J. F. MONNOT.

PROCESS AND APPARATUS FOR MAKING METAL INGOTS.

APPLICATION FILED JUNE 15, 1908.

944,370. Patented Dec. 28, 1909.

2 SHEETS—SHEET 1.

Fig. 1.

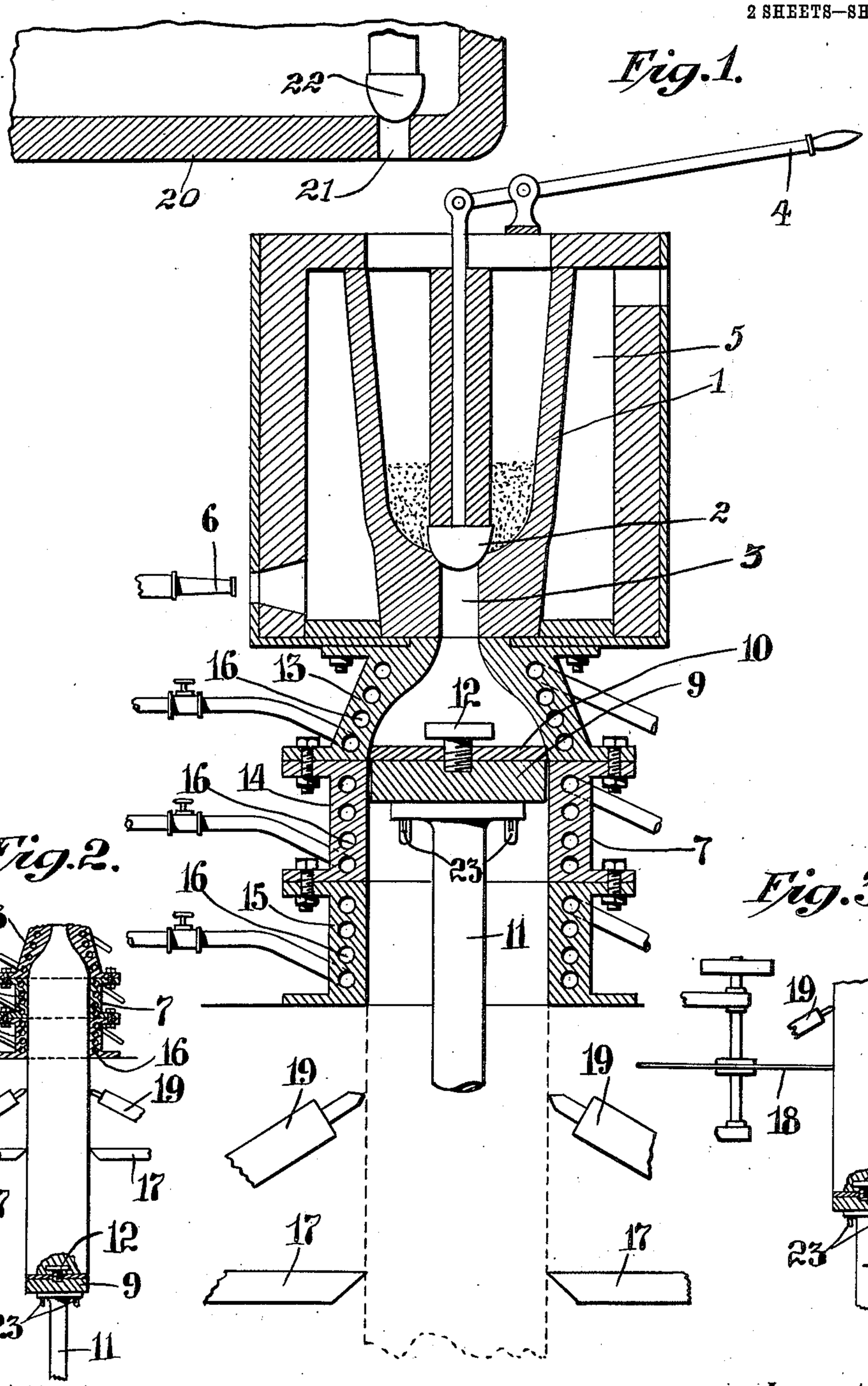
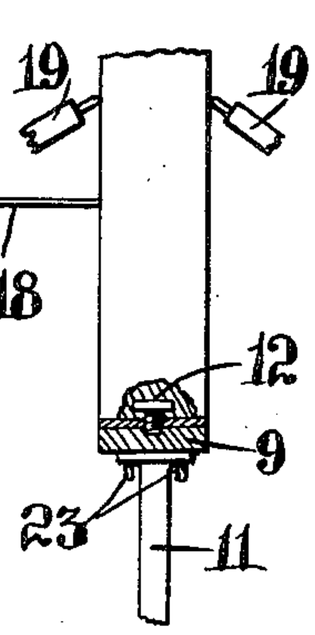


