

April 12, 1938.

W. E. MOORE

2,114,230

ELECTRIC FURNACE

Filed Dec. 22, 1933

7 Sheets-Sheet 1

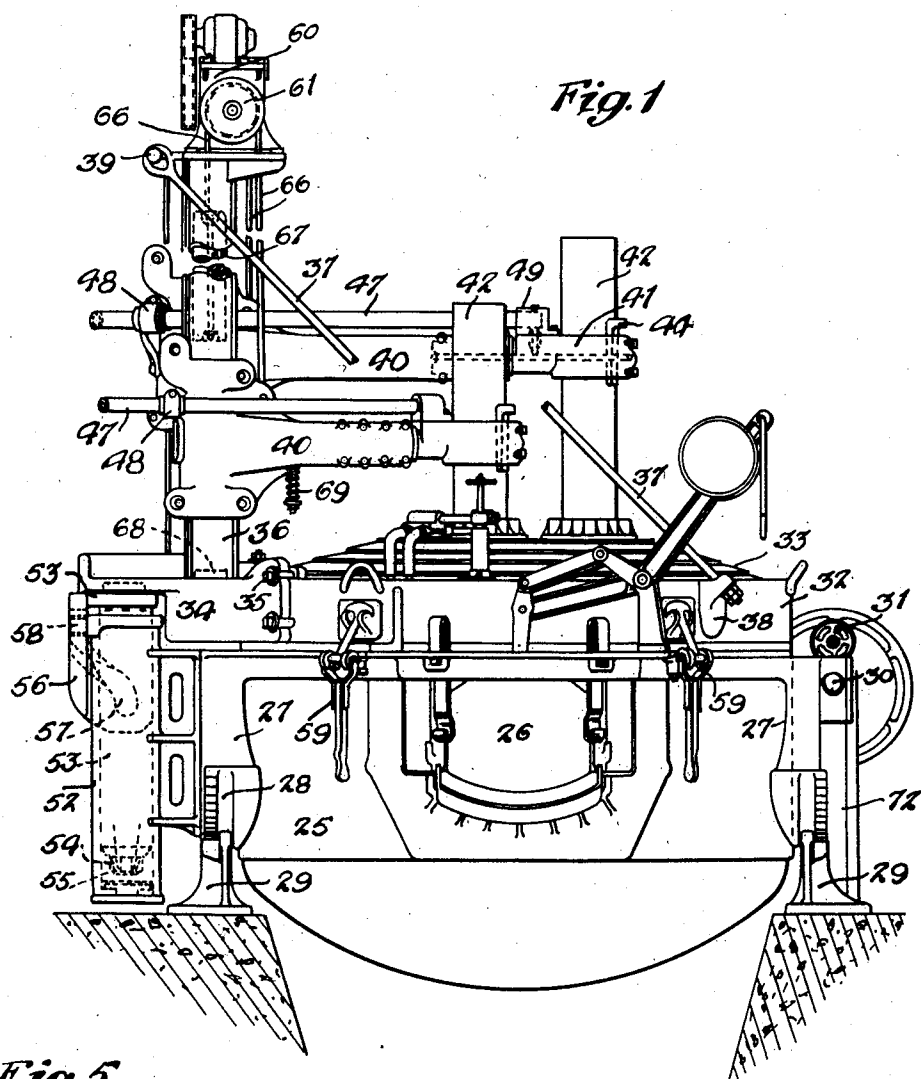


Fig. 5

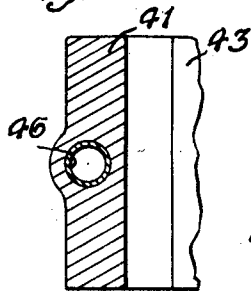
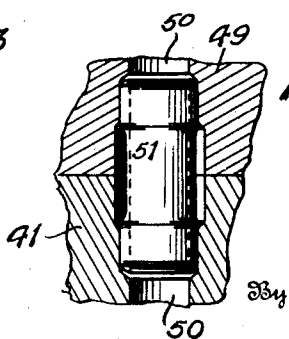


