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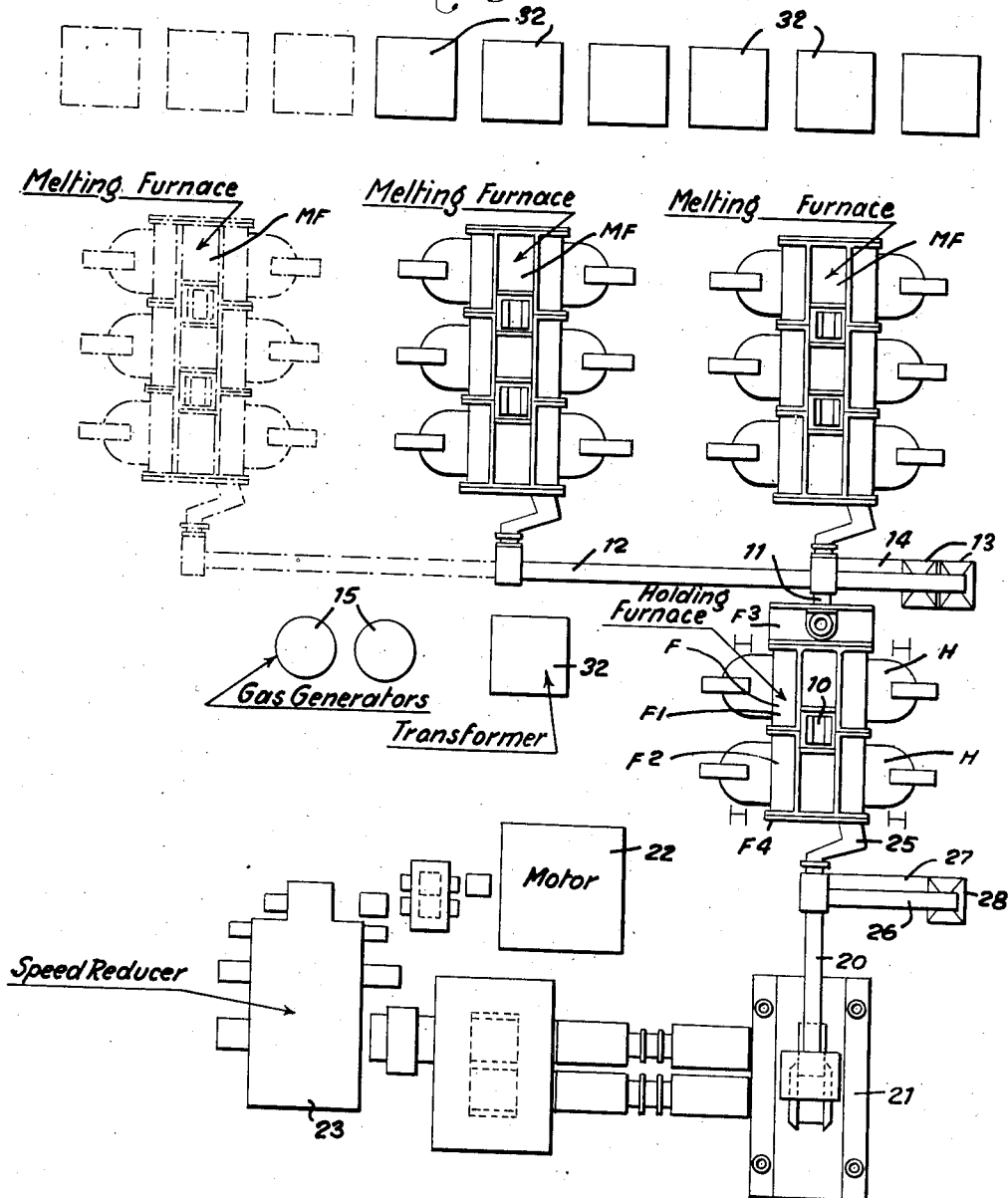
L. W. BAHNEY ET AL
METALLURGICAL APPARATUS

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Fig. 1.



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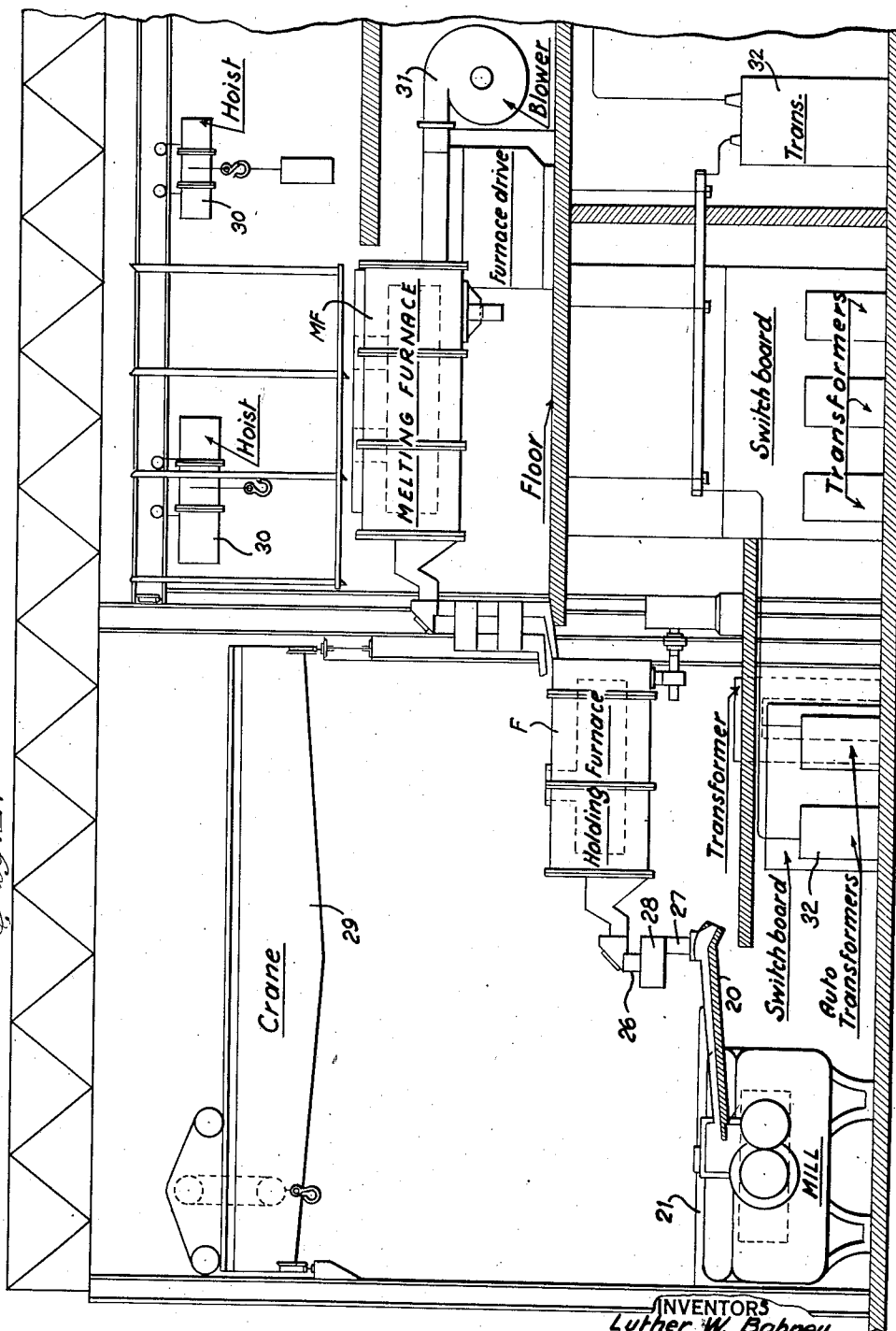
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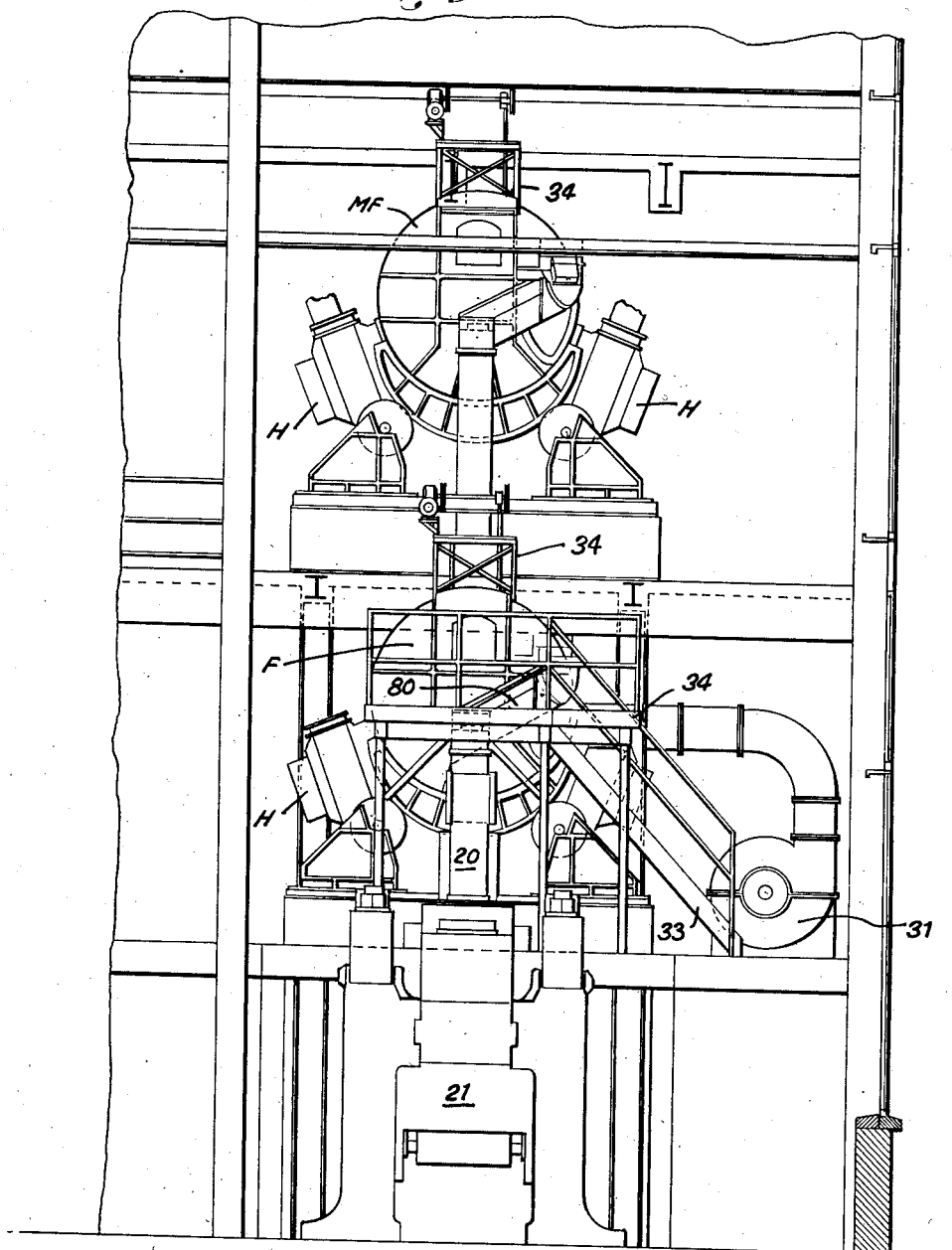
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Fig. 3.



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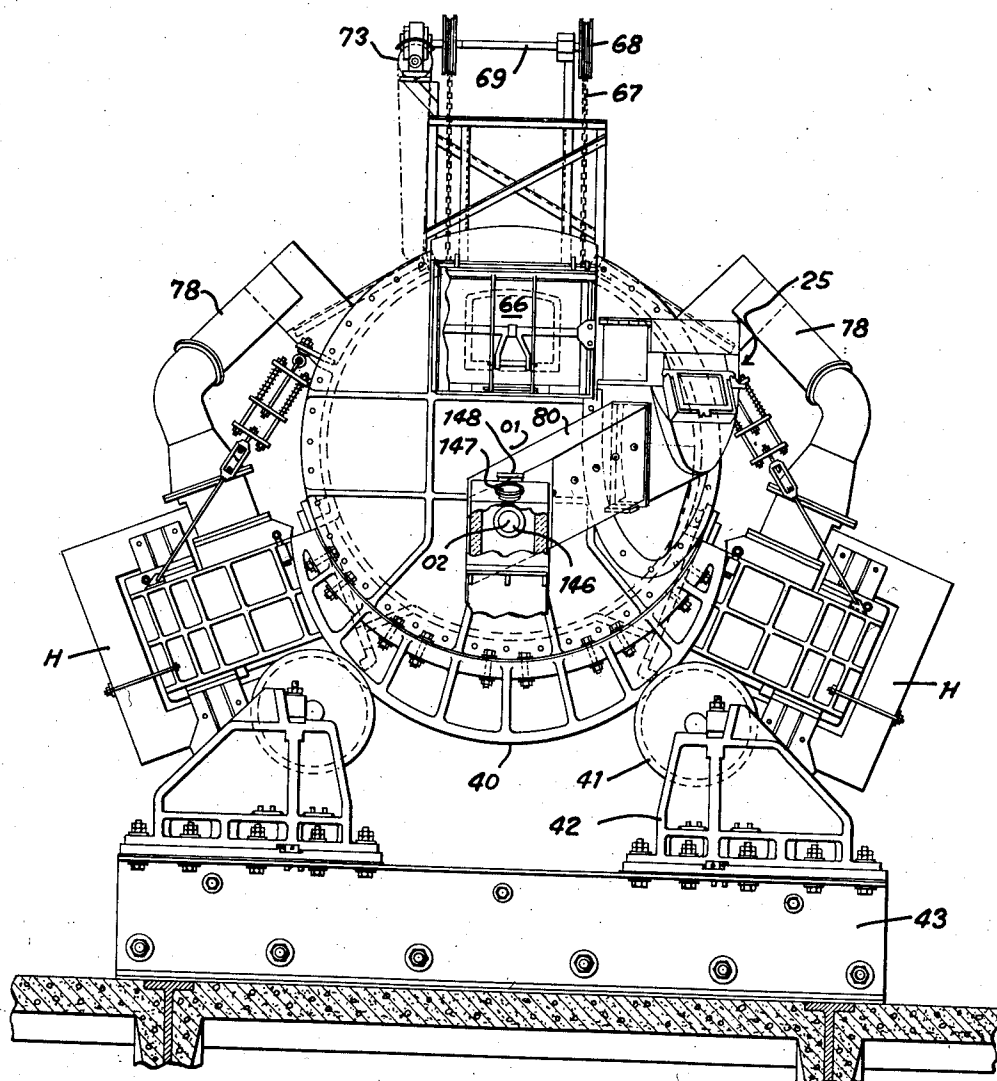
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Fig. 4.