Fig. 2.

Fig. 3.



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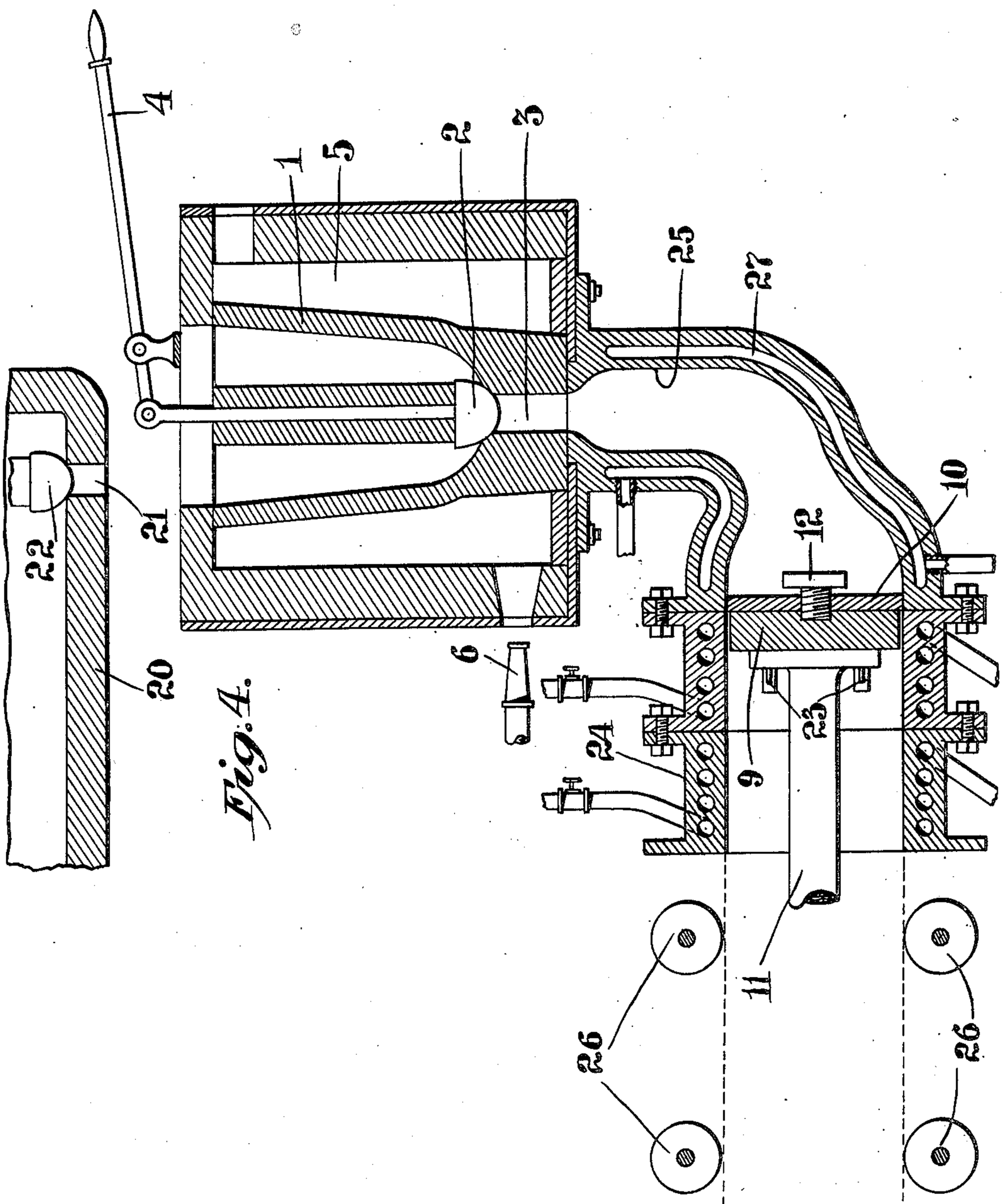