Fig. 6



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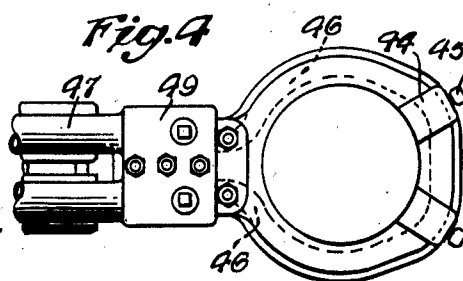
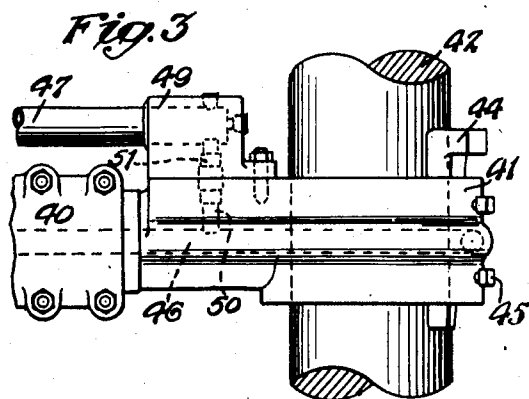
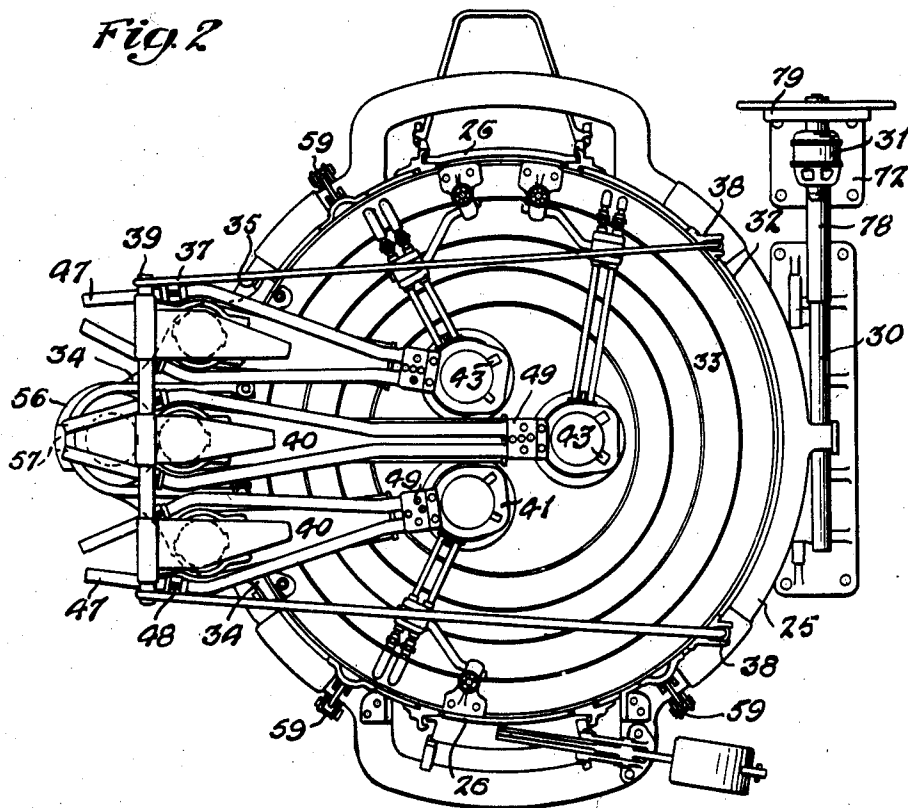
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7 Sheets-Sheet 2