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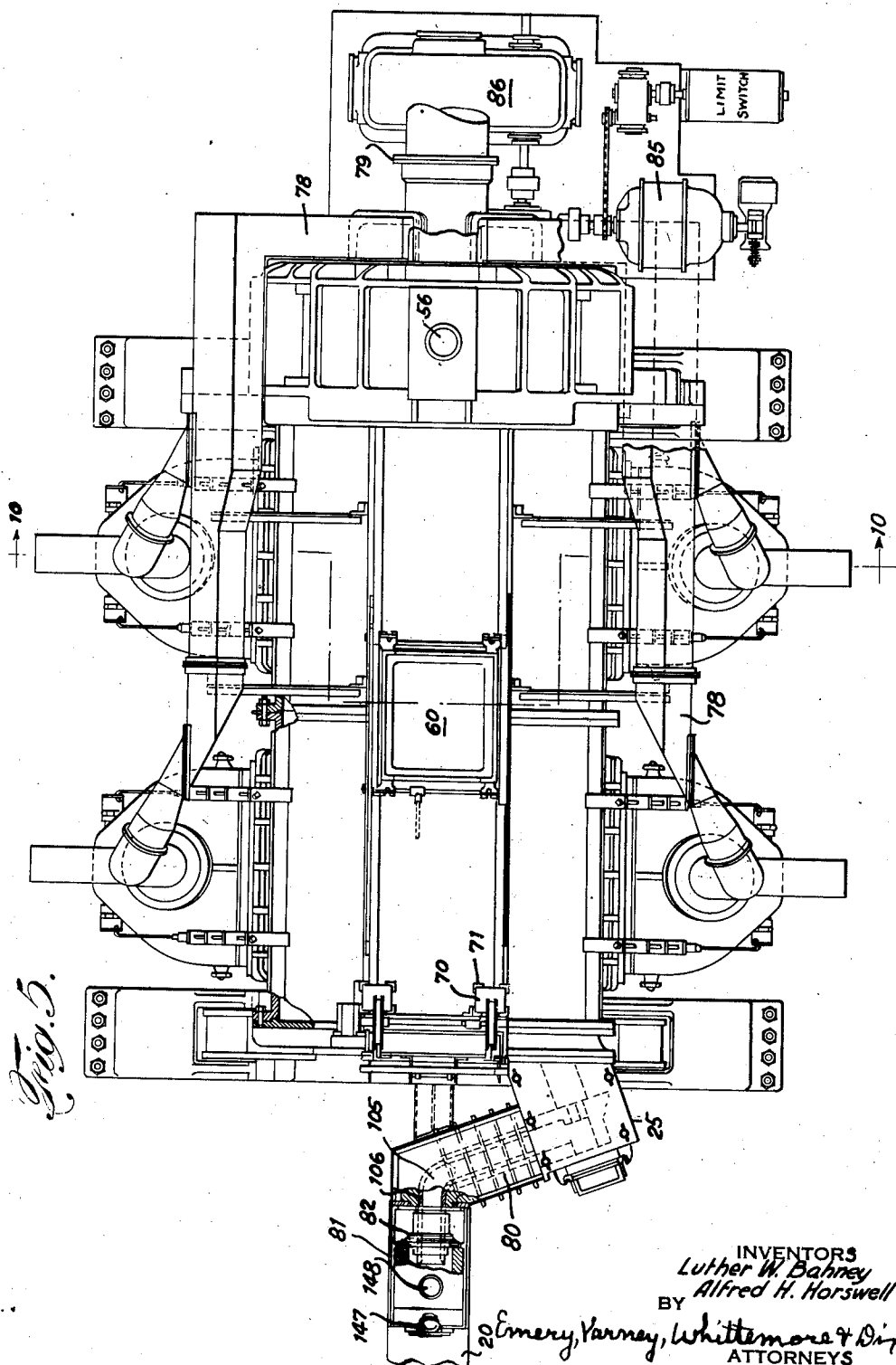
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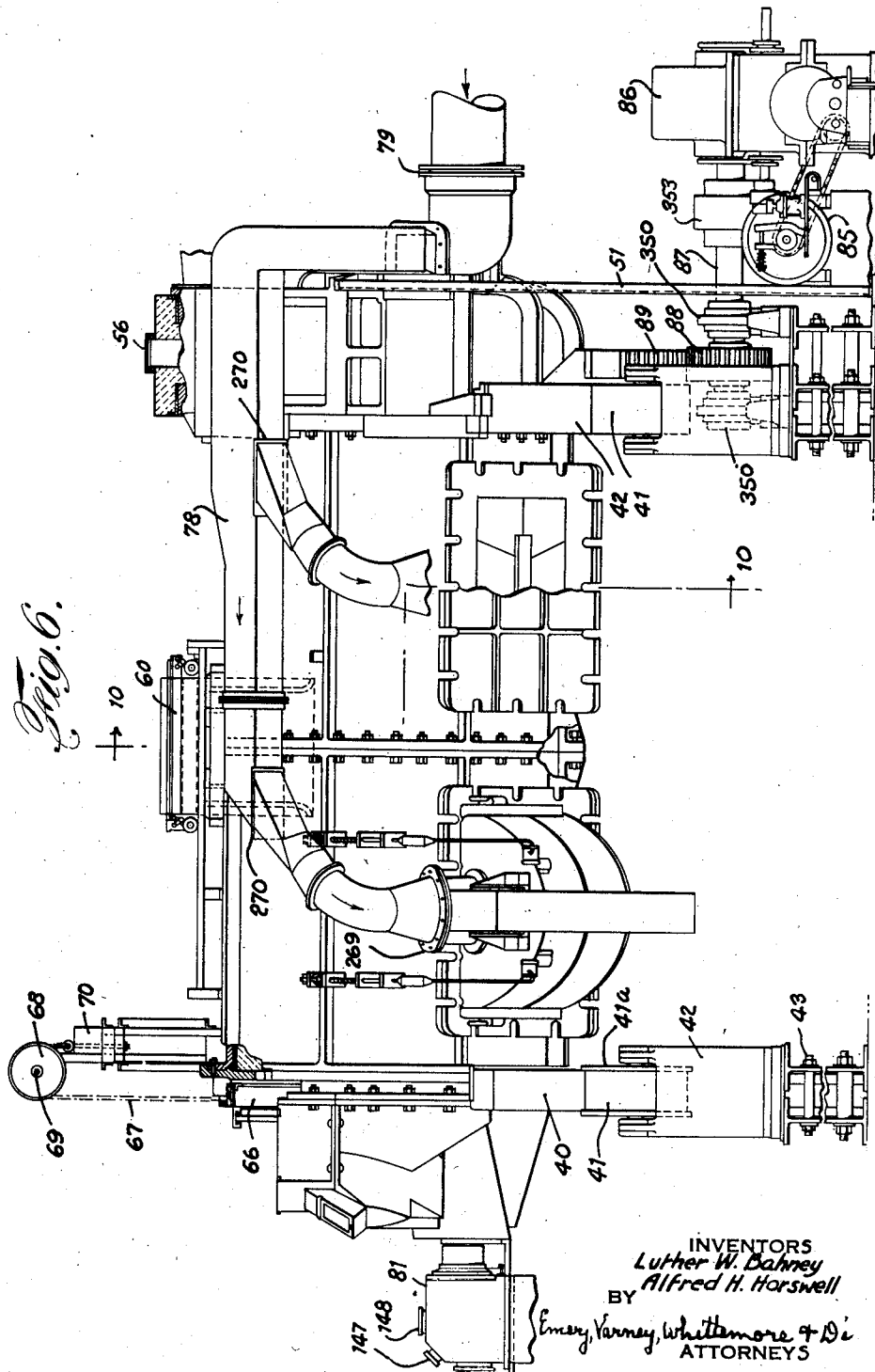
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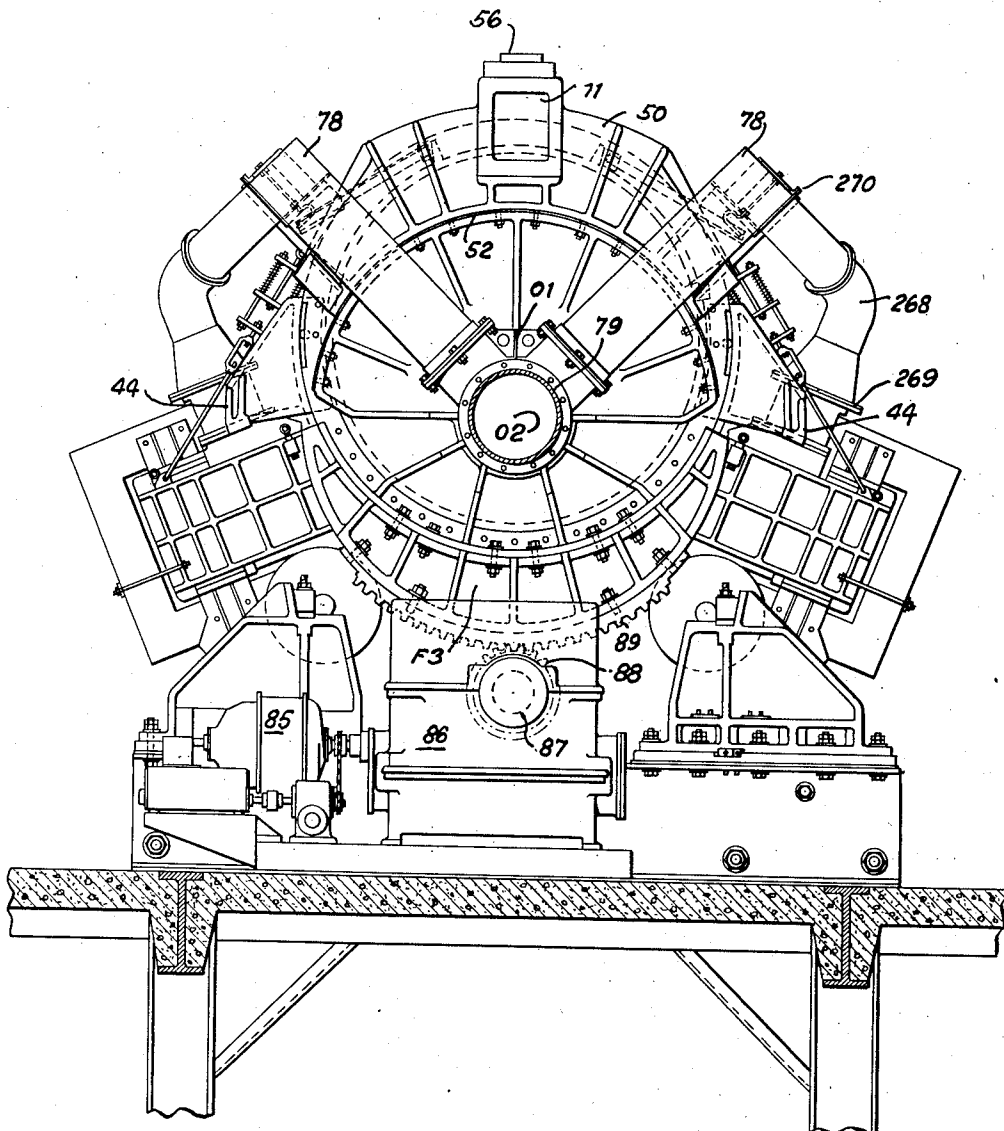
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Fig. 7.



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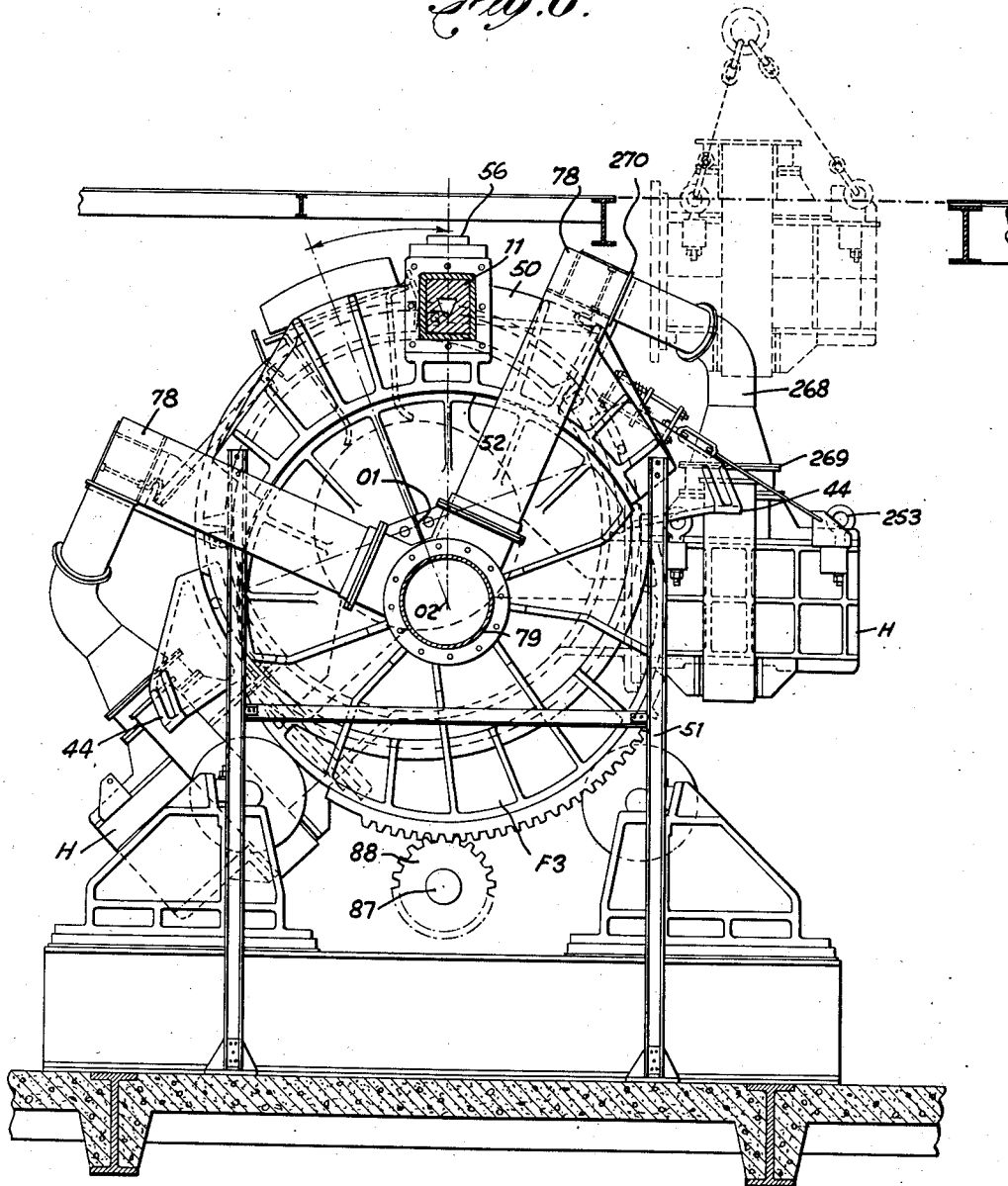
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Fig. 8.



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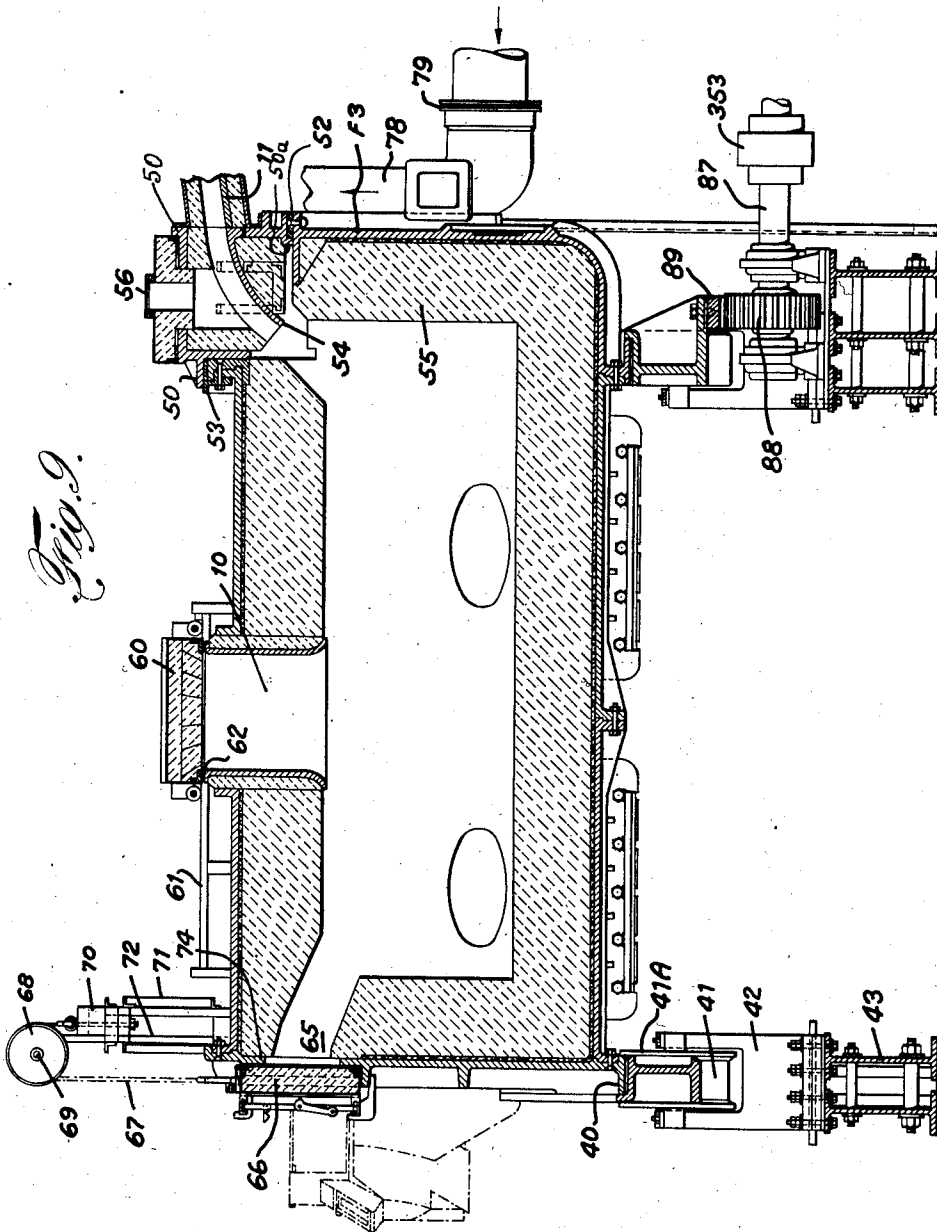
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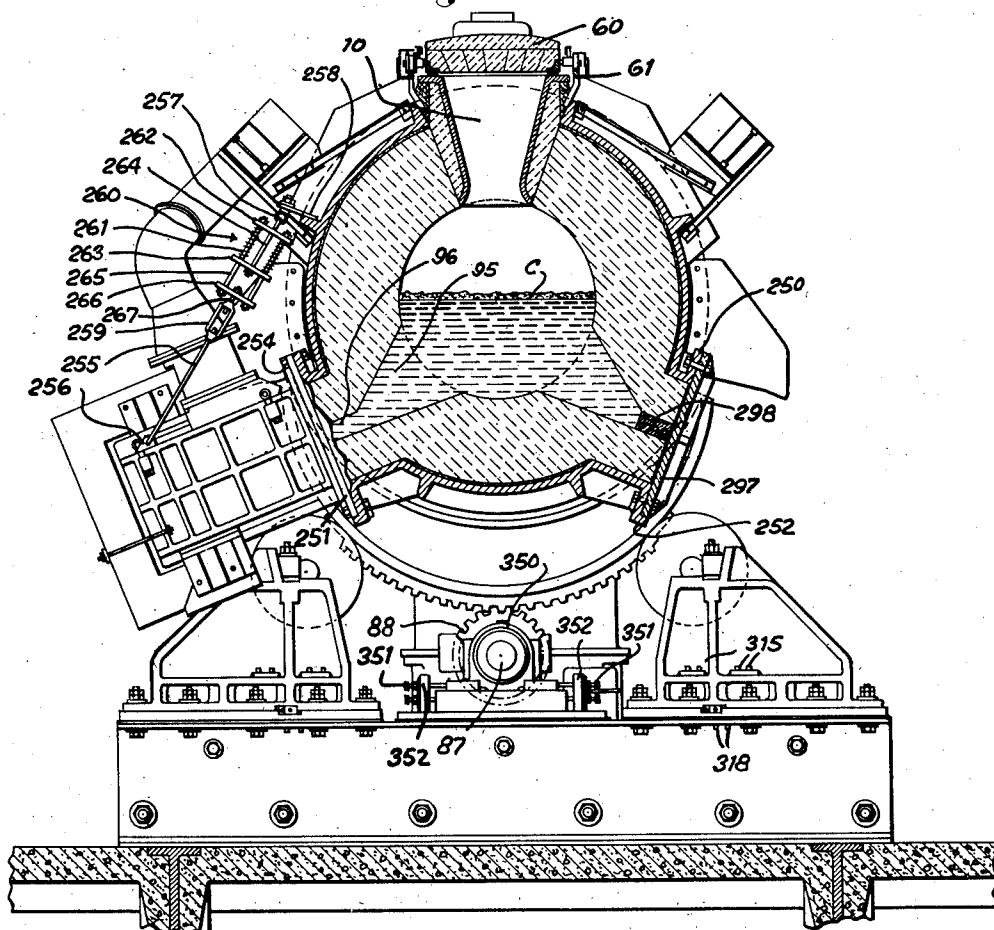
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Fig. 10.



