by the withdrawal of the ingot. The longitudinal movement of the ingot and the supply of molten metal to the ingot mold are made to correspond with each other and both are regulated to correspond with the cooling of the metal in the mold. When the movement of the ingot and the feeding of the fresh metal has thus been adjusted, the continuous formation of an ingot in the mold will become automatic and as the upper end of the semi solidified shell 35 is drawn downward in the ingot mold, a clearance is effected between the ingot and the inner tapering wall 2 of the ingot mold. As the ingot passes the interior tapering wall 2 it is expanded to completely fill the mold by the weight of the superimposed column of molten metal. Ample clearance is provided for the ingot at the lower end of the mold 1 by slightly flaring the lower end of the mold as shown at 3, the enlargement of the inner diameter of the mold at its lower end being sufficient to compensate for the decreased expansion liable to exist at the extreme lower end of the mold owing to its being confined within the lower head 13 and subjected to the initial cooling action of the stream of water passing through the annular space 11. As the ingot is drawn through the extension tube 25 it is further subjected to the cooling action of a current of steam under pressure which is admitted through the pipe 27 to the annular space 26, and passing through the perforations 31 of the annular plate 30 it enters the upper end of the pipe 25 and is crowded downward until it escapes through the series of grooves 34 at the lower end of the tip 32. As the grooves 34 form a restricted exit for steam from the extension pipe 25, a body of steam is maintained within the annular space 29 having a pressure substantially equal to the initial pressure of the steam received through the pipe 25, said pressure being uniformly applied to the entire outer surface of the ingot and serving to resist the lateral pressure of the vertical column 36 of fluid metal which would otherwise tend to bulge or expand the more or less plastic retaining wall of the ingot.

The length of the interior tapered wall 2 of the ingot mold relatively to the entire length of the mold itself can only be determined by experiment and it will depend upon the rapidity of the cooling process by which a semi-solidified shell or skin is formed upon the ingot, and also upon the longitudinal movement of the ingot as it is withdrawn from the mold by the withdrawing rod 23, but it should be of such length as will afford a clearance to the ingot as it is withdrawn and allow the weight of the superimposed column of molten metal to expand the shell

or skin of the ingot so it will fill the interior of the mold. In the operation of cooling the ingot I prefer to admit a stream of water through the pipe 15 and discharge it through the pipe 12 as the colder water is then applied to the lower end of the ingot mold where the ingot has already become partially cooled, and as the current of water rises in the annular space 11 toward the top of the ingot mold, it will have already become heated as it flows around the more heated portion of the ingot mold.

As the ingot is withdrawn from the lower end of the ingot mold 1 its outer shell or skin will have become thickened, while its interior or core still remains in a fluid or semi-fluid state. In this condition the ingot is drawn through the extension tube 25 surrounded by a body, preferably of steam under pressure, which provides a yielding wall in contact with the outer surface of the ingot and exerting a pressure thereon sufficient to withstand the interior pressure caused by the column of molten metal forming the core of the ingot. As the steam is admitted through the pipe 27 to the upper end of the extension tube 25 it will become gradually superheated as it passes downward through the annular space 29 until it finds an exit at the lower end of the extension tube 25 through the grooves or channels 34. The greatest cooling effect of the steam therefore is produced at the upper end of the extension tube 25 where the ingot is the hottest, and as the ingot becomes gradually cooler toward the lower end of the extension tube 25, the steam becomes gradually hotter, so that its cooling effect upon the ingot is greatly reduced. At the same time a radiant heat from the core of the ingot is allowed to diffuse itself through the already thickened shell of the ingot, so that the heat as the ingot leaves the extension tube 25 has become uniformly diffused through the entire mass of the ingot, this operation being substantially the same as that now practiced in the ordinary method of working ingots and known as "soaking".

The presence of a yielding body like steam in the annular space 29 entirely surrounding the ingot enables the ingot to be drawn through the extension tube practically without friction. The sudden cooling of the ingot at the upper end of the extension tube 25 by the first impact of steam and the subsequent re-heating of the outer shell of the ingot has a tempering effect which improves the quality of the metal somewhat similar to the well known effect produced upon metal by rapid cooling and heating and for this reason I have termed the extension tube with its annular space 29 a "tempering chamber", the suitable length of which can only be determined by experiment and depending upon the size of the ingot, the temperature and pressure of the steam, the rapidity of movement of the ingot through the tempering chamber and the extent to which the ingot has been cooled when it leaves the ingot mold.

I have shown in the accompanying drawings a tempering chamber of nearly the same length as the ingot mold, but it may be found advisable to make the tempering chamber several times the length of the ingot mold, and I think it may profitably be made to extend from the ingot mold to the rolls of a rolling mill by which the ingot may be reduced in cross section. If such reducing rolls are placed near the delivery end of the tempering chamber, the ingot will be practically protected from contact with the outside air from the time it leaves the ingot mold until it enters the reducing rolls, and if the tempering chamber be filled with steam under pressure or with neutral gases, the amount of oxidation of the ingot may be appreciably reduced.