Fig. 4.

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PROCESS AND APPARATUS FOR MAKING METAL INGOTS.

944,370. Specification of Letters Patent. **Patented Dec. 28, 1909.**

Application filed June 15, 1908. Serial No. 438,679.

To all whom it may concern:

Be it known that I, JOHN F. MONNOT, a citizen of the United States, residing at New York, county of New York, and State of New York, have invented certain new and useful Processes and Apparatus for Making Metal Ingots; and I do hereby declare the following to be a full, clear, and exact description of the same, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to a process of and apparatus for making metal ingots; and my invention comprises a continuous process whereby molten metal may be cast into a mold, caused to solidify therein as a flawless casting, withdrawn from the mold and cut to desired lengths, without stopping the operation of the apparatus or checking the flow of molten metal into the mold; and my invention also comprises apparatus for carrying out the above process.

In the ordinary methods of making metal ingots, particularly steel ingots, it is difficult to produce sound and flawless castings because of occlusion and entrainment of air and gases, oxidation, the irregular contraction and piping, etc. In a common method of operating a number of ingot molds are placed on a pouring table, and are connected at the bottom through ducts in said table with a central riser. Steel is poured into this riser and passes therefrom into the ducts and the ingot molds until all the latter are full; after which the pouring is stopped, the molten metal allowed to solidify, the ingot molds are emptied and the operation repeated. The operation is an intermittent one, and requires a large number of ingot molds, also a considerable investment in pouring tables, etc., and the tables themselves are quite bulky. Pouring the ingot molds from below is resorted to in order avoid, so far as possible, entrainment of air in the metal, to permit filling of a number of molds at one operation, to facilitate rise of impurities to the top of the metal in each mold, and for various other reasons. But as is well known, ingots so produced are of poor quality at or near the center, there being more or less extensive "pipes" at the center which necessitate immediate and vigorous working of the metal in the attempt to press out these pipes and weld the sides of the pipes together and to condense the metal; furthermore, the metal at the top of the ingot is always of poor quality, for which reason it is the custom to cut off or "crop" the upper portion of each ingot, the metal so cut off being remelted. Much waste therefore results. Furtheremore, steel as made to-day, particularly Bessemer steel, is apt to contain much oxid, presence of which materially impairs the quality of the steel, rendering its strength uncertain and making it particularly subject to oxidation.

I have discovered that, (as set forth in my application Sr. No. 391,674, filed Sept. 6, 1907 on which Patent No. 929,688 was granted August 3, 1909,) the formation of entrained and occluded gases, oxid and other impurities may be prevented and these impurities present may be removed from molten metal in the process of casting, and a very good quality of metal obtained, by casting the molten metal through a deep or substantial layer of molten flux or equivalent material, such as water glass, glass, neutralized borax, etc.; and to such materials I have applied the term "wiping material"; and as also set forth in said application, I have found that by delaying the cooling of the upper portion of the ingot, forming at the top of the ingot a pool of molten metal which remains molten after the main portion of the ingot has solidified, piping and the like in the ingot may be substantially overcome, the molten metal in this upper portion of the ingot serving to compensate for shrinkage, to fill up any pipes, blowholes and the like which may form, and so to make a very dense and homogeneous metal. Vitreous materials being very poor conductors of heat, the layer of flux above the top of the ingot serves efficiently in preserving the heat of this pool of molten metal and securing the desired delayed cooling.