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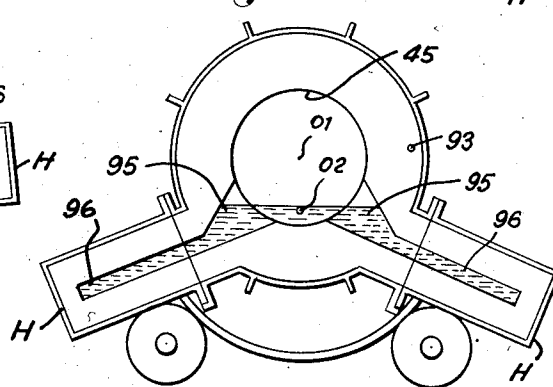
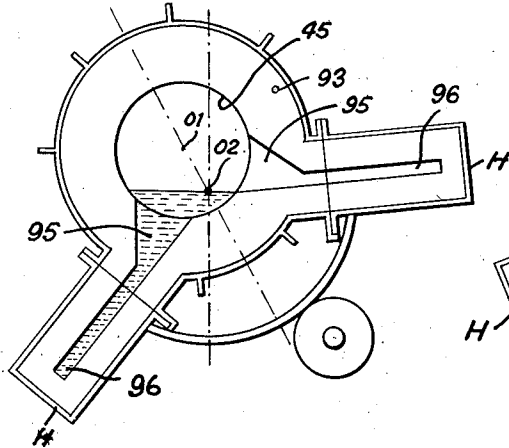
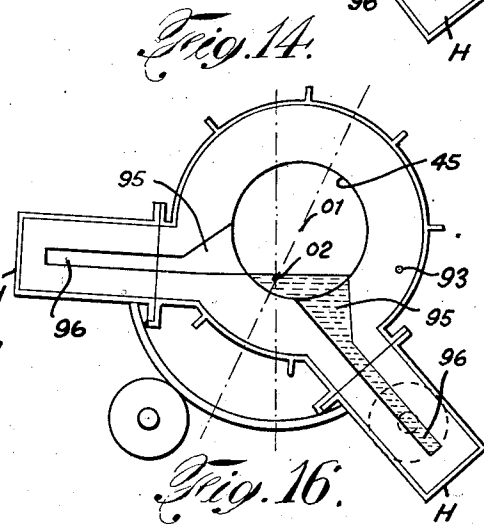
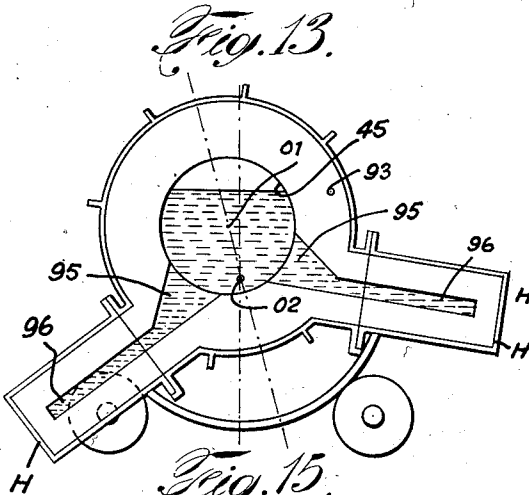
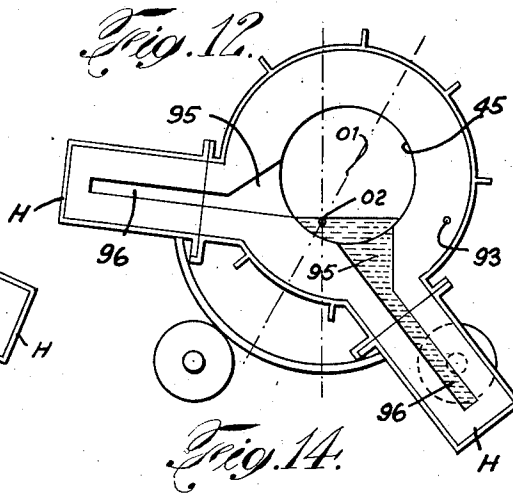
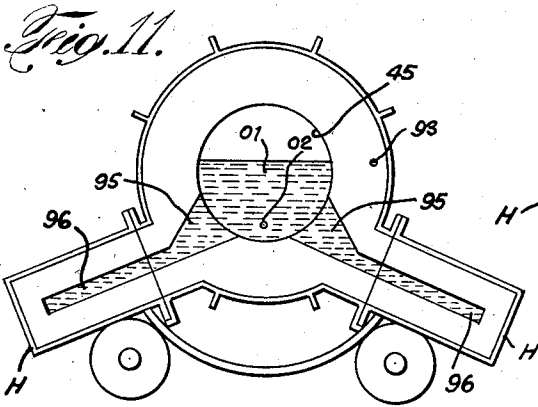
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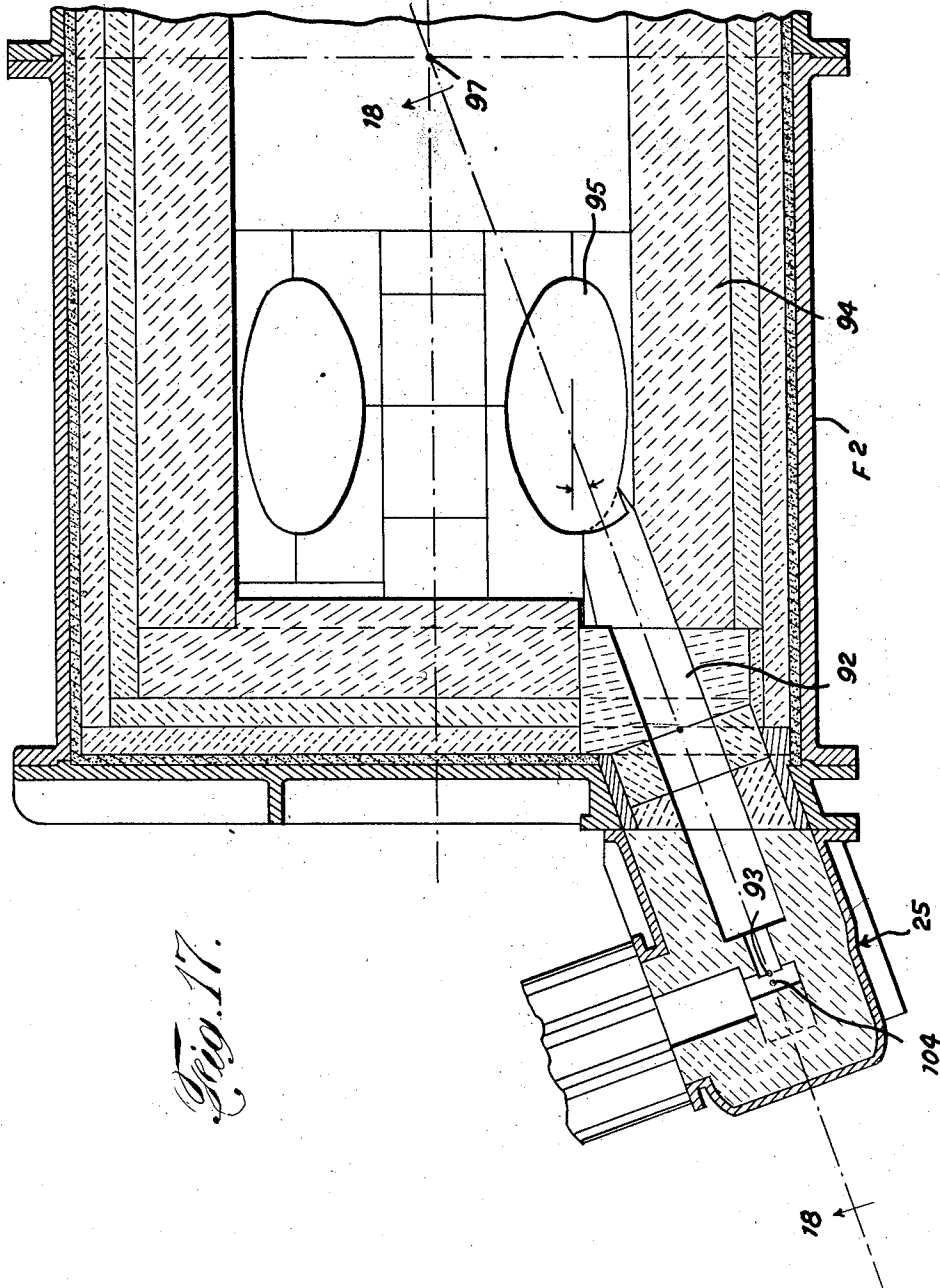
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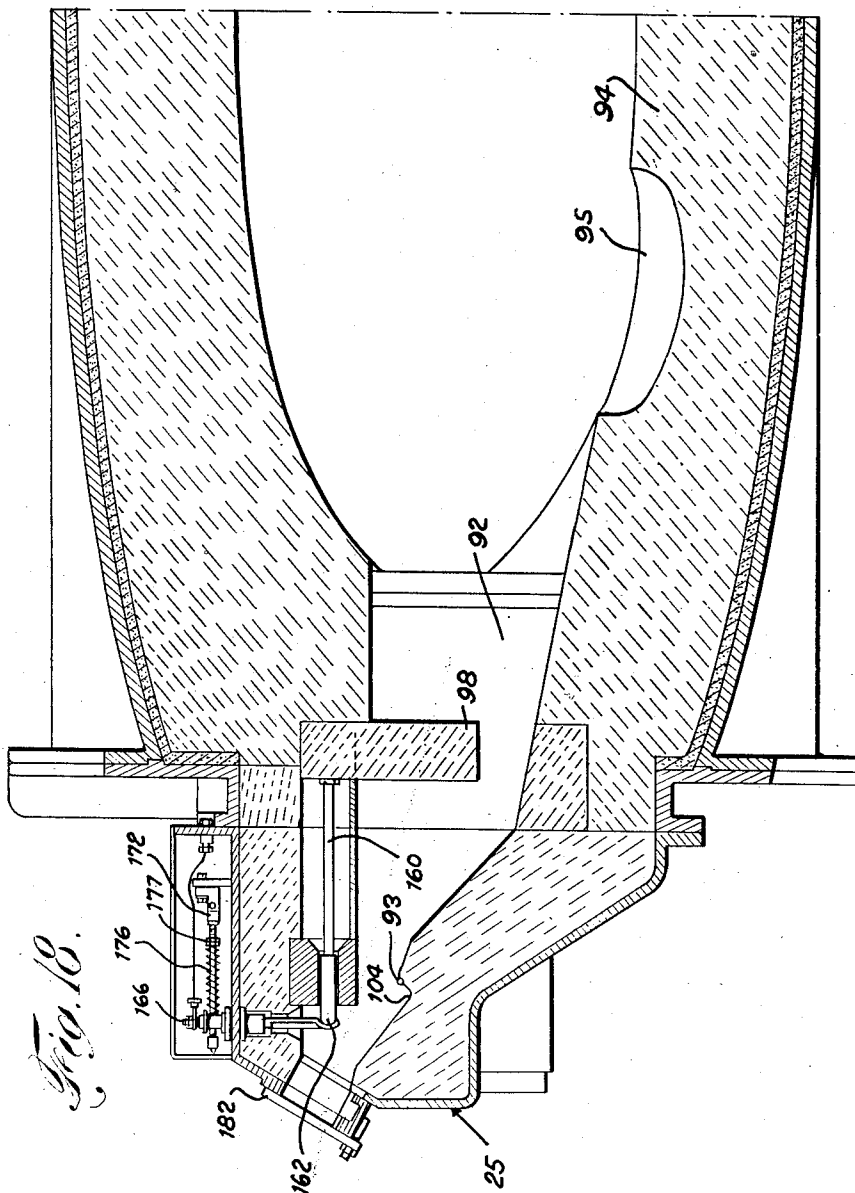


Fig. 18.

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Fig. 19.

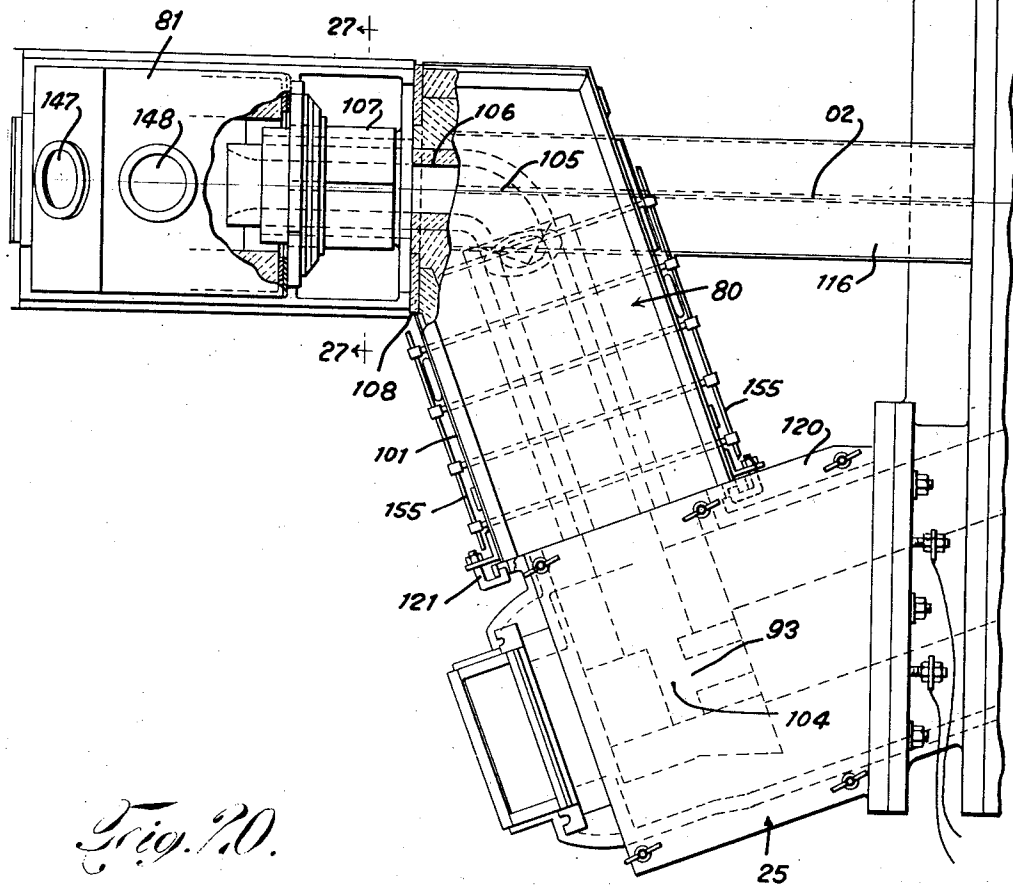
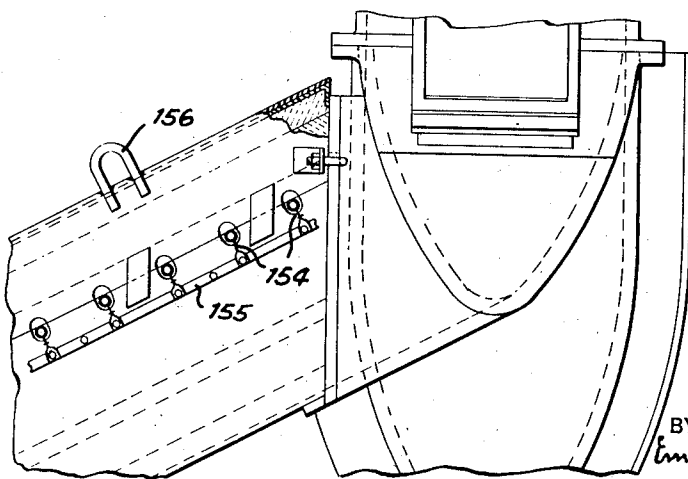


Fig. 20.