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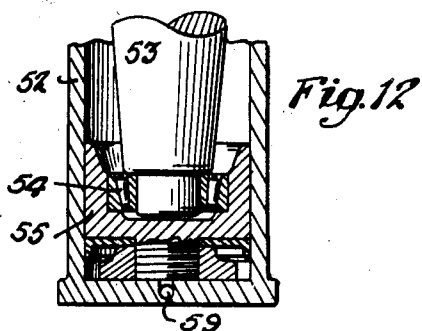
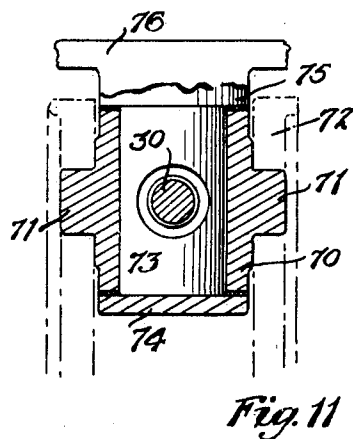
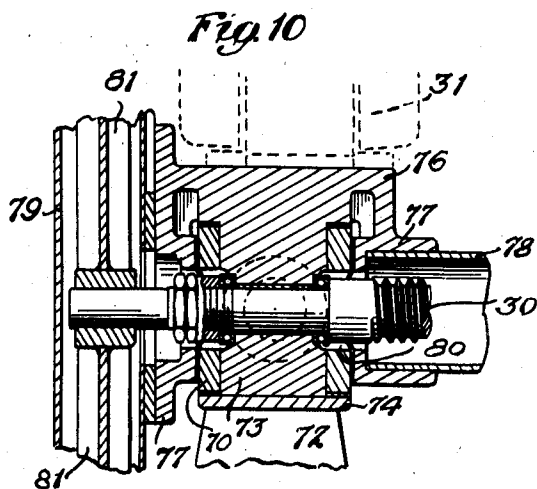
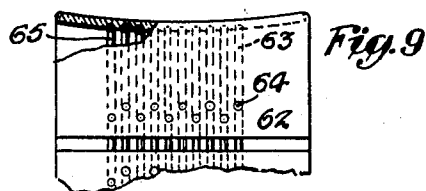
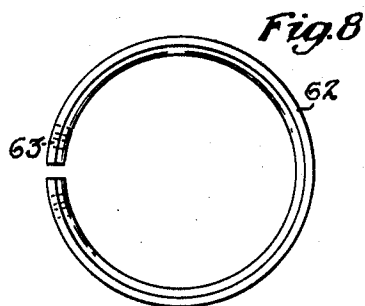
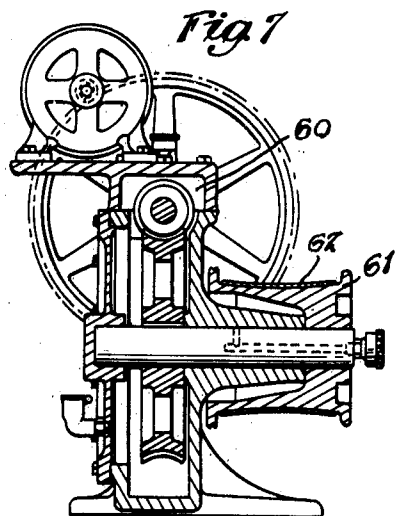
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7 Sheets-Sheet 3



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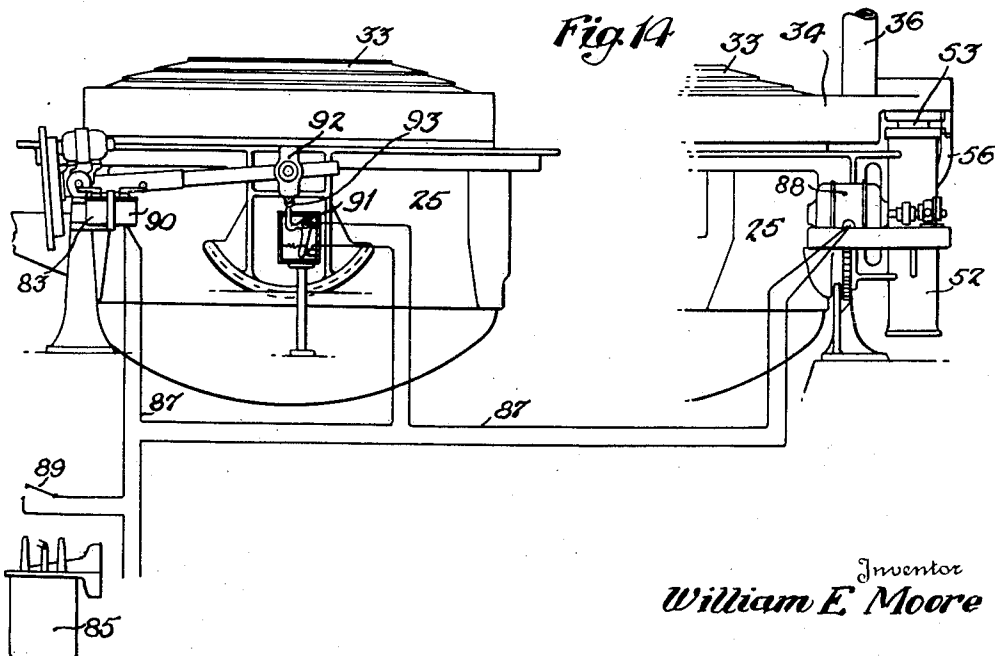