According to the present invention, I provide a suitable crucible or receptacle containing a substantial body of molten wiping material, and provided with a pouring hole through which its contents may be discharged into a mold below. This crucible or receptacle I commonly locate in a furnace by which it may be kept hot constantly for long periods of time, so as to keep the wiping material molten. Said crucible or receptacle is provided with a discharge opening communicating with an ingot mold

below it, said ingot mold being open at the bottom, but provided, initially, with a movable false bottom formed by the plunger of a suitable ram or equivalent device. The said crucible being partly filled with molten wiping material, molten metal from a suitable source of supply is admitted into said crucible and permitted to replace the wiping material at the bottom thereof, owing to the greater specific gravity of the molten metal; and when a sufficient quantity of molten metal is in said crucible, as shown by the level of the wiping material therein floating on the molten metal, to form a substantial body thereof the discharge opening is opened and the molten metal permitted to flow down into the mold. When the level of the flux or wiping material in the crucible begins to rise, indicating that the space between the false bottom of the mold and the crucible is full of molten metal, said false bottom is permitted or caused to descend slowly, carrying with it the contents of the mold, the upper part of the mold being kept full, meanwhile, by molten metal descending from the crucible above, and more molten metal being continuously admitted to the crucible to replace that which escapes therefrom and maintain the substantial body of such metal. The ingot mold is of such length, or is provided with such cooling means, that the metal will be solid by the time the bottom of the ingot mold is reached. When a suitable length of molten metal has emerged at the bottom of the mold, suitable cutting means cuts off the protruding length of metal, and the portion so cut off is removed, the metal continuing to descend, and new lengths being cut off from time to time, in the same manner. Each length so cut off is an ingot, and may be taken away and worked. The operation may continue in this manner so long as molten metal is supplied to the crucible. It will be observed that the molten metal admitted to the crucible reaches the discharge opening thereof only by passing down through the substantial layer of wiping material, whereby it is freed from entrained and occluded gases, oxid impurities etc., the several drops or bodies of molten metal being wiped free of gases and impurities and left clean-surfaced and in a condition to coalesce to a homogeneous body of molten metal; and it will further be observed that the upper portion of the ingot mold always contains molten metal, which will fill in spaces left by shrinkage, etc., so that piping is avoided. Furthermore, the metal must be of even quality throughout, and hence the necessity of cropping the upper portion of each ingot does not exist. The pool of molten metal being comparatively quiet (since dense liquids do not agitate readily any contained oxid, cinder, slag or non-metallic impurity not previously removed, rises to its surface and mixes with the flux body, so that the lower portions of the pool are pure, sound metal. Under the flux cover the metal does not oxidize, neither can it entrain air with it in flowing into the molding device as customarily happens with metal filmed over with an oxid coating.

In the accompanying drawings I illustrate apparatus for carrying out my process as above described, Figure 1 showing, more or less diagrammatically, a central vertical section of one form of apparatus; Fig. 2 is a similar view on a smaller scale indicating the method of forming the ingot and cutting off sections therefrom; Fig. 3 is a similar view to Fig. 2 illustrating alternative means for cutting off sections of the ingot; Fig. 4 is a view similar to Fig. 1 illustrating an alternative form of apparatus.

In Fig. 1, 1 designates the said crucible or receptacle for molten wiping material and for molten metal; 2 designates the usual stopper for closing the discharge opening, 3, in the bottom of the crucible, and 4 the customary handle for raising or lowering said stopper. To keep the wiping material in the crucible molten during periods of rest, and to avoid possible chilling of the molten metal, I provide suitable means for heating the crucible, the particular means illustrated being a furnace 5 into which the crucible is set and which is provided with a burner 6 for surrounding the crucible with flame.