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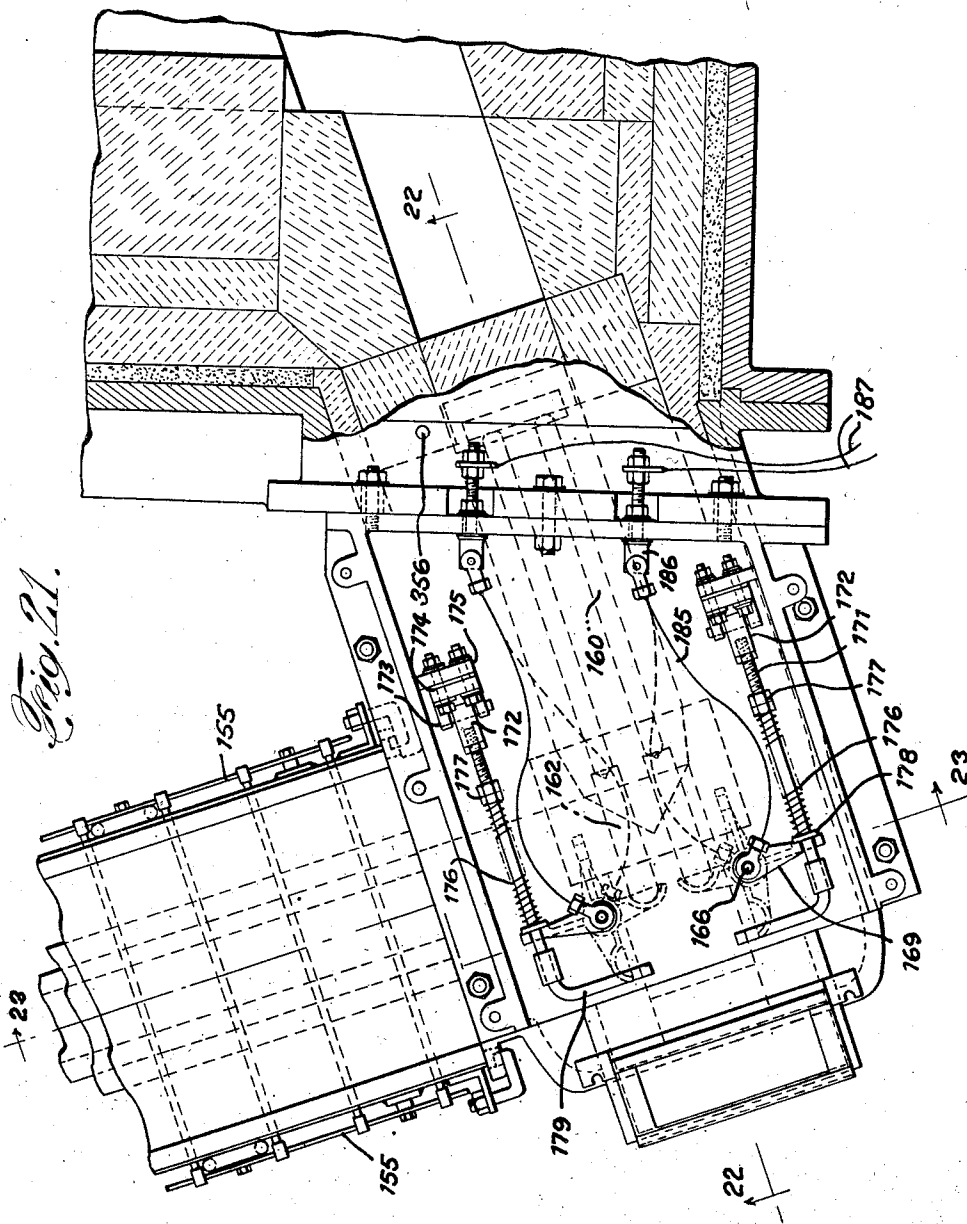
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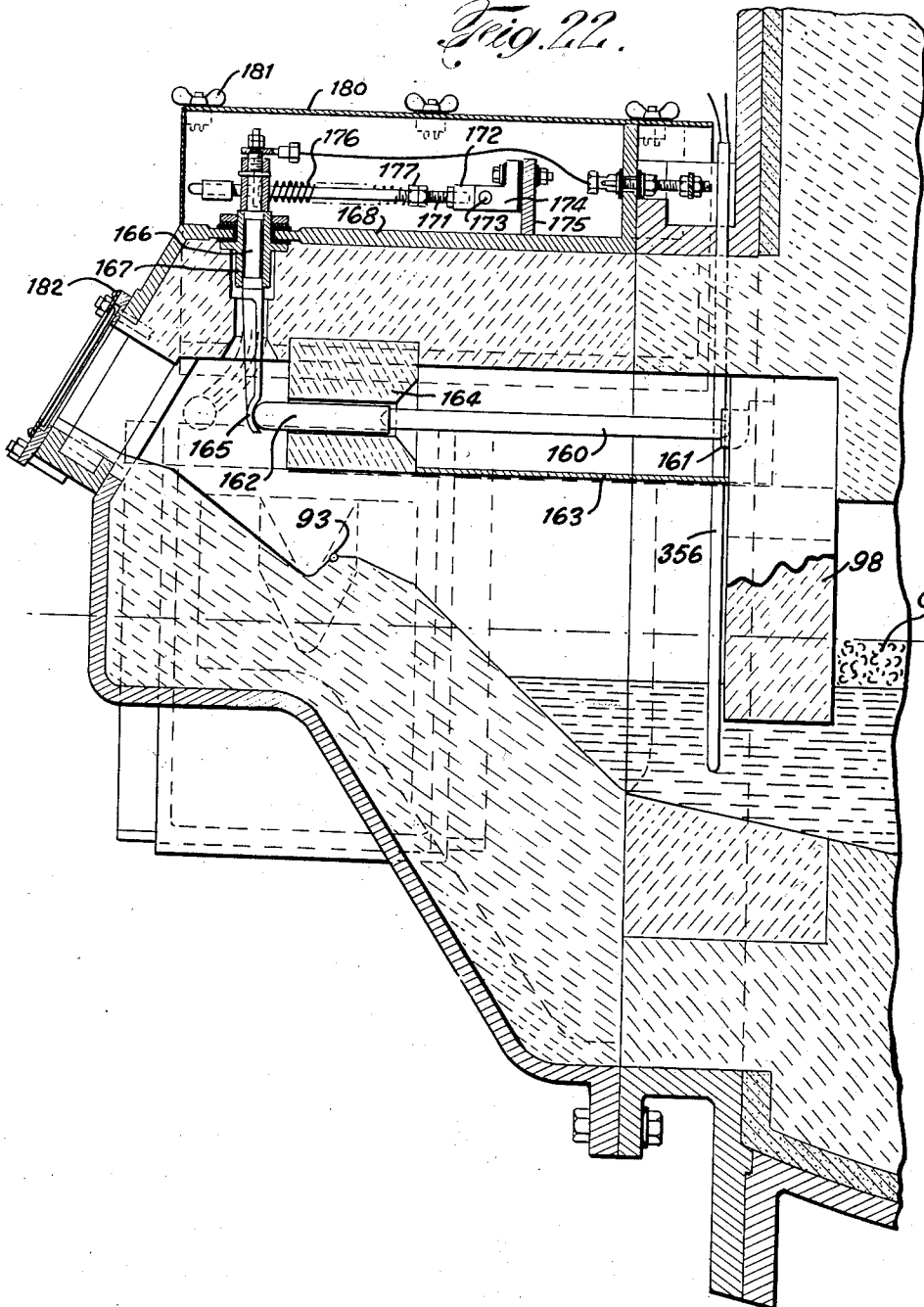
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Fig. 22.



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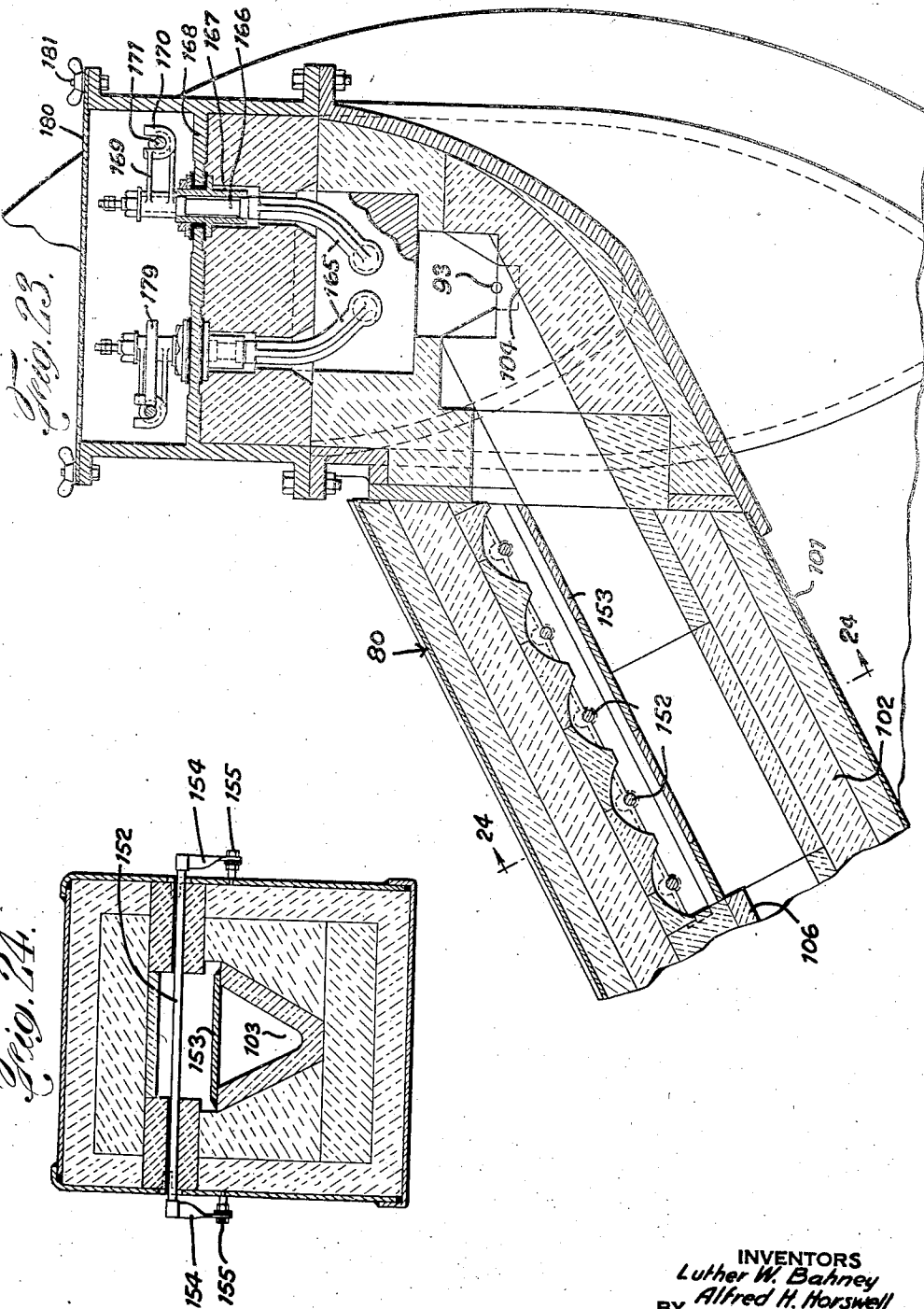
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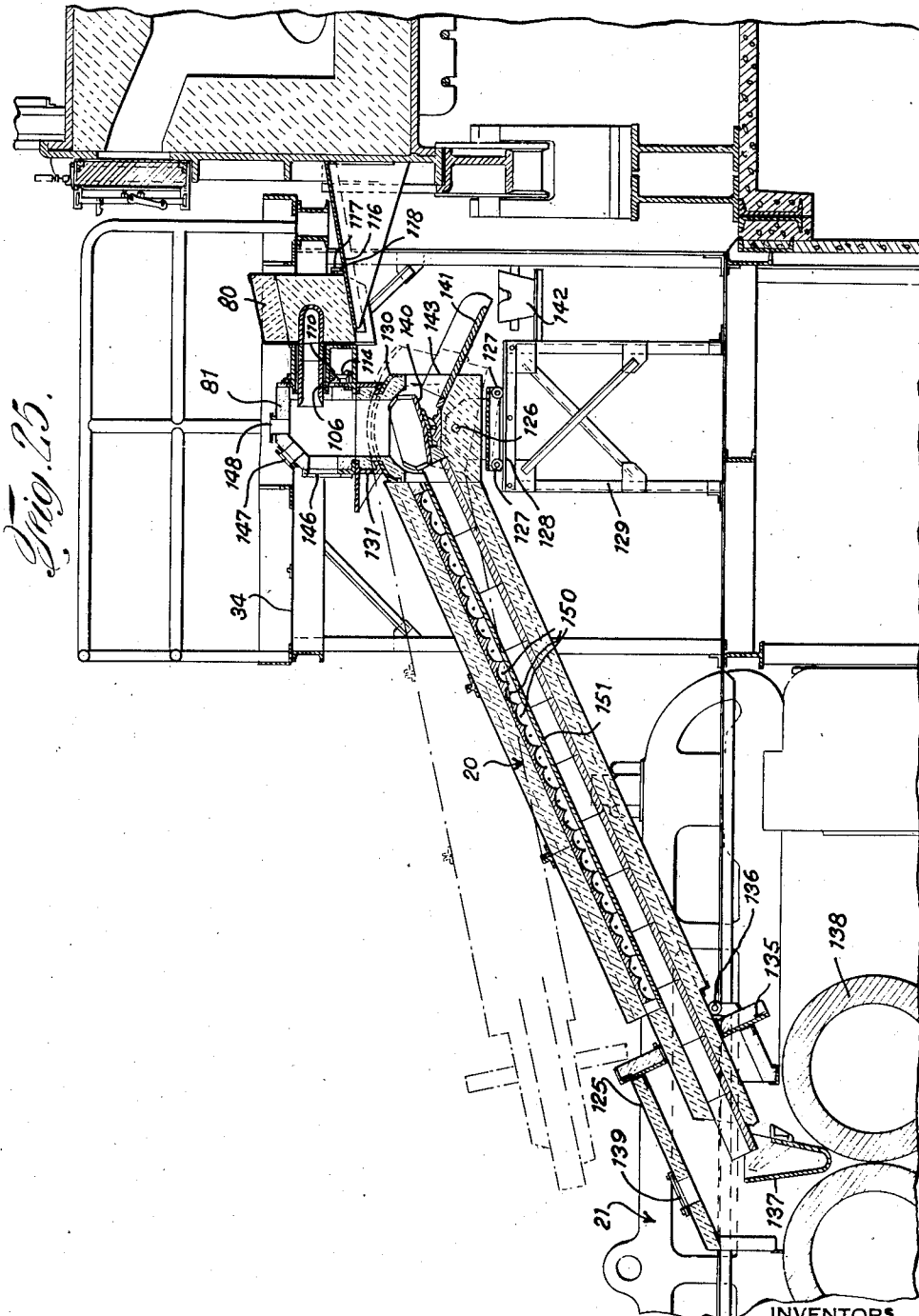
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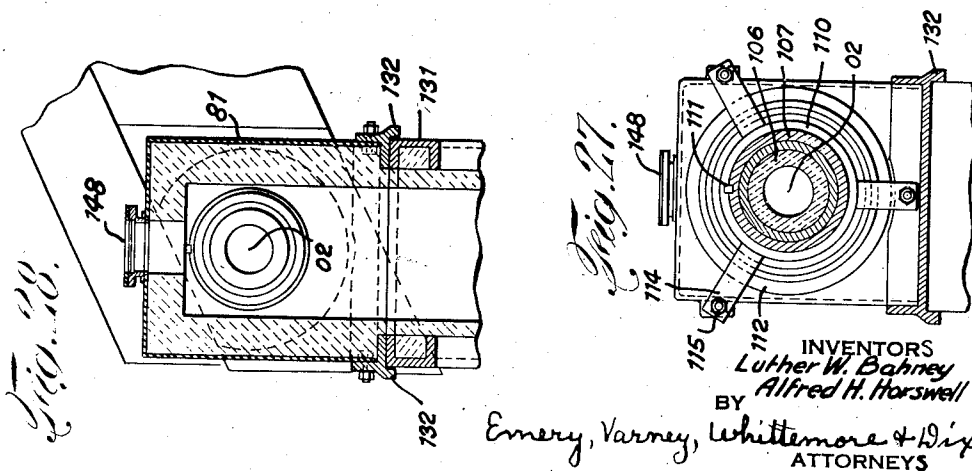
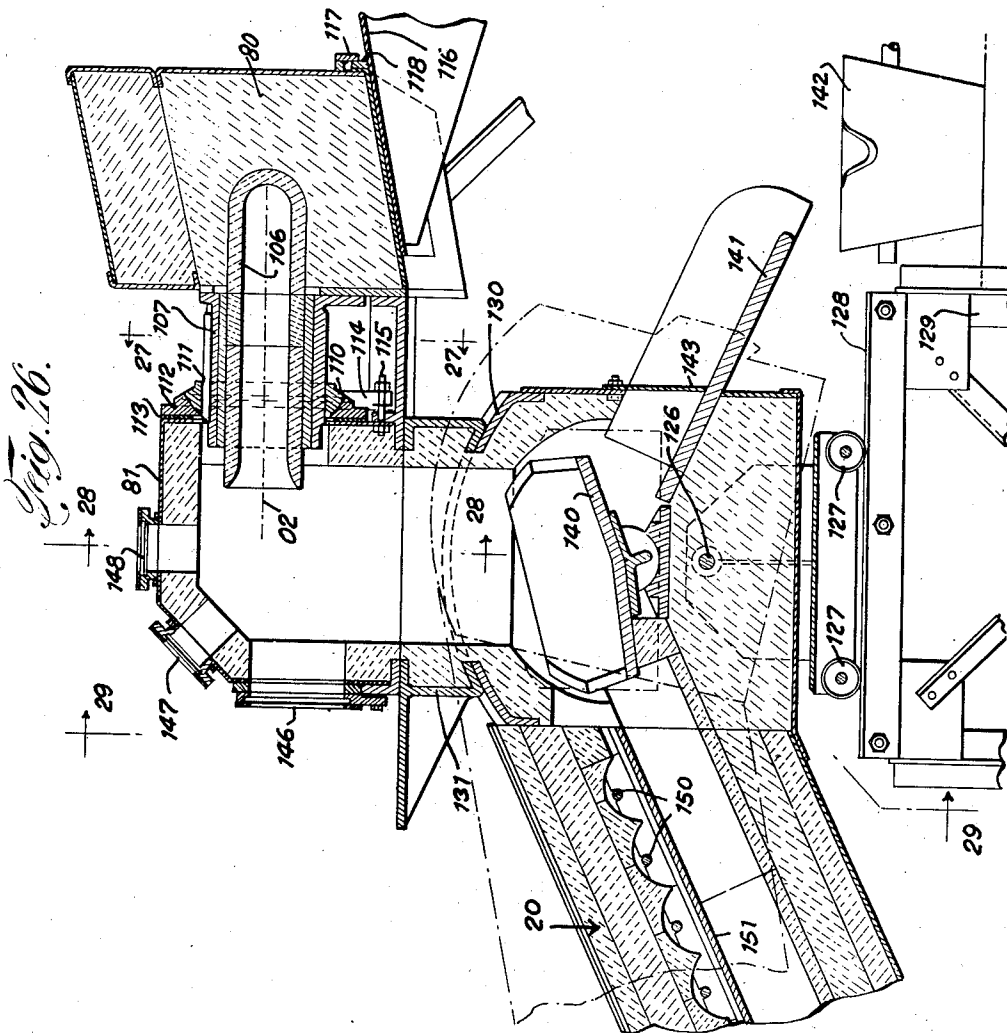
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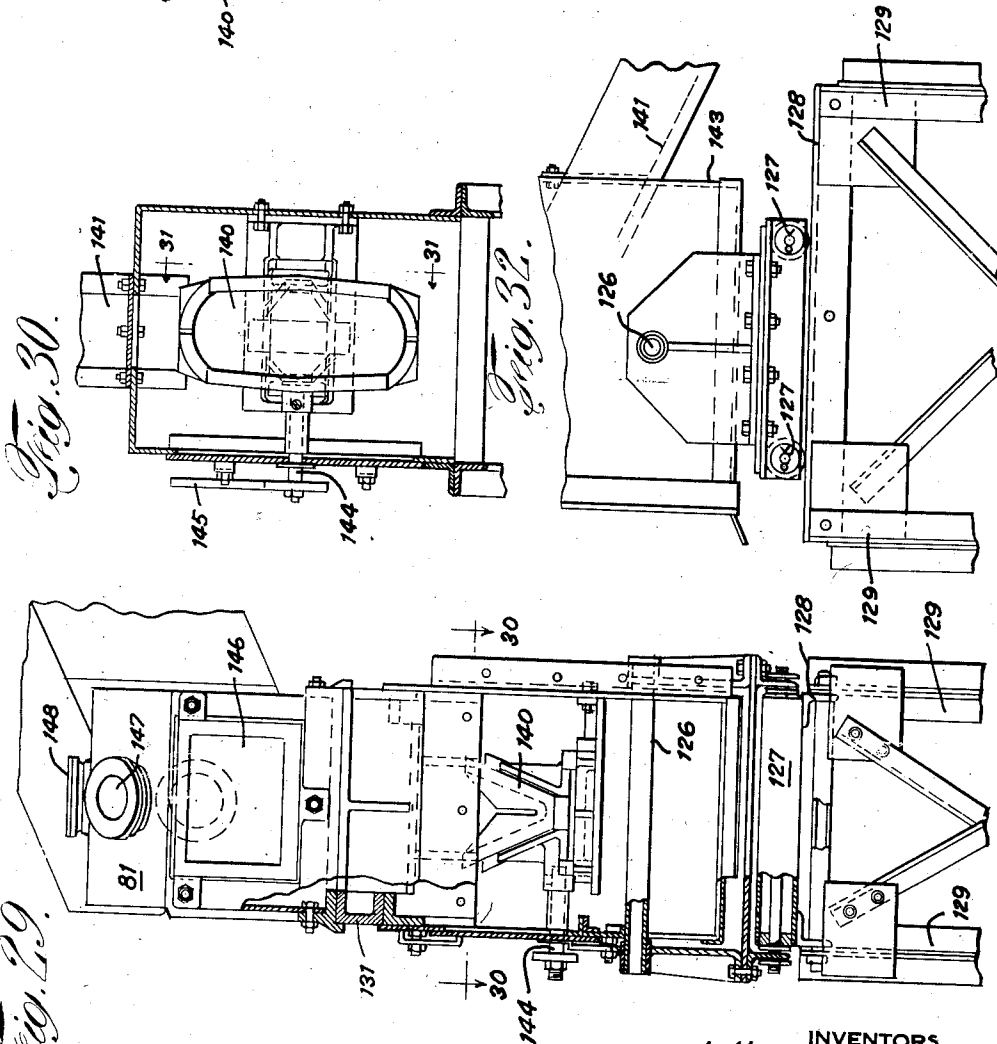
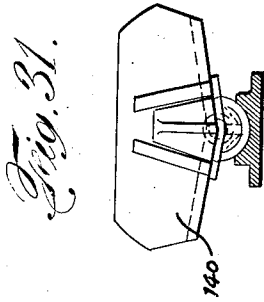