It will be observed, therefore, that the tempering chamber performs a variety of useful functions among which may be mentioned, first, the reduction of friction upon the moving ingot; second, the application of pressure to resist the expansive power exerted by the fluid core of the ingot; third, to continue the operation of cooling and solidifying the shell of the ingot as it enters the tempering chamber; fourth, to produce a tempering effect upon the shell of the ingot by which the quality of the metal is improved; fifth, to secure a uniform diffusion of heat through the mass of the ingot as it leaves the tempering chamber by the process of "soaking", and sixth, to protect the ingot from undue oxidation.

What I claim as my invention and desire to secure by Letters Patent is:—

1. In an apparatus for casting ingots, the combination of an ingot mold having its upper or receiving end reduced in diameter to form slightly inclined sides, means for cooling the outer surface of the ingot in the mold, and means for imparting a longitudinal movement to the ingot from the receiving end toward the delivery end of the mold.

2. In an apparatus for casting ingots, the combination with an ingot mold open at both ends and having its upper or receiving end reduced in diameter to form slightly inclined sides, means for cooling the outer surface of the ingot in the mold, means for feeding molten metal to the receiving end of the mold, and means for withdrawing the ingot from the delivery end of the mold.

3. In an apparatus for casting ingots, the combination of an ingot mold having its delivery end increased in diameter, a removable bottom of less diameter than the delivery end of the mold, and a dam mounted on said bottom and closing the annular space

around the bottom, and means for cooling the ingot in said mold.

4. In an apparatus for casting ingots, the combination with an ingot mold, of a pipe inclosing a tempering chamber of larger diameter than said mold, said chamber arranged in alinement with said mold, means at the top of said chamber for admitting steam simultaneously upon all sides of an ingot in said chamber, and means at the bottom of said chamber for the simultaneous escape of steam from all sides of the ingot in said chamber.

5. In an apparatus for casting ingots, the combination with an ingot mold and a tempering chamber in alinement therewith but with their opposing ends separated, an annular cup shaped shell inclosing the space between the mold and the receiving end of the chamber, and means for admitting steam to said cup shaped shell.

6. In an apparatus for casting ingots, the combination with an ingot mold and a tempering chamber in alinement therewith, but with their opposing ends separated, an annular cup shaped shell inclosing the space between the mold and the receiving end of the tempering chamber, and having an inclosed space for steam under pressure communicating with the tempering chamber.

7. In an apparatus for casting ingots, the combination with an ingot mold, of a tempering chamber of greater diameter than the mold and in alinement with said mold but separated therefrom, a shell inclosing the space between the mold and the receiving end of said tempering chamber, and having an annular space for steam under pressure communicating with the interior of said tempering chamber, whereby a yielding annular wall of compressed steam is provided between the ingot and the wall of the tempering chamber.

8. In an apparatus for casting ingots, the combination with an ingot mold, of a tempering chamber in alinement with said mold and having its inner diameter greater than the diameter of the ingot, thereby forming an annular chamber around the ingot, means for admitting an annular blast of steam to the top of said chamber around said ingot and a restricted opening surrounding the ingot at the bottom of said chamber for the escape of steam from said chamber, whereby steam under pressure is constantly maintained in said chamber.

9. In an apparatus for casting ingots, the combination with an ingot mold, of a tempering chamber in alinement therewith but of greater diameter, an annular shell around the receiving end of said tempering chamber and having an inclosed annular chamber communicating with the interior of said tempering chamber, means for admitting steam under pressure to said annular chamber, and a restricted opening at the lower end of said tempering chamber for removing steam therefrom.

10. In an apparatus for casting ingots, the combination with an ingot mold, of an extension tube at the delivery end of said mold having its interior diameter greater than the diameter of the ingot, a metallic head uniting said tube and mold and inclosing an annular space communicating with the interior of the extension tube, an inlet pipe to said annular space and an outlet at the opposite end of the extension tube, whereby steam admitted at the upper end of the extension tube may become superheated by its contact with the heated ingot, and means for moving an ingot from the mold through said extension tube.

11. In an apparatus for casting ingots, the combination with an ingot mold, of a pipe inclosing a chamber of larger diameter than said ingot mold, said chamber forming an extension of said mold and communicating therewith, said pipe provided at its ingot receiving end with an opening for the admission of steam, and at its ingot delivery end with an opening for the escape of steam, with the area of said openings arranged to allow the escape of steam more slowly than its entrance, whereby a predetermined pressure of steam may be maintained in said pipe in contact with said ingot.

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Witnesses:
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