7 designates the ingot mold, the upper portion of which is tapering, as shown, and provided with an opening 8 registering with the discharge opening 3 of the crucible; and 9 designates the false bottom for the ingot mold, having a refractory lining, 10, said false bottom supported on a plunger, 11, which may be connected to any suitable mechanism, not shown, for raising and lowering it; for example, the piston of a hydraulic cylinder. Once the ingot mold is full of metal the weight of the metal will, in general, insure steady feed of the metal down through the mold, and it may even be necessary to check the rate of descent of the metal by means of the false bottom, 9, which then becomes a movable platform below the mouth of the ingot mold and against which the end of the ingot rests; but at the commencement of operations it may be necessary to pull the metal toward the bottom of the ingot mold, for which reason I show the false bottom provided with a T-head, 12, which will be embedded in the metal as the latter surrounds it and solidifies, and will permit the plunger 11 and the mechanism which operates that plunger to draw the ingot down until its weight suffices to insure further feeding. When the first length of the ingot has been cut off this T-head may be removed with it, the false bottom there-

after serving merely as a support for the end of the ingot.

To insure solidification of the ingot before it leaves the mold, and to avoid use of a mold of excessive length, said mold is preferably provided with cooling means, as for example a water jacket. Since different portions of the mold will commonly require cooling to different degrees, the mold is preferably formed in sections, each having its independent jacket. I have shown the mold as comprising three such sections, 13, 14, and 15, each provided with a separate jacket, 16. There may be a greater or less number of sections to the mold, as conditions may require. Preferably the mold has a slight taper, to facilitate the feeding down of the ingot.

For cutting off the ingot, any suitable cutting means may be employed. I have indicated for the purpose shear blades, 17, 17, which in practice will usually be worked hydraulically, but do not limit myself thereto. In Fig. 3 I have indicated a hot saw 18 for the same purpose. To support the weight of the upper portion of the ingot, still in the mold, while a portion of the ingot is being cut off, suitable supporting means may be provided, for example, plungers 19 with pointed ends. These plungers may be actuated hydraulically or otherwise.

The molten metal for the ingot may be drawn from any suitable source, for example, from the usual ladle 20 having a pouring hole 21 in its bottom adapted to be closed by a stopper 22.

The method of carrying on the process is as follows: The crucible 1 being charged with a suitable quantity of molten wiping material, and being kept molten as described, and the ladle 20 being over this crucible, the stopper 22 is raised, (stopper 2 of crucible 1 being down) and the molten metal from ladle 20 is allowed to run into the crucible, wherein it passes through the layer of molten wiping material to the bottom, displacing the wiping material and raising it. When the level of the wiping material shows that there is a sufficient quantity of metal in the crucible, stopper 2 is raised, false bottom 9 being near the top of the mold 7, and the molten metal is permitted to run into the mold, the false bottom being gradually lowered as the rise of the wiping material in the crucible shows that the mold is full above the false bottom. The flow of cooling fluid through the jackets of the several sections of the mold causes regulated cooling of the ingot, until when the ingot emerges from the mold it will be entirely set, the interior being certainly no more than plastic. When a sufficient length of the ingot has emerged from the mold the descent of the false bottom or platform 9 is checked temporarily, the supporting plungers 19 are advanced until they support the ingot above where the cutters are to operate, the shear blades or other cutting device is caused to operate, and the section of the ingot so cut off is carried off for working, the platform 9 being then raised into contact with the new end of the ingot, the plungers 19 retired, and the ingot permitted to descend again.

The end of the ingot which has been cut off, if locked to the platform 9 by means of the T-head 12 or otherwise, is readily freed by driving out keys 23 and removing the platform altogether, a new platform being put in its place.

When for any reason the metal has all been drawn off from the crucible 1 the stopper 2 thereof is closed to retain the wiping material in the crucible, this wiping material being kept molten by the heat of the furnace, as described.

By the method described a pure metal casting of homogeneous texture may be obtained in a cheap and practically continuous operation. Pipes, blow-holes, and the like are rendered impossible, as all entrained and occluded gases are removed by the action of the molten wiping material on the stream of molten metal passing through such wiping material to the lower portion of crucible 1, and oxid impurities and the like are removed in the same manner. The metal will be of very dense texture for this reason and also because it is cast under the pressure of the column of molten metal and of the wiping material above it; and all portions of the ingot are, it will be seen, exposed to the same degree of pressure.