Fig. 29.

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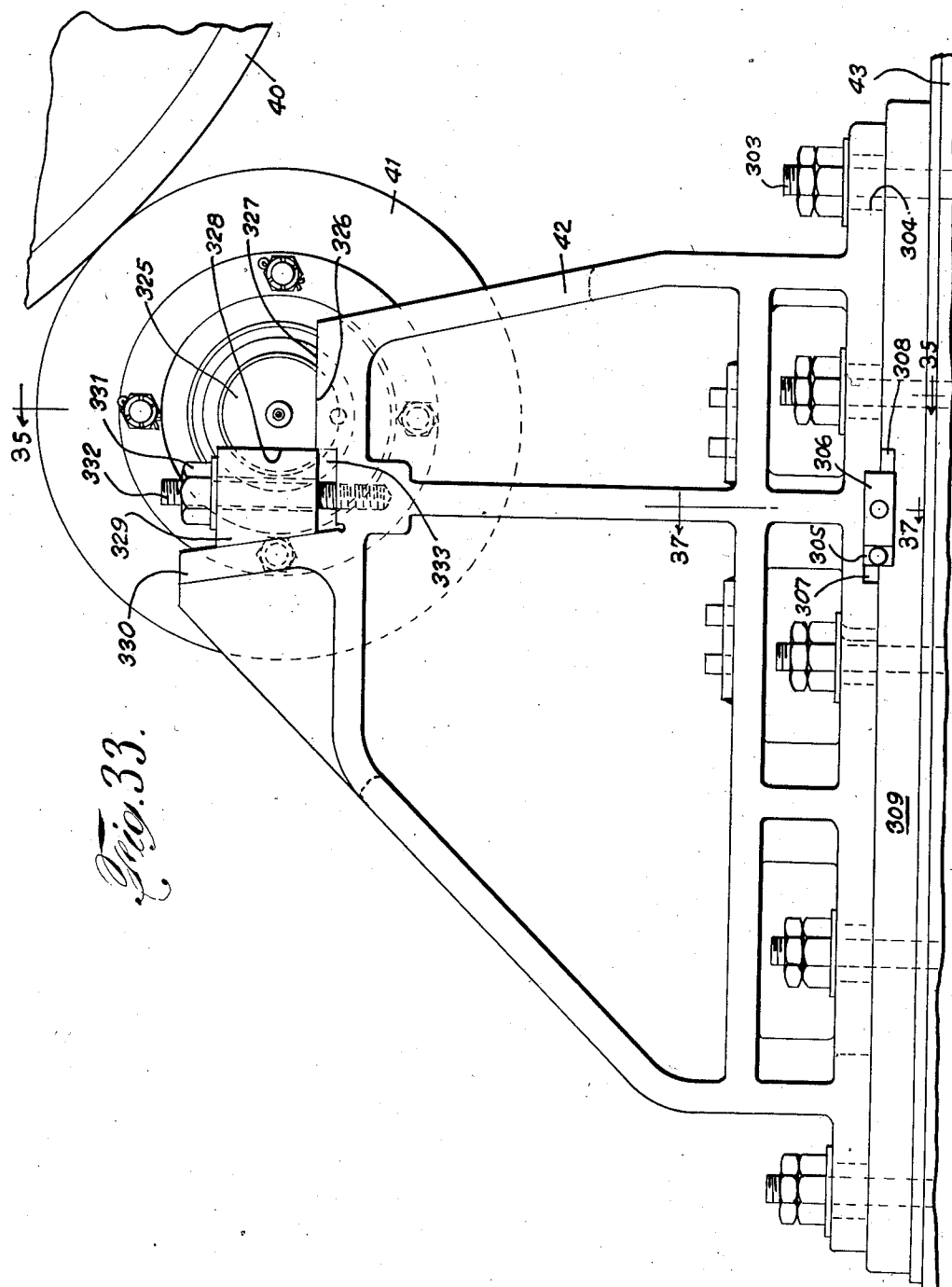
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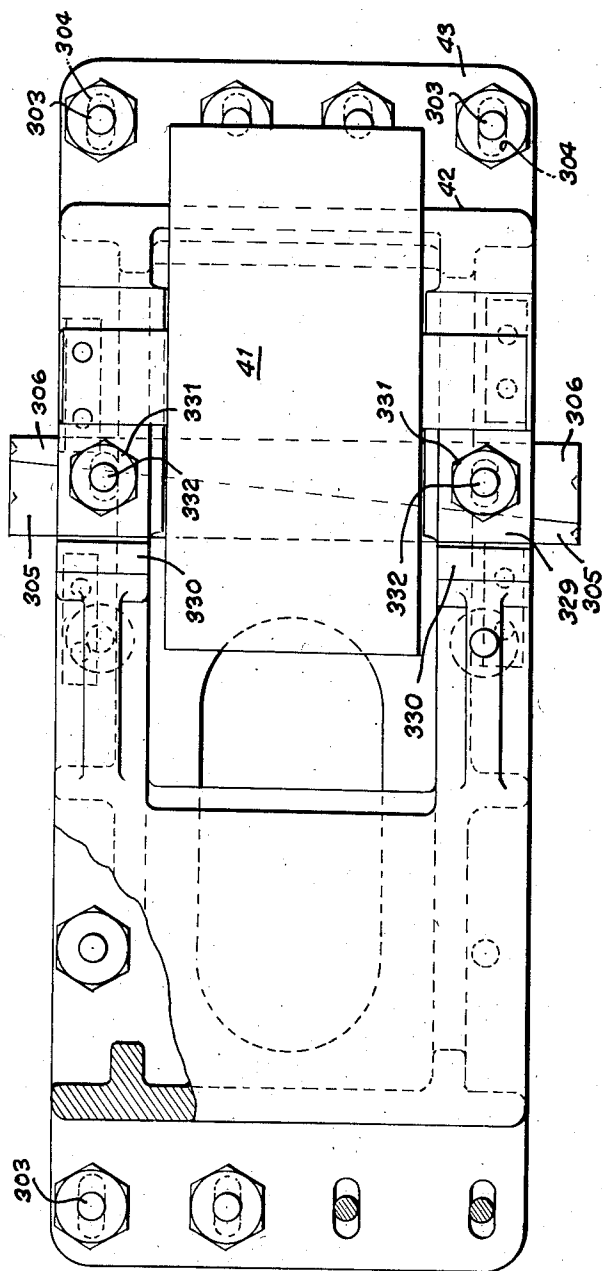


Fig. 34.

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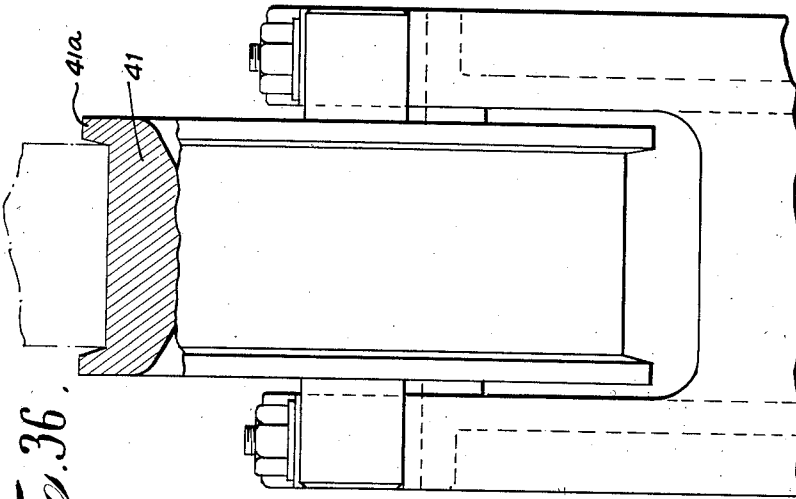


Fig. 36.

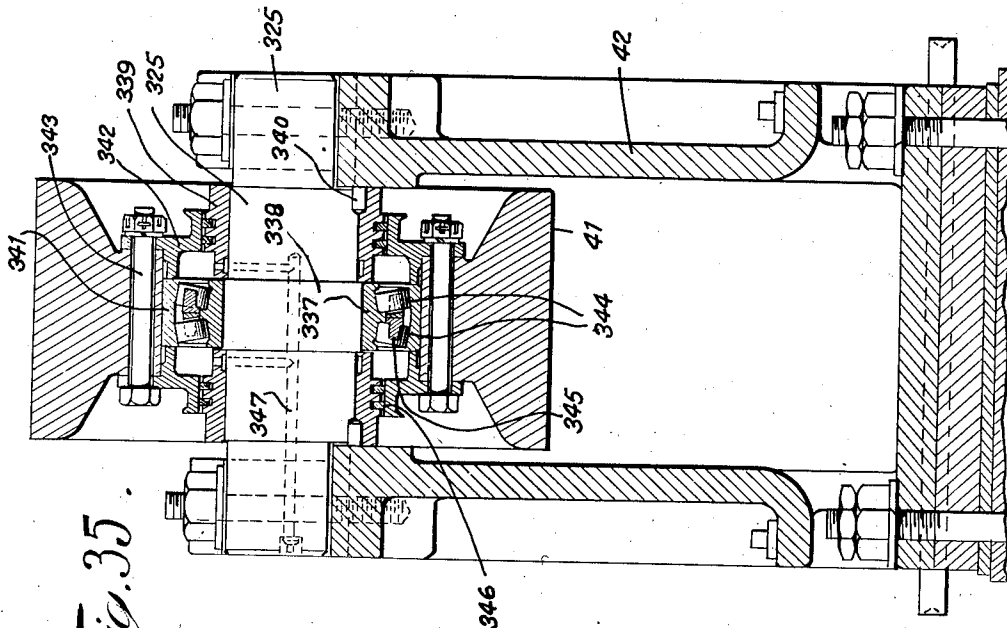


Fig. 35.

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Fig. 38.

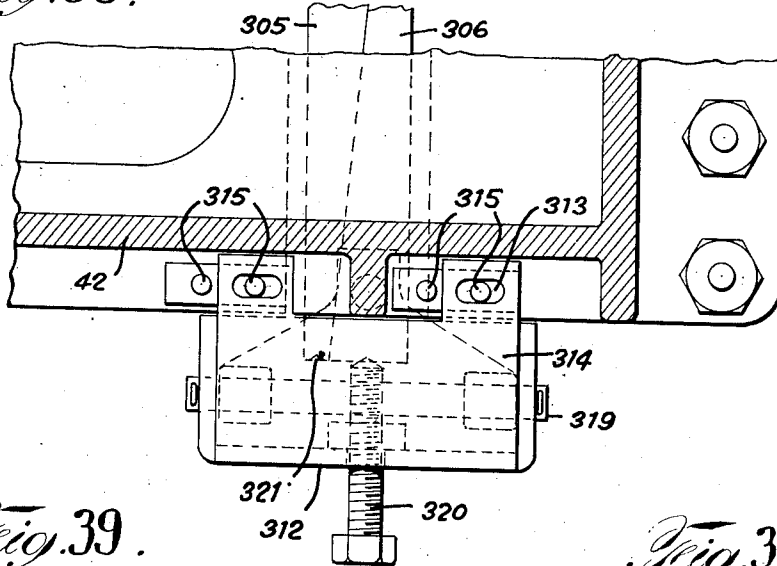


Fig. 39.

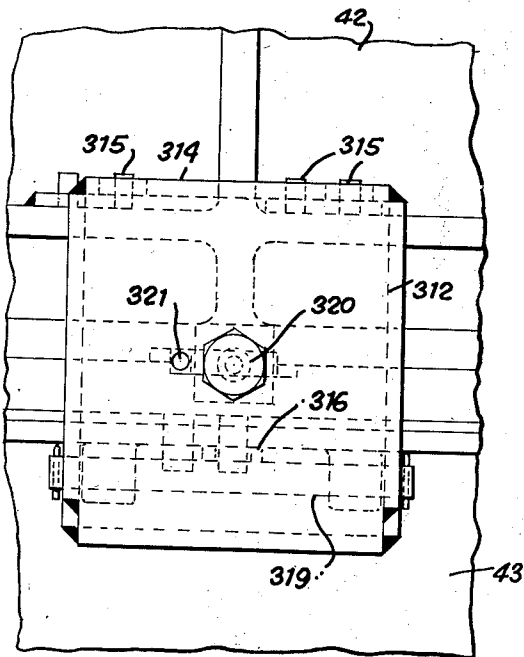
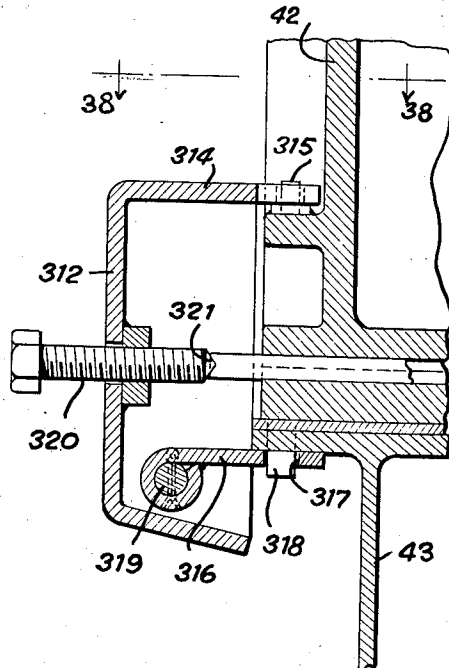


Fig. 37.



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Fig. 41.

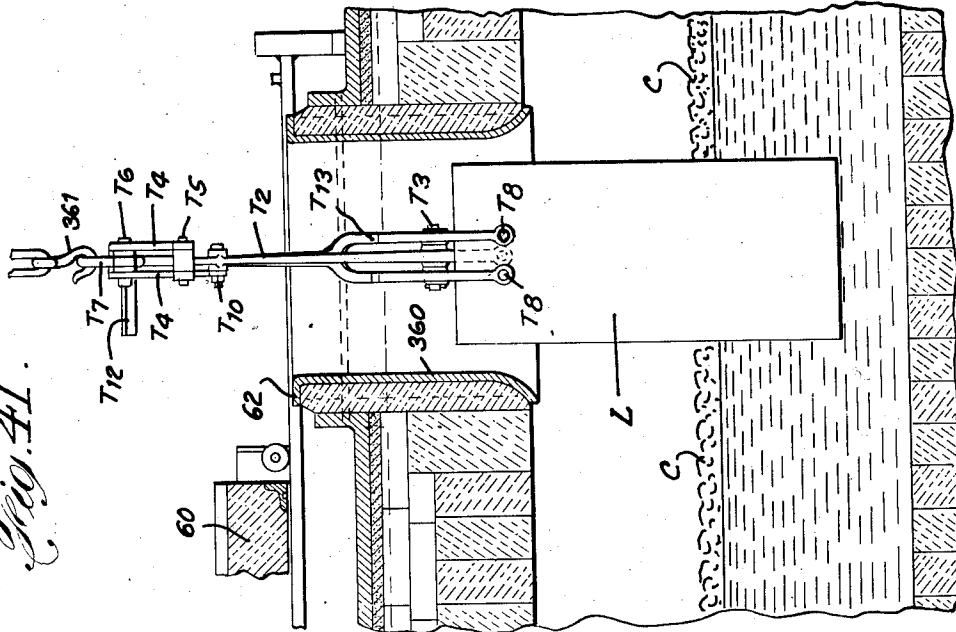
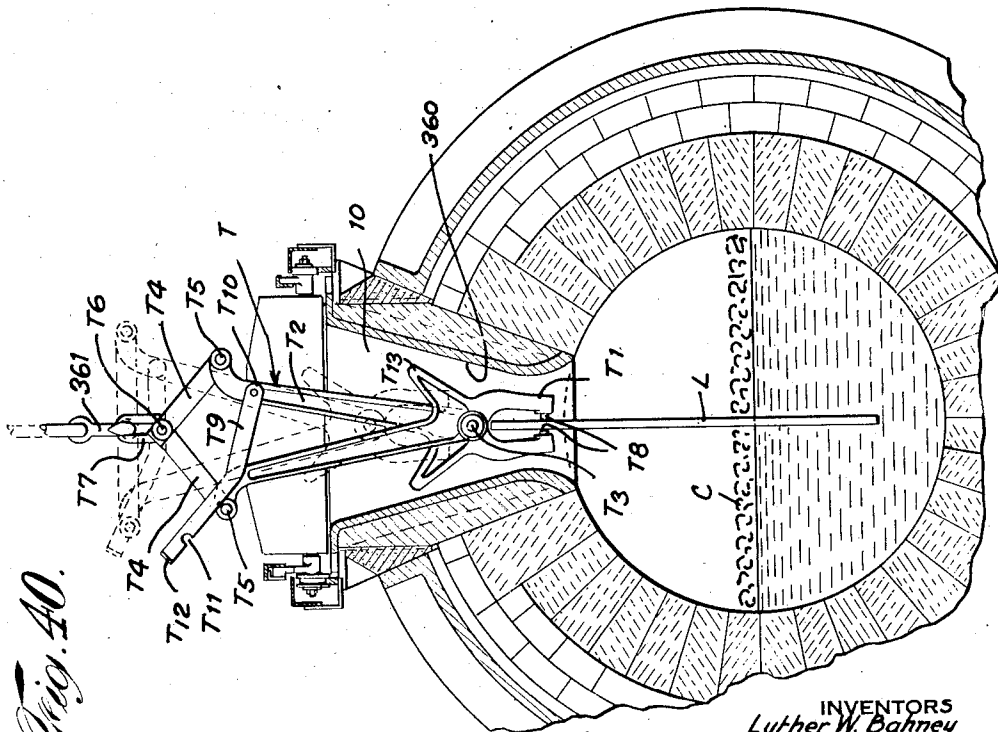


Fig. 40.



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UNITED STATES PATENT OFFICE

2,369,272

METALLURGICAL APPARATUS

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Application April 16, 1942, Serial No. 439,212

24 Claims. (Cl. 266—38)

This invention relates to metallurgical apparatus and process and has for an object the provision of improvements in this art.

Among the objects of the invention are the provision of an electric melting and pouring furnace installation which embodies improved furnace casing, mounting and tilting means; improved melting and heat controlling means; improved pouring means; improved metal conducting, heating and protecting means; improved electric induction heating units and mounting means therefor; improved charging means for solid metal; improved charging means for molten metal; improved closure means for furnace openings; improved means for accommodating expansion; improved means for mounting electrical resistor units; improved plant arrangement; and other improvements and features of novelty in apparatus and process which will appear from the following description of an exemplary embodiment of the invention.

The invention in one or another of its aspects is adapted for a variety of uses; but the particular use for which it has been developed and for which it will be described is in connection with a copper refining process and plan of the type disclosed in the patents to David L. Summey, Nos. 2,060,133 and 2,060,134; and the furnace proper is similar in type to that disclosed in the patent to David L. Summey, No. 2,102,582. This is sometimes referred to as a holding furnace or pour hearth. While the present invention, like the Summey inventions, was developed in connection with the production of oxygen-free copper, it is adapted for other metals which require careful protection and control. For present purposes it is not essential that all these metals be enumerated; but it may be noted that aluminum and magnesium may benefit by the superior means for protection and control which are provided.

The Summey apparatus was illustrated in connection with the supply of metal to molds. The present apparatus likewise is adapted to supply metal to molds; but it is adapted to serve any metal receiving means and will be illustrated in connection with the supply of metal to a continuous casting device, specifically a roll casting mill.

The furnace disclosed herein is particularly adapted to deliver molten metal under very accurately controlled conditions; but it is also adapted for melting metal and embodies a constructional design which adapts it to be assembled in various sizes for various capacities and

uses. The same type of furnace may thus be used in multiple in various groupings and in various sizes for both melting and delivering molten metal.

An illustrative embodiment of the invention is shown in the accompanying drawings wherein:

Fig. 1 is a diagrammatic plan view of a general plant assembly;

Fig. 2 is a corresponding diagrammatic side elevation;

Fig. 3 is an enlarged end elevation of the parts shown in Figs. 1 and 2;

Fig. 4 is an enlarged end view of an oscillatable electric furnace or pour hearth which appears in the middle of Fig. 3, the view being taken somewhat closer to the end of the furnace;

Fig. 5 is a top plan view of the furnace shown in Fig. 4;

Fig. 6 is a corresponding side elevation;

Fig. 7 is a corresponding rear end elevation;

Fig. 8 is a view similar to Fig. 7 but taken slightly further back and showing the furnace oscillated to the left or counter-clockwise for the removal of an induction heating unit on the right hand side;

Fig. 9 is an approximately central vertical axial section through the furnace;

Fig. 10 is a transverse vertical section taken on the line 10—10 of Figs. 5 and 6, one induction heating unit being removed and its channel blanked off and capped as shown in Fig. 6;

Figs. 11, 12, 13, 14, 15 and 16 are transverse vertical sectional diagrams through the furnace to illustrate its movements;

Fig. 17 is an enlarged sectional plan view of the pouring spout and adjacent parts of the furnace;

Fig. 18 is a vertical section taken on the line 18—18 of Fig. 17;

Fig. 19 is an enlarged top plan view of the pouring spout and related parts;

Fig. 20 is a partial end view of the parts shown in Fig. 19;

Fig. 21 is an enlarged top plan view of the pouring spout and related parts, taken with the protective cover removed to show the spout heating means;

Fig. 22 is a vertical section taken on the line 22—22 of Fig. 21;

Fig. 23 is a vertical section taken on the line 23—23 of Fig. 21;

Fig. 24 is a vertical section taken on the line 24—24 of Fig. 23;

Fig. 25 is an enlarged vertical section, as compared to Fig. 2, through the center line of the

furnace and the launder for conducting molten metal to the casting apparatus;

Fig. 26 is a further enlarged section of a portion of the assembly shown in Fig. 25;

Fig. 27 is a vertical section taken on the line 27—27 of Fig. 26;

Fig. 28 is a vertical section taken on the line 28—28 of Fig. 26;

Fig. 29 is a vertical section, partly in elevation, taken approximately on the line 29—29 of Fig. 26;

Fig. 30 is a horizontal section taken on the line 30—30 of Fig. 29;

Fig. 31 is a vertical section taken on the line 31—31 of Fig. 30;

Fig. 32 is a partial side elevation of the lower portion of Fig. 29;

Fig. 33 is a side elevation of a trunnion support for the furnace;

Fig. 34 is a top plan view of the parts shown in Fig. 33;

Fig. 35 is a vertical section taken on the line 35—35 of Fig. 33;

Fig. 36 is an elevation, partly in section, of a flanged wheel used at one end of the furnace as a complement to the flangeless wheel shown in Fig. 35;

Fig. 37 is a partial vertical section taken on the line 37—37 of Fig. 33 showing a trunnion adjusting device applied to the adjusting wedges;

Fig. 38 is a section taken on the line 38—38 of Fig. 37;

Fig. 39 is a corresponding side elevation of Figs. 37 and 38;

Fig. 40 is a vertical transverse section through the furnace at the charging door, showing a charging device in use; and

Fig. 41 is a corresponding axial section.

Plant assembly

In Figs. 1, 2 and 3 there is shown an illustrative lay-out of a plant which provides considerable flexibility in use between large and small capacity and which includes convenient floor and hoist arrangements for obtaining large and economical production with a high degree of accessibility for servicing and repair.

The central unit, about which the present development centers, is an electric induction furnace F of the oscillating type, which may be formed of tubular cylinder or pipe segments F1 and F2 of almost identical design and head or end cap assemblies F3 and F4 suited to the service to be performed. One or more of the heads may be deep, as shown in Fig. 1, to increase the capacity by about half that of a pipe segment thus giving size increments by half units as well as whole units, ranging from one unit up to any desired number. If the furnace F is to be used as a melting furnace it may be provided with a freely accessible charging opening 10 at the top and intermediate the length or with a plurality of charging openings as shown in connection with the furnace MF; and if it is to be used as a holding and pouring furnace for molten metal obtained elsewhere it may be provided with an opening near the top and preferably near one end for cooperating with a supply launder 11. Both constructions are incorporated in the apparatus illustrated herein, permitting ready conversion from one type of operation to the other.

Insofar as the segments F1 and F2 are concerned, the difference is merely that of providing or omitting pattern pieces for the top opening; insofar as the receiving end assembly F3 is con-

cerned, the difference is merely that of providing a launder receiving end assembly, as shown, or a full end closure or cap; and insofar as the pouring end assembly F4 is concerned, there is no change required for making the furnace either a melting furnace or a holding furnace.

Each cylinder segment F1, F2 is adapted to take a plurality of electric induction heating units H at spaced points about its circumference. Two such heating units for each segment are shown herein but this is not to be taken as a limit. Neither is it necessary in all cases to use two heating units for each segment, because, as will be seen hereinafter, one or more of the positions may be blanked off. For simplicity most of the heating units are omitted in Fig. 2.

The furnace F may be supplied with molten metal by one or more melting furnaces MF, the last to the left being shown in broken lines to indicate how additional furnaces may be added. Metal from the melting furnaces may flow to the pouring furnace F through an enclosed heated launder 12 which may extend beyond the launder 11 to one or more hoods 13 and back through a launder 14 to spread the drop and control the flow of metal between furnaces. Protective gas for all furnaces and enclosures may be furnished by gas generators 15. For copper this gas may be largely carbon monoxide. The gas generating system may be like that disclosed in the patent to Bahney 2,269,392, January 6, 1942.

The melting furnaces may be formed of standard tubular segments like those used for the holding furnace F. As shown, three segments are used to make up each furnace instead of the two units for furnace F, it being assumed that the melting furnaces require more metal and heating capacity than the holding furnace. Each melting furnace is shown as being provided with two top charging doors, a plain head closing the rear end, and a spouted head for the pouring end.

Metal from the pouring or holding furnace F may be employed for any desired purpose. As illustrated, it is conveyed by a launder 20 to a continuous casting device 21, here shown as a roll casting mill driven by a motor 22 through suitable speed reducing gearing 23. In Figs. 1 and 2 the launder 20 is shown to be connected to the spout 25 of the furnace F by lateral launders 26 and 27 connected at the outer ends by a hood 28. In the subsequent views the lateral launders are omitted. Fig. 2 shows various auxiliary equipment, such as crane 29, hoists 30, blowers 31, transformers 32, and the like, which do not require attention in the subsequent views. Fig. 3 shows certain stairways 33 and platforms 34 which do not require further attention.

Furnace assembly

Referring to Figs. 4 to 16, the furnace F is generally cylindrical about its horizontal axis or chamber center O1 and oscillates about a lower axis or center O2, crescent shaped rockers 40 being interposed between the furnace shell or casing 45 and rollers 41 carried by adjustable trunnion supports 42 mounted on floor beams 43. Rocking movement is limited by abutments 44 on the shell which come against the supporting rollers on one side or the other, depending on which direction the furnace is tilted.

When the furnace is in medial position with the chamber center O1 vertically above the turning center O2 the electric induction heating unit H are disposed symmetrically with respect to

vertical plane through the turning center O2. The diagrams, Figs. 11-16, show this relationship (Fig. 11) and illustrate (Figs. 12-16) the permissible movements which will be described later. From these diagrams it will also be seen that the bottom of the cylindrical chamber 45 at its highest position lies near the turning center O2.

As best seen in Figs. 8 and 9, the supply launder 11 enters a fixed saddle 50 held in position by supports 51. There are sealing joints between the saddle and the head F3 of the furnace, one of which joints is shown at 52 in Fig. 8. The joint 52 and a front joint 53 are shown to better advantage in Fig. 9. Here it is seen that the lip 54 of the launder stands clear of the refractory lining 55 of the head F3 to allow metal to fall clearly into the bath of metal in the furnace. If the furnace is used regularly as a melting furnace without receiving molten metal from a prior melting furnace, the saddle need not be held in a fixed position but instead may be secured to the end assembly F3 as by bolting or welding, the supports 51 in this case being omitted. Changeable wear strips may be provided between the saddle and the furnace shell and the saddle may be retained against outward displacement by a downturned lip 50a (Fig. 9) which engages the inner edge of a wear strip. A peep sight 56 is provided on the top of the hood for observing the metal stream when molten metal is supplied to the furnace.

A protective environment of either gaseous or solid material can readily be maintained in the furnace, that selected being the one best suited for the metal and purposes. Usually a carbonaceous reducing medium, such as a deep bed of glowing carbon C (Fig. 10) is maintained on the bath of molten metal if copper or other metals or alloys for which it is suited are being treated.

The charging opening 10 is closed by a door 60 which operates upon tracks 61, means, described hereinafter, being provided for lifting the door directly away from sealing engagement with the frame 62 of the opening before it is moved on the tracks and for dropping it back after it is returned to position over the opening.

A service opening 65 is provided in the end cap F4, this opening being closed by an end door 66 supported by chains 67 from the sheaves 68 of a hoist shaft 69. The door is balanced by counterweights 70 secured to the other ends of chains 67 and slidable in guides 71 (Fig. 5) secured to the columns 72 which support the hoist shaft. The shaft 69 may be operated by a chain hoist 73 (Fig. 4). Means are provided for moving the door directly away from sealing engagement with the frame 74 of the opening before the door is raised and for forcing it back into sealing engagement after it is returned to its lower position. When the door is raised, the opening may be used for inspection, for polling, or for charging covering material.

The induction heating units H are artificially cooled by air derived from blowers 31 (Fig. 3), the air being conveyed by conduits 78 provided with a turning joint 79 (Figs. 5, 6 and 7) concentric with the oscillating axis O2 of the furnace. The air connection is disposed at the rear end of the furnace.

At the front end of the furnace the pouring spout 25, which is arranged on one side of the furnace axis, is connected by a spout launder 80 (Figs. 4, 5 and 6) with the connection box or hood 81 leading to the pouring launder 20. It is an important feature of this invention that

this connection is established in a turning joint 82 which is concentric with the axis of oscillation O2 of the furnace. In the patent to Bahney 2,195,071, March 26, 1940, there is disclosed an axially concentric spout joint; but in that construction the metal chamber is normally disposed below the turning and pouring axis, whereas in the present construction the metal chamber is normally disposed largely above the turning and pouring axis; hence a different pouring construction is required. This improved construction will be described in detail hereinafter.

As shown in Figs. 6 and 7, the furnace is oscillated by a motor 85 through a reducing gear set 86, shaft 87, pinion 88, and an arcuate rack 89 secured to the furnace shell. The rack may be turned around and bolted in a reverse position to extend its life when worn, the pinion shaft 87 being adjustable to adapt the pinion to the rack when worn or reversed.

In Fig. 6 it may be noted that the supporting rollers 41 of the left set adjacent the pouring spout are provided with flanges 41a to embrace the rocker 40 whereas the rollers 41 of the right set are smooth or without flanges to permit axial movement of the rocker 40 relative thereto. This provides for endwise expansion of the furnace shell while maintaining the spout end in a relatively fixed axial position. The rollers 41 are adjustable on their spherical bearing mountings and the mountings are adjustable on the supports 42, 43 toward and from the vertical axial plane.

In Fig. 8 it will be seen that the induction heating units H are provided with improved mounting and supporting means facilitating quick removal and replacement.

Spout assembly

Reference may now be made principally to Figs. 17 to 24. From Figs. 17 and 18 it will be seen that the spout 25 is located at the end and side of the furnace. In plan (Fig. 17), the spout channel 92 extends at an angle from adjacent the end and side of the cylindrical metal chamber to a spillover point 93 located at a greater distance from the center line than the inner end. The refractory lining 94 within the shell is relatively thick and this gives the channel considerable inclination, the angle in this case being indicated as about 20° to the center line. The channel terminates at the edge of the pocket 95 which connects the inner ends of the loop channel 96 (see Fig. 11) of the right hand induction heating unit H. The center line of the spout channel practically bisects the inner end of the pocket and strikes the chamber axis O1—or rather the vertical axial plane, since it strikes below the axis—at a point 97 which falls practically in the plane of the end of the tubular segment F2. In vertical section the spout channel cuts down at an angle through the end and side linings into the side of the pocket 95. Near the outer end the channel rises more abruptly toward the spillover point 93. The channel is relatively deep to avoid freezing of metal therein. A skimmer 98, located near the outside of the end lining, extends downward toward the bottom of the channel. The arrangement is such that metal in the spout channel inside the skimmer is freely stirred by the action of the heating units and the metal in the channel outside the skimmer is easily heated by auxiliary heating elements later to be described. The advantages of the spout disposition will also be discussed later in connection with the functional operation of the furnace.

The spout launder 80 (Fig. 23) is provided with a metal shell 101 and interior lining 102 forming a V-shaped channel 103 extending from a point 104 below the spillover point 93 to and along the axis of oscillation O2 of the furnace (Figs. 19, 27 and 28). The channel turns at the point 105 (Fig. 19) where it strikes the axis. Above the point 105 the launder inclines forwardly at an angle from the spout (Fig. 19) and downwardly at an angle (Fig. 23), in plan the channel of the launder being approximately at right angles to the spout channel. From and below the point 105 the launder channel is formed by a tubular elbow refractory piece 106 which is secured within a reduced tubular casing extension 107 which is attached to the shell casing 101 and projects into a lateral opening in the hood 81 (note Fig. 6).