The center of the ingot solidifies last, and is supplied with metal by the column of molten metal above it to compensate for shrinkage and prevent piping, so insuring a sound ingot. Each separate ingot being cut off from the end of the continuous ingot passing down through the mold, there are no crop ends, and, consequently, the loss of metal in the operation and in the subsequent working is reduced to a minimum.

The process above described is particularly adaptable to the making of steel ingots, but is also applicable to the making of ingots of other metals, copper and brass for example.

It will be understood that any suitable cooling medium may be passed through the jackets of the ingot mold. Instead of circulating water therethrough, air or other gas may be passed therethrough or expanded therein.

In Fig. 4 I illustrate an alternative form of the apparatus, the upper portion of which is substantially the same as of the apparatus shown in Fig. 1, the ingot mold here numbered 24 being horizontal and having an elbow connection 25 within crucible 1. The

false bottom 9 becomes in this case, a horizontally movable piston provided with the T-head 12 to draw out the ingot as formed until it can be engaged by feeding rollers 26 by which it can be fed out continuously as produced. Either of the cutting off means shown in Figs. 2 and 3 or any other suitable cutting off means may be employed.

The cooling jackets of the sections of the mold need not necessarily be spiral conduits as indicated in Fig. 1. In Fig. 4 I have illustrated the cooling jacket of section 25 of the ingot mold as a continuous jacket 27.

What I claim is:—

1. A process of casting metal ingots which comprises casting molten metal down through a layer of fused wiping material into one portion of a mold to form a molten body therein at one point and causing the metal to move through such mold and to emerge therefrom at another point in a solidified state.

2. A process of casting metal ingots which comprises casting molten metal down through a layer of fused wiping material into one portion of a mold to form a molten body therein at one point and causing the metal to move through such mold and to emerge therefrom in a solidified state at another point, and cutting the metal into lengths successively as it so emerges.

3. A process of casting metal ingots which comprises casting molten metal through a layer of wiping material into a mold and causing the metal to move through such mold during solidification and to emerge therefrom at another point.

4. A process of casting metal ingots which comprises casting molten metal through a layer of wiping material into a mold and causing the metal to move through such mold during solidification and to emerge therefrom at another point, and cutting the metal into lengths successively as it so emerges.

5. A process of casting metal ingots which comprises casting molten metal down through a layer of fused wiping material into one portion of a mold and causing the metal to move through such mold during solidification and to emerge therefrom at another point, and cooling the ingot as it passes through said mold.

6. A process of casting metal ingots which comprises casting molten metal down through a layer of fused wiping material into one portion of a mold and causing the metal to move through such mold during solidification and to emerge therefrom at another point, cooling the ingot as it passes through said mold and cutting the metal into lengths successively as it so emerges.

7. A process of casting metal ingots which comprises casting molten metal through a layer of wiping material into a mold to form a permanent pool under such layer at one point in said mold and causing the metal to move through such mold during solidification and to emerge therefrom at another point and cooling the ingot as it passes through said mold.

8. A process of casting metal ingots which comprises casting molten metal through a layer of wiping material into a mold to form a permanent pool under such layer at one point in said mold and causing the metal to move through such mold during solidification and to emerge therefrom at another point, cooling the ingot as it passes through said mold and cutting the metal into lengths successively as it so emerges.

9. A process of casting metal ingots which comprises casting molten metal down through a layer of fused wiping material to form a pool of molten metal in a suitable mold and causing it to move therethrough and to emerge therefrom in a solid condition, and maintaining the metal in a fluent condition in one portion of the mold while the metal is solidifying and cooling in another portion thereof and so causing such molten and fluent metal to flow and compensate for shrinkage of the solidifying and cooling metal.