Means are provided for holding the lower end of the launder in perfectly sealed operating relationship with the hood 81 and for furnishing required relative movements for expansion, pouring, constructional alignment, and operating adjustment. This construction (Figs. 19, 26 and 27) comprises a collar 110 slidably mounted on the tubular extension 107, a key 111 preventing relative turning movement between the collar and extension. The collar has a spherical face which fits the spherical socket of a plate 112 which slidably fits against a face plate 113 on the hood casing 81. Spring clips 114 secured to the hood casing by bolts 115 press the collar 110 against the socket plate 112 and in turn press the socket plate 112 against the face plate 113.

The launder 80 is supported for longitudinal sliding movement upon a ledge 116 attached to the front end cap F4 of the furnace, an overhanging slide 117 of the launder casing cooperating with a rib guide 118 of the ledge to retain the launder on the ledge during the adjusting movements.

At its upper end the casing 101 of the launder 80 is secured to the casing 120 of spout 25 by hook bolts 121 (Fig. 19). The launder is made of correct length to place the center of its tubular part 106 approximately on the center of oscillation O2 when the heat expansion has been realized.

It will be seen that the elbow spout arrangement, wherein the spout opening is on the side of the furnace axis and the spout launder returns to the axial turning center, provides for a tight pouring enclosure and an arcuate control of pouring cut-off at all times. Also that, due to the outward inclination of the spout channel, a very slight movement will control the pouring of a considerable amount of metal. When the spout is turned to a high position (Fig. 13) the furnace chamber will retain a large volume of metal, although it is practically all above the elevation of the discharge channel 106 on the oscillating center O2. And when the spout is turned to a low position (Fig. 12) most of the metal is drained from the furnace.

There are other features of the spout assembly which require attention, but before taking them up, it will be helpful to consider the launder 20 leading to the roll casting device 21 and the connections of the launder with the hood 81 and the casting device.

Launder assembly

The pouring launder 20 for conducting metal between the hood 81 and the roll casting device 21 is best shown in Figs. 25 to 32. It forms a

complete heated enclosure which is provided with the necessary movements to take care of expansion and to permit it to be disconnected from the enclosure 125 of the roll casting device. The launder can be swung upward about a pivot point 126 at its upper end, as indicated in dotted lines in Fig. 25. It can move longitudinally at its upper end, this being provided with rollers 127 which operate upon tracks 128 on the top of a platform 129.

The cylindrical top sealing plate 130 fits against the concave cylindrical surface of an auxiliary housing 131 which slides beneath the hood 81 between guides 132 (Figs. 27 and 28).

At its lower end the launder carries a sealing plate 135 which is slidable thereon to permit of being brought down into sealing engagement with the housing 125 or to be pushed back to clear the housing when the lower end of the launder is raised. A roller 136 carried by the plate supports the spout for sliding movement relative thereto. Suitable packing is provided to seal the plate to the launder 20 and to the housing 125. The top of the roll housing 125 lifts up to permit the end of the launder to be raised.

The end of the launder discharges metal into a distributor 137 for the rolls 138 and the position of the parts relative to each other is important. The adjustment movements provided for the launder permit the required accuracy of location to be obtained. An inspection pane 139 permits the operator to view the pouring stream of metal.

It may be necessary to halt the flow of metal to the metal receiving device very suddenly but without tilting the furnace spout up quickly. Or it may be desirable to pour into molds or other devices. To provide for this the launder means at some point ahead of the final metal receiving means, for example the upper end of the launder, is equipped with a pivoted pot or trough device 140 which can be quickly shifted from a position to discharge into the launder, as shown, to a position to discharge into a spout 141. A ladle 142 is representative of a receiving vessel for the metal from the spout. A plate 143 normally seals the spout opening but this can be quickly removed and may, if desired, be formed of a fusible or burnable material so as to be breached by the molten metal. As seen in Figs. 29 and 30, the pot or trough 140 is provided with a protruding shaft 144 carrying an external operating arm 145. Inspection panes 146, 147 and 148 in the hood 81 provide views from different positions of the stream of metal falling from the lip of the upper launder part 106 to the pot 140.

For certain purposes it is possible to dispense with the apparatus shown below hood 81 and to connect the launder 20 to the hood itself, a flow arrangement from the lip of tube 106 to the launder being readily effected.

Launders

Means are provided for heating the metal as it flows down the launder 20 to keep it molten. The means herein provided include electrical resistors 150 known to the trade as "Globars" which are positioned above the metal. To prevent injury of the resistors by splashing metal or protecting gas confined with the metal, they may be protected by separating plates 151 of a refractory material such as silicon carbide or "Carborundum." These plates have been found to transmit radiant heat very efficiently.

Reverting to Figs. 19 to 24, it may be seen that the spout launder 80 is heated by trans-

versely disposed resistors or "Globars" 152 disposed above the metal channel 103, refractory plates 153 of silicon carbide or carborundum separating the resistors from the metal space, as in the case of launder 20 previously described. The resistors are of an improved type in which a high resistance portion is integrally united with low resistance portions which are connected to external leads, here the leads 154 and bus bars 155.

The launder casing is split horizontally to permit separation at any desired point. The line of separation shown is in the region of the resistors, but another convenient line of separation might be in the region of the refractory plates 153. Lifting rings 156 may be provided for raising the cover of the launder assembly. The launder 20 may be similarly arranged.

No claim is made herein to the launders.

Spout heating

The metal in the spout proper, outside the skimmer 98, may be heated by resistors or "Globars" 160 secured under pressure between a fixed cupped electrode 161 (which may be a single integral part for both resistors) and movable cupped electrodes 162. A refractory or carborundum plate 163 separates the resistor space from the metal space.

The movable electrodes 162 are disposed in through passages in a refractory insulating block 164 secured in the top lining of the spout. As best seen in Figs. 22 and 23, the electrodes 162 are pressed by the cupped ends of arms 165 carried by vertical shafts 166 mounted in bearings 167. The arms 165 are inclined or sloped relative to the axes of the shafts. Above a metal supporting web 168, which carries the bearings 167, the shafts 166 are provided with arms 169 terminating in open topped yokes 170 in which pressure rods 171 are normally disposed. The rods 171 (see also Fig. 21) are secured to butts 172 which are hinged by pins 173 to anchors 174 carried by brackets 175. On each rod a spring 176, disposed between adjustable nuts 177 and a slidable collar 178, is provided for pressing against the rear face of the yoke 170 of an arm 169 to clamp the resistor between the electrodes. The outer end of each rod 171 is provided with a handle 179 for swinging it up and down about the hinge pin 173.

The parts are readily accessible by removing a cover 180 which is normally held in place by thumb nuts 181. When the cover is removed the spring adjustment nuts 177 are turned back to take pressure off the springs, after which the rods 171 are swung up to release the arms 169, whereupon the lower inclined arms 165 may be swung far outward, as shown in broken lines in Figs. 21 and 22, to stand fully clear of the electrodes 162 and beyond their path of movement. A closure plate 182 at the end of the spout is then removed to permit removal of the electrodes 162 and the resistors 160. A pane in the plate 182 gives a view into the spout at normal times.

Leads 185 are secured to the upper ends of the vertical shafts 166, the leads extending to connectors 186 and external leads 187.

Induction heating units

The induction heating units are adapted to be changed while the furnace is maintained in service, that is, while a charge of molten metal is retained; and normal operation is reestablished as soon as a new unit is attached. It is apparent from Figs. 8 and 15 that the right hand units may be removed by turning the furnace counter-

clockwise until the channels of the heating units are empty, there being a sufficiently small amount of metal in the furnace at this time to permit of emptying the channels in this position. While a change is being made the heating units on the left maintain the metal in molten condition. To change a heating unit on the left side, the furnace is turned by a like amount in the clockwise direction, as shown in Fig. 14, the metal having been poured off sufficiently to prevent outflow from the spout or channel opening during the change. In each case the plane of the channel loop 96 is raised to a slight angle above the horizontal plane through the center of oscillation O2 to cause the metal to drain from the channel. At the time the units are exchanged the channel may be disposed in a substantially horizontal position. Here it may be noted that the bottom plane of the channel loop is approximately aligned with the bottom edge of a pocket 95 and directed approximately toward the oscillation center O2. The upper edge of the pocket is inclined upwardly at a considerable angle to cause good vertical circulation of metal.

In order to facilitate the rapid and effective change of heating units, novel means are provided for attaching and supporting the units. As shown in Fig. 10, the furnace shell is provided with faced flanges 250 to which the faced flanges 251 of the heating units H are secured. An insulating gasket, for example a mica sheet, covering both the brick or rammed lining and the metal flanges may be provided to prevent metal leakage and to permit easy separation of units. The mica sheet separates readily during removal of the unit. The furnace flanges 250 at the bottom edge are provided with a forwardly extending ledge 252 upon which the bottom edge of the heating unit flange 251 rests when the parts are correctly aligned.

When the heating unit H on one side is raised to a horizontal position, as shown in Fig. 8, or slightly higher, as shown in Fig. 15, it may be lifted by a hoist, as shown in broken lines in Fig. 8. And if a unit is being placed, it may be lowered directly into a position of partial support on the ledge 252. Lifting eyes 253 are provided on the heating unit for cooperation with the hooks of the hoist. The flanges 250 and 251 are secured together by bolts 254.

To minimize strain on the connecting flanges, auxiliary means are provided for supporting the heating units, the means being suitable to provide free expansion or contraction of the units. The means shown in Figs. 5 and 10 comprise anchor rods 255, secured at their lower ends to apertured lugs 256 located on opposite sides of and near the outer end of each heating unit and at their upper ends to eye bolts 257 carried by brackets 258 secured to the furnace shell. The anchor rods include adjustment and tension means of suitable form, such as the turnbuckle 259 for adjustment and the spring yoke device 260 for tension. The springs 261 are secured in compression between plates 262 and 263 which are slidable respectively upon rods 264 and 265. The rod 264 is secured to the eye bolt 257 and to the lower plate 263 and the rods 265 are secured to the upper plate 263 and to a yoke plate 266. The springs are mounted upon the rods 265. The yoke plate 266 is connected by a short rod 267 to the turnbuckle 259. The tension rods of the spring yoke device or one of them may be calibrated and marked to register the tension upon

erably secured before a heating unit is released from the hoist, the final tension is adjusted after the furnace is returned to normal working position.

It is to be understood (Fig. 7) that the cooling air conduit section 268 is removed by disconnection at the flange joints 269 and 270, or otherwise, before the units are changed.

As shown in Fig. 10, a heating unit position may be blanked by a cap 297 when no heating unit is wanted at that position, the inner portion of the loop channel being filled with refractory material 298, and the pocket also being filled if desired.

Furnace supports

The furnace supports provide the necessary adjustments for lining up the furnace and for absorbing irregular movements due to expansion or other causes. It has already been noted that the furnace rocker rails 40 rest upon a plurality of rollers 41, some of which are smooth and some flanged. Also that the rollers 41 are carried by trunnion supports 42 secured to base beams 43. One of these supports is shown in Figs. 33 to 39.

In Figs. 33 and 34 it may be seen that the support 42 is secured to the beam 43 by bolts 303 which pass through elongated holes 304 in the bottom flanges of the support. When the bolts 303 are loosened sufficiently the support may be adjusted in position on the base beam. For this purpose opposed wedges 305, 306 are disposed in juxtaposed slots 307 and 308 formed respectively in the lower surface of the support 42 and in the upper surface of a pad 309. The pad is immovably secured to the beam 43, as by welding—or by the bolts 303 if the holes therefor in the pad are close-fitting. If the large ends of the wedges are moved toward each other the support 42 is moved toward the furnace; and if they are moved away from each other the weight of the furnace forces the support in the other direction.

Means are provided for moving the wedges in either direction. Positively acting means of considerable power is necessary because the weight of the furnace is great. If desired, the action may be eased by raising the furnace, as by a hoist or jack. The taper of the wedges is relatively small to avoid unauthorized movement under all conditions.

As shown in Figs. 37 to 39, the adjusting means comprises an attachment or clamp 312 which can be anchored to the base in any convenient way, either permanently or detachably as a tool, the attachment illustrated being detachable and including laterally elongated openings 313 in its upper flange 314 which are adapted to engage stud pins 315 provided on a flange of the support 42. On its lower portion the attachment carries a hinged plate or flap 316 provided with openings 317 adapted to engage stud pins 318 provided on a flange of the I beam 43. The flap 316 is mounted on a hinge pin 319 and may be pressed upward by springs or may be held up by hand until held by pressure engagement. The fixed stud pins 315 and 318 are shown in assembly position in Fig. 10. While the pins are shown on the fixed frame parts and the holes in the attachment, the relationship may be reversed, or other connecting means may be provided.

Set screws 320 are threaded through the outer wall of the attachment in position to engage sockets 321 in the ends of the wedges. As shown in Fig. 38, a shift of the attachment from one set of stud pins to another shifts the set screw

from one wedge to the other, in one case to force the heads of the wedges together to expand their width in their slots and in the other case to force the heads apart to contract their width. After the support has been adjusted by the wedges it is securely clamped by tightening the nuts on the bolts 303.

Roller adjustment

In addition to the adjustment of the support as a unit by the wedges 305, 306, further adjustment is provided at and in the roller bearing. This permits further bodily movement of the roller, which is useful in obtaining fine adjustment after the support has been clamped in place; permits the roller to be turned about a horizontal axis to fit properly against the rocker rail; and also permits the roller to have free spherical movement to adjust itself to the face of the rocker rail at all times, even if the rail should be warped.

As shown in Figs. 33 to 35, the roller 41 is mounted on a short shaft or axle 325 which is provided with flat horizontal faces 326 at each end which rest upon flat seats 327 formed on the top of the support 42. The shaft is also provided at each end with flat vertical faces 328 which engage the front faces of wedges 329 which are vertically adjustable against abutments 330. Adjustment on either side is effected by a nut 331 threaded upon a stud 332 which passes through an oversized hole in the wedge and is tapped into the support 42 at the bottom of a recess 333.

It will be readily understood that by screwing down the wedge 329 on one side the end of the shaft on that side will be moved forward toward the furnace rocker. In this way the face of the roller 41 can be aligned with the face of the rocker 40. By screwing down the wedges on both sides the roller can be moved forward bodily toward the rocker. This provides a fine additional adjustment which may be useful when the support has already been clamped by the bolts 303.

A bearing sleeve or race 337 is secured on an enlarged portion 338 of the shaft 325. At each end of the race 337 and on smaller portions of the shaft there are secured spacer sleeves 339, key pins 340 being employed to prevent rotation between the sleeves and shafts. The sleeves fit closely between spaced faces on the support 42 and prevent endwise movement of the shaft 325.

The outer bearing race 341 is secured to the roller 41 by clamp plates 342 and bolts 343 therefor.

The bearing races 337 and 341 are provided with spherical travel surfaces for roller bearings 344 placed in staggered relationship in a retainer 345. Clearance space is left between the outer surfaces of the spacer sleeves 339 and the inner surfaces of the clamp plates 342 and this space is sealed by packing rings 346 which retain lubricant but permit adjusting movements of the roller 41. Lubricant is forced in through passages 347, a sealing fitting of any desired type being provided at the outer end of the passage for cooperating with a grease gun or a permanently connected oil pipe or the like.

The provision of roller bearings in a force-lubricated space furnishes advantages in the present furnace assembly which are not realized in the usual application of such bearings. This may be explained by reference to the type of service which may be required of the furnace. If it be assumed that the furnace is being used

as a pouring furnace which receives a steady

stream of metal from above and which delivers an approximately constant amount of metal to a continuous casting device or to molds, it will be evident that the rocking movements required of the furnace may be extremely small. Consequently, the arc of movement in the bearing surfaces of the supporting rollers will be very small. If plain shaft bearings are used the movement may be so small that certain portions of the very large contact surfaces are not exposed to lubricant in the lubricant grooves. As a consequence, certain sectors of the bearing surfaces will rub dry and wear excessively and possibly freeze together in a manner which would never occur if the parts rotated or even had extensive oscillating movement relative to each other. But with roller bearings this can never happen because each bearing roller has practically line or point contact with its race and any movement, however slight, will bring it into contact with the lubricant which is always maintained under pressure upon all exposed portions of the bearing rollers and their races.

Drive pinion adjustment

It has already been noted that the arcuate racks 89 may be turned end-for-end to provide new wear surfaces and that the drive pinions 88 may be adjusted. It will also be evident that the racks may be made long enough and be shifted endwise to provide new wear sectors, and this will be especially useful if the furnace is used exclusively for pouring and is held near a given position for long periods of time, whereby wear is localized.

In Figs. 6, 9 and 10 the means for adjusting the pinion are shown. Here it is seen that the pinion 88 on shaft 87 is placed between separate shaft bearings 350 which are independently adjustable by opposed set screws 351 (Fig. 10) threaded in fixed brackets 352. A flexible coupling 353 is provided in the shaft 87. It will be seen that this adjustment provides for proper alignment of the pinion with the gear rack and also provides some lateral movement of the pinion for more accurate meshing with the teeth of the gear rack.

Temperature control

The pouring temperature of the metal should be carefully controlled. To provide for this (Figs. 21, 22) a thermo-couple 356 is maintained in the metal in the throat of the spout in front of the skimmer 98. The thermo-couple will be protected by a suitable refractory material, such as "sillimanite." The connections for automatic control of the heating units may be the same as in the Summey Patent No. 2,102,582, referred to above. In the Summey patent it was disclosed that the provision of oxygen-free metal made it possible to use a thermo-couple for continuous temperature regulation because the oxygen-free metal did not appreciably attack the refractory protecting tube. The thermo-couple is there shown in the body of the furnace. This is satisfactory so long as pre-melted and purified metal is furnished to the pouring furnace; but when cathodes are charged into the furnace for melting, it has been found that the hydrogen carried on them tends to attack the refractory tube. By placing the thermo-couple in the throat of the spout outside the skimmer at a distance from the top opening 10 through which the cathodes are charged, this injury by harmful agents carried by the charged metal is avoided.

Charging solid metal

It has been noted that solid metal may be charged into the furnace through the top opening 10. This opening and one convenient form of charging means therefor are shown in Figs. 40 and 41.