10. A process of casting metal ingots which comprises casting molten metal into a mold through a layer of molten wiping material to form a pool of molten metal therein, and causing the metal to move therethrough and to emerge therefrom in a solid condition, and maintaining the metal in a fluent condition in one portion of the mold while the metal is solidifying and cooling in another portion thereof, and so causing such molten and fluent metal to flow and compensate for shrinkage of the solidifying and cooling metal.

11. Apparatus for forming metal ingots comprising a mold provided with internal means for cleansing molten metal cast thereinto and having an open lower end through which a solidified ingot may emerge, in combination with a plunger movable through such mold from near the point of introduction of the molten metal to and out of the open end thereof, and adapted to form a closure for the mold to prevent escape of the molten metal until after the solidification thereof.

12. Apparatus for casting metal ingots which comprises a vertical ingot mold provided with internal means for cleansing molten metal cast thereinto and having an open lower end, in combination with a false bottom adapted to move through such mold from near the point of introduction of the molten metal to and out of the open end of the mold and adapted to prevent escape of molten metal from the mold until after solidification of such metal.

13. Apparatus for forming metal ingots comprising a mold provided with internal means for cleansing molten metal cast thereinto and having an open lower end through which a solidified ingot may emerge, in combination with a plunger movable through such mold from near the point of introduction of the molten metal to and out of the open end thereof, and adapted to form a closure for the mold to prevent escape of the molten metal until after solidification thereof, and cutting means for cutting off portions of the ingot.

14. Apparatus for casting metal ingots which comprises a vertical ingot mold provided with internal means for cleansing molten metal cast thereinto and having an open lower end, in combination with a false bottom adapted to move through such mold from near the point of introduction of the molten metal to and out of the open end of the mold and adapted to prevent escape of molten metal from the mold until after solidification of such metal, and cutting means for cutting off portions of the ingot.

15. Apparatus for forming metal ingots comprising a mold provided with internal means for cleansing molten metal cast thereinto and having an open end through which a solidified ingot may emerge, in combination with a plunger movable through such mold from near the point of introduction of the molten metal to and out of the open end thereof, and adapted to form a closure for the mold to prevent escape of the molten metal until after solidification thereof, cutting means for cutting off portions of the ingot, and supporting means for supporting the ingot while the same is being cut.

16. Apparatus for casting metal ingots which comprises a vertical ingot mold provided with internal means for cleansing molten metal cast thereinto and having an open lower end, in combination with a false bottom adapted to move through such mold from near the point of introduction of the molten metal to and out of the open end of the mold and adapted to prevent escape of molten metal from the mold until after solidification of such metal, cutting means for cutting off portions of the ingot and supporting the ingot while the same is being cut.

17. Apparatus for forming metal ingots comprising a mold and a receptacle above said mold, and provided with a deep layer of fused wiping material, said receptacle having means in its lower part for discharging molten metal into said mold.

18. Apparatus for forming metal ingots comprising a mold and a receptacle provided with a deep layer of fusible wiping material, said receptacle having means in its lower part for discharging molten metal into the mold and means for heating said receptacle.

19. Apparatus for forming metal ingots comprising a mold and a receptacle provided with a deep layer of fusible wiping material, said receptacle having means in its lower part for discharging molten metal into the mold and means for closing such discharging means.

20. In casting metal, the process which comprises producing and maintaining a molten body of inorganic wiping material comprising impurity-removing material and an underlying body of molten metal beneath said wiping material, withdrawing molten metal from a point below the surface of said body of metal and replenishing said body of metal by pouring fresh molten metal through said overlying wiping material.

21. In casting metal, the process which comprises producing and maintaining a molten body of inorganic wiping material comprising impurity-removing material and an underlying body of molten metal beneath said wiping material, withdrawing molten metal into a mold from a point beneath the surface of said body of metal, and replenishing said body of metal by pouring fresh molten metal through said overlying wiping material.

In testimony whereof I affix my signature, in the presence of two witnesses.

JOHN F. MONNOT.

Witnesses:
H. M. MARBLE,
FRANK E. RAFFMAN.