Here the door 60 is shown in the open position clear of the opening 10 and the top frame 62 thereof. In Fig. 40 it may also be seen that the casing 360 of the opening 10, in at least one direction, is tapered inward from top to bottom. In the other direction the casing may be parallel-sided for the most part. For constructional reasons and for enabling flat slabs, such as cathodes or parts thereof, to be charged parallel to the axis of the furnace, the tapered sides are disposed parallel to the furnace axis and the parallel sides are disposed transversely to the furnace axis. A load L, such as a cathode, is shown in the charging position. Bales or cabbages may also be charged by the means to be described; and long strips or small pieces of scrap may be charged by hand.

The lower edge of the casing, on both the tapered and the parallel sides, is flared outward to the inner surface of the furnace lining for the purpose of more securely anchoring the lining. The flare on the tapered sides serves another purpose in relation to the charging device, as will be noted presently.

A convenient charging device which cooperates well with the tapered walls of the opening casing 360 is exemplified in the tongs T adapted to be suspended by the hook 361 of a hoist chain or cable.

The tongs comprise jaws T1 and integral crossed arms T2 pivoted together by a pin T3. At their upper ends the arms are connected by toggle links T4 which are pivoted to the arms by pins T5 and to each other by a pin T6. A lifting ring T7 may be placed on the pin T6 for cooperation with the lifting hook 361.

The jaws T1 are provided with gripping pins T8 at their lower ends, which, as shown in Fig. 41, may be staggered, the one on the single jaw on one side being disposed between the two spaced pins on the bifurcated jaw on the other side.

The upward pull on the left ring and toggle links pulls the jaws together while the tongs are supported. The jaws may be held apart by a latch arm T9 which is pivoted to one of the arms by a pin T10 and which is provided with a notch T11 adapted to engage the toggle pin T5 of the other arm. The latch arm may be manipulated by a handle T12 extending laterally from the outer end thereof.

The jaws T1 are provided with upwardly and outwardly inclined ears T13 which are adapted to engage the converging sides of the casing 360 when a load is being lowered into the furnace to open the jaws and release the load. This provides assurance that the tongs will not descend into or be retained in the heated interior of the furnace when the load is of short length; and also provides that the load will be lowered sufficiently before it is released to prevent injury to the bottom of the furnace lining if it drops the rest of the way. The rate at which the load is lowered by the hoist is not sufficient to cause injury to the lining if the load should strike bottom while still held by the tongs.

In some cases the load, such as the strip or cathode L, may be long enough to touch bottom before the ears T13 engage the tapered casing

walls. When this happens the jaws are released by another action. The arms T2 are overweighted about the hinge pin T3 and drop outward by gravity to release the jaws. In any case, when the arms are swung outward sufficiently the notch T11 of the latch arm T9 will engage the pin T5 to hold the jaws in open position in spite of the lift on the toggle links.

It has just been explained that the arms may be spread open by the action of the ears against the tapered sides of the casing or by engagement of the load with the bottom of the furnace. The arms may also be spread open by hand when a load is to be engaged by the tongs. Of course, the arms may be already latched in open position by a previous operation. In any event, after the tongs have been positioned upon the load the latch is swung up to release its notch from the pin and allow the toggle to collapse and grip the load in the jaws as the tongs are lifted by the hoist.

If, by chance, the tongs should be lowered into the furnace chamber with the ears T13 in the spread position, that is with the jaws in their closed position, the ears will engage the outflared bottom edge of the casing and be pressed together sufficiently to allow the tongs to pass out of the opening when pulled upward by the hoist. The flared sides also provide proper charging when the furnace is in tilted positions.

In Fig. 40 the clamping position of the tongs is shown in full lines and the open position is shown in broken lines. Although not illustrated, the position when the ears engage the casing can readily be understood from the above description. It can be seen that with the present load the ears will engage the casing walls before the end of the suspended piece L engages the bottom of the furnace. After release the piece will fall gently through the bath until its end engages the bottom and thereafter it will melt away from the lower end until the remaining part falls into the bath and melts.

The use of the tongs assures that flat pieces will be charged edgewise and pass readily through the covering material C. This avoids the possibility that the piece will be deposited flatwise upon the bed of covering material where it might float and require a longer time to melt.

Operation

Referring to the diagrams, Figs. 11 to 16, the hearth or chamber center O1, the oscillating center O2, the spout spill-over point 93, and the heating units H are shown in each view.

Fig. 11 shows a normal position in which the chamber center O1 is disposed in a vertical plane over the oscillating center O2. The induction heating units are disposed symmetrically with respect to the axial vertical plane. And a large charge of metal reaching to the level of the spill-over point 93, which is above the chamber center O1, stands in the chamber.

Fig. 12 shows a position where the furnace has been turned to the right (clockwise) until the channels of the left hand heating units have been emptied, the spout spill-over point 93 being disposed slightly above the oscillating center O2. This is a limiting position in which the stop abutment 44 (Fig. 8) practically comes against a support roller.

In practice the abutment does not strike but instead the movement is halted by a limit switch associated with the drive motor as shown in Fig. 5. It will be understood that the motor may be

inched by very small amounts and stopped immediately the current switch is released by an electro-magnetic brake which is also shown in Fig. 5. The control switch box may be portable and one convenient location for it (Fig. 25) is on the platform 25 in front of the hood 81 where the operator can watch the pouring stream as it passes to the launder 20. Another convenient and perhaps preferable location is near the hood 125 of the roll casting mill where the actual casting of the metal can be watched.

The units on the left may be changed in the Fig. 14 position after they have been turned back from the Fig. 12 position to bring the metal away from the pouring spout lip. Here the channel is practically horizontal but care is taken to insure that metal does not spill out of the throat of the pocket leading to the channel.

It will be noted that the chamber center O1 has dropped relative to the oscillating center O2, that the right hand pockets and channels are full of metal, and that there is a body of metal in the chamber connecting the bodies of metal in the pockets. There is therefore an adequate head of metal on the heating unit channels to permit of enough heating to keep all of the metal in molten condition.

Fig. 13 shows the position of the furnace when a very large charge of molten metal is disposed in the chamber. Here the spout is turned up sufficiently to retain the large bath of metal.

Fig. 14 shows a position in which the furnace has been turned back from the Fig. 12 position for changing a unit on the left side as previously described.

Fig. 15 is a view similar to Fig. 14 but illustrating the position for changing units on the right side. The metal has previously been drained to the amount shown by turning the furnace in the other direction to the Fig. 12 position.

Fig. 16 shows the furnace when it has been turned back to a central position after the metal has been poured down to the minimum level shown in Fig. 12. Here it will be seen that there is always enough metal to fill all channels and pockets and to leave a connecting body of metal in the bottom of the chamber.

The furnace may run for a long time without emptying all of the metal from it. There is therefore no necessity to provide for complete drainage in normal operation. Should complete drainage ever be necessary, it may readily be effected by removing the units on one side and then turning the furnace down on that side to allow all the metal to run out the ends or throats of the pockets, vessels being of course placed to receive the metal.

While one embodiment has been described in detail to illustrate the principles of the invention it is to be understood that the invention may have various embodiments within the limits of the prior art and the scope of the subjoined claims.

We claim:

1. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a metal pouring spout on the vessel at one side of the axis, a metal delivery conduit located on and aligned with said axis, and connecting metal conduit means between said spout and said delivery conduit, whereby metal is poured from the spout when the vessel is turned about said axis and runs back to the delivery conduit without requiring move-

ment of the delivery conduit relative to said axis.

2. Metallurgical apparatus comprising in combination, a metal holding vessel having a metal holding chamber and being mounted to turn about a horizontal axis located near the lowest part of the chamber, a metal pouring spout located in one end of the vessel at one side of and above the level of the axis, a metal delivery conduit located on and aligned with said axis, and connecting metal conduit means between said spout and said delivery conduit, whereby metal is poured from the spout when the vessel is turned about said axis and runs back to the delivery conduit without requiring movement of the delivery conduit relative to said axis.

3. Metallurgical apparatus comprising in combination, a metal holding vessel having a metal holding chamber with an arcuate bottom, said vessel being mounted to turn about a horizontal axis located near the lowest part of the bottom, a metal pouring spout located in one end of the vessel at one side of and above the level of the axis, a metal delivery conduit located on and aligned with said axis, and connecting metal conduit means between said spout and said delivery conduit, whereby metal is poured from the spout when the vessel is turned about said axis and runs back to the delivery conduit without requiring movement of the delivery conduit relative to said axis.

4. Metallurgical apparatus comprising in combination, a metal holding vessel having a metal holding chamber with an arcuate bottom, said vessel being mounted to turn about a horizontal axis located near the lowest part of the bottom, a metal pouring spout located in one end of the vessel at one side of and above the level of the axis, said spout having its channel extending inward and downward toward the axis inside the vessel, a metal delivery conduit located on and aligned with said axis, and connecting metal conduit means between said spout and said delivery conduit, whereby metal is poured from the spout when the vessel is turned about said axis and runs back to the delivery conduit without requiring movement of the delivery conduit relative to said axis.

5. Metallurgical apparatus comprising in combination, a metal holding vessel having a metal holding chamber and being mounted to turn about a horizontal axis located near the bottom of the chamber, heating units on each side of the axis and including metal holding and heating channels which extend away from the axis, a metal pouring spout for said vessel located at one side of and above said axis, a metal delivery conduit located on and aligned with said axis, connecting metal conduit means between said spout and said delivery conduit, means for turning the vessel to pour metal through said spout, and means for limiting the turning movement when the heating channel on one side is empty and enough metal is retained in the other channel and vessel chamber to fill both channels and provide a connecting body of metal in the vessel chamber when the vessel is turned back to normal operating position.

6. Metallurgical apparatus comprising in combination, a metal holding vessel having a cylindrical metal holding chamber and being mounted to turn about a horizontal axis located near but slightly above the bottom of the chamber, a heating unit on each side of the vessel, each unit having a metal holding and heating channel

directed approximately toward said axis, a spout on said vessel having its spillover point located at one side of the axis beyond the metal chamber and above the heating unit channel on that side, a metal delivery conduit located on and aligned with said axis, and connecting metal conduit means between said spout and said delivery conduit.

7. Metallurgical apparatus comprising in combination, a metal holding vessel having a cylindrical metal holding chamber and being mounted to turn about a horizontal axis located near but slightly above the bottom of the chamber, a heating unit on each side of the vessel, each unit having a metal holding and heating channel directed approximately toward said axis, a spout on said vessel having its spillover point located at one side of the axis beyond the metal chamber and above the heating unit channel on that side, the spillover point of said spout also being located above the extended plane of the channel of the heating unit on the opposite side of the vessel, a metal delivery conduit located on and aligned with said axis, and connecting metal conduit means between said spout and said delivery conduit.

8. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a pouring spout on said vessel at one side of the axis, a metal delivery conduit located on and aligned with said axis, and a lateral metal conduit between said spout and said axial conduit which has a joint with the axial conduit which provides relative rotational and axial sliding movement between the conduits.

9. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a pouring spout on said vessel at one side of the axis, a conduit aligned with the turning axis, and a lateral conduit between said spout and said axial conduit, said lateral conduit being constructed and connected to accommodate for expansion along its length between said spout and the axis.

10. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a pouring spout on said vessel at one side of the axis, a conduit aligned with the turning axis, and a lateral conduit between said spout and said axial conduit, said lateral conduit being connected to the spout at one end and being slidably supported along its length upon a part secured to said vessel.

11. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a pouring spout on said vessel at one side of the axis, a metal receiving device having an opening on the turning axis, a lateral conduit connected to said spout, an axial conduit aligned with the turning axis and connected to the lateral conduit, and means providing a turning joint between said axial conduit and said receiving device, said joint means being constructed to provide lateral movement between the parts to accommodate expansion in the lateral conduit, and said joint means also being constructed to provide spherical movement to accommodate irregularities of construction.

12. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a pouring spout on said vessel at one side of the axis, a metal re-

ceiving device having an opening on the turning axis, a lateral conduit connected to the spout, an axial conduit aligned with the turning axis and connected to the lateral conduit, and means providing a turning joint between said axial conduit and said receiving device, said joint means being constructed to provide relative axial movement between said axial conduit and said receiving device.

13. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, an axial conduit aligned with the turning axis through which metal from said vessel is poured, a hood enclosing the end of said axial conduit, said hood being mounted for axial turning movement relative to said axial conduit, and a delivery launder connected with said hood, said launder being mounted for axial movement with said hood.

14. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, an axial conduit aligned with the turning axis through which metal from said vessel is poured, a hood enclosing the end of said axial conduit, said hood being mounted for axial and turning movement relative to said axial conduit, and a delivery launder connected with said hood, said launder being mounted for axial movement with said hood and for vertical movement about a horizontal axis with respect to said hood.

15. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a spout on said vessel at one side of its axis, an axial conduit aligned with the turning axis of said vessel, a lateral launder between said spout and said axial conduit, a delivery launder for conveying metal from said axial conduit, and connecting means between said delivery launder and said axial conduit providing relative axial movement, relative turning movement about the conduit axis, lateral movement relative to the conduit axis, and vertical turning movement about a horizontal axis located transversely of said vessel and conduit axis.

16. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, an axial conduit aligned with the turning axis of said vessel through which metal is poured, a heating unit on each side of the vessel, each unit having a metal holding and heating channel directed approximately toward said axis and inclined downwardly, each heating unit including a casing having a connecting flange at its inner end, said vessel having a casing with mating flanges for the heating unit flanges, said flanges normally being inclined at an angle to a vertical plane, means for turning said vessel to either side until one of said channels is above the metal level and empty and the other channel is full of metal to keep the vessel in operation, the flanges of the elevated heating unit being approximately vertical when the channel is empty, a short horizontal ledge on one of said flanges upon which said heating unit rests at the inner end when turned to the empty position, means for securing said flanges together, and a suspension guy rod between the outer portion of the heating unit casing and an upper portion of the vessel casing.

17. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, an axial conduit aligned with the turning axis of said vessel through which metal is poured, a heating unit

on each side of the vessel, each unit having a metal holding and heating channel directed approximately toward said axis and inclined downwardly, each heating unit including a casing having a connecting flange at its inner end, said vessel having a casing with mating flanges for the heating unit flanges, said flanges normally being inclined at an angle to a vertical plane, means for turning said vessel to either side until one of said channels is above the metal level and empty and the other channel is full of metal to keep the vessel in operation, the flanges of the elevated heating unit being approximately vertical when the channel is empty, a short horizontal ledge on one of said flanges upon which said heating unit rests at the inner end when turned to the empty position, means for securing said flanges together, and a suspension guy rod between the outer portion of the heating unit casing and an upper portion of the vessel casing, said guy rod including adjustable and resilient elements for regulating the supporting tension on the outer end of the channel shell.

18. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, a heating unit on each side of the vessel, each unit having a metal holding and heating channel directed approximately toward said axis and inclined downwardly, each heating unit including a casing having a connecting flange at its inner end, said vessel having a casing having mating flanges for the heating unit flanges, said flanges normally being inclined at an angle to a vertical plane, means for turning said vessel to either side until one of said channels is full of metal to keep the vessel in operation, the flanges of the elevated unit being approximately vertical when the channel is empty, a short horizontal ledge on one of said flanges upon which said heating unit rests at the inner end when turned to the empty position, and means for securing said flanges together.

19. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, an axial conduit aligned with the turning axis through which metal from said vessel is poured, a saddle seat provided on said vessel which is concentric with said horizontal turning axis, a saddle mounted in a fixed position and having an interfitting joint with the saddle seat to permit the vessel to turn beneath it, and means associated with the saddle for pouring metal into the vessel in any turned position thereof.

20. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, an axial conduit aligned with the turning axis through which metal from said vessel is poured, a saddle seat provided on said vessel which is concentric with said horizontal turning axis, a saddle mounted in a fixed position and having an interfitting joint with the saddle seat to permit the vessel to turn beneath it, and means associated with the saddle for pouring metal into the vessel in any turned position thereof, said saddle having axially spaced concentric sealing faces and concentric end sealing faces mating with faces on said seat.

21. Metallurgical apparatus comprising in combination, a metal holding vessel mounted to turn about a horizontal axis, an enclosed axial conduit at one end of said vessel aligned with the turning axis through which metal from said vessel is poured, and an enclosed metal charging device turnably fitted with the top of the vessel

at the end opposite the pouring conduit to permit turning movement of the vessel relative thereto and to provide for charging metal in any position of the vessel about its turning axis.

22. Metallurgical apparatus comprising in combination, a metal holding vessel including a casing providing a horizontal cylindrical metal holding chamber formed about a horizontal axis means supporting the vessel for turning movement about a second horizontal axis which is parallel with and disposed below the axis of said chamber, means providing a sealed joint concentric with the turning axis of said vessel and which provides for relative turning movement of the vessel about its turning axis for charging metal into the vessel in any turned position, and means providing a sealed joint concentric with the turning axis of said vessel permitting metal to be poured therefrom in various turned positions about the turning axis of the vessel.

23. Metallurgical apparatus comprising in combination, a metal holding vessel including a casing providing a horizontal cylindrical metal holding chamber formed about a horizontal axis, means supporting the vessel for turning movement about a second horizontal axis which is parallel with and disposed below the axis of said chamber, means providing a sealed joint concentric with the turning axis of said vessel and which provides for relative turning movement of the vessel about its turning axis for charging metal into the vessel in any turned position, and means

providing a sealed joint concentric with the turning axis of said vessel permitting metal to be poured therefrom in various turned positions about the turning axis of the vessel, said turning axis being located near the bottom of the cylindrical metal chamber.

24. Metallurgical apparatus comprising in combination, a metal holding vessel including a casing providing a horizontal cylindrical metal holding chamber formed about a first horizontal axis, means supporting the vessel for turning movement about a second horizontal axis which is parallel with and disposed below the axis of said chamber, means providing a sealed closure with the top of the vessel casing having a joint concentric with the turning axis for charging metal in any turned position about said turning axis, and means providing a sealed joint with said vessel casing concentric with the turning axis permitting metal to be poured therefrom in various turned positions about the turning axis of the vessel while maintaining the sealing enclosure therewith in all positions, said supporting means including axially spaced turning supports near each end of the vessel, the supports at one end holding the vessel against axial movement at that end and the supports at the other end providing axial movement of the turning support at that end to accommodate axial expansion of said vessel.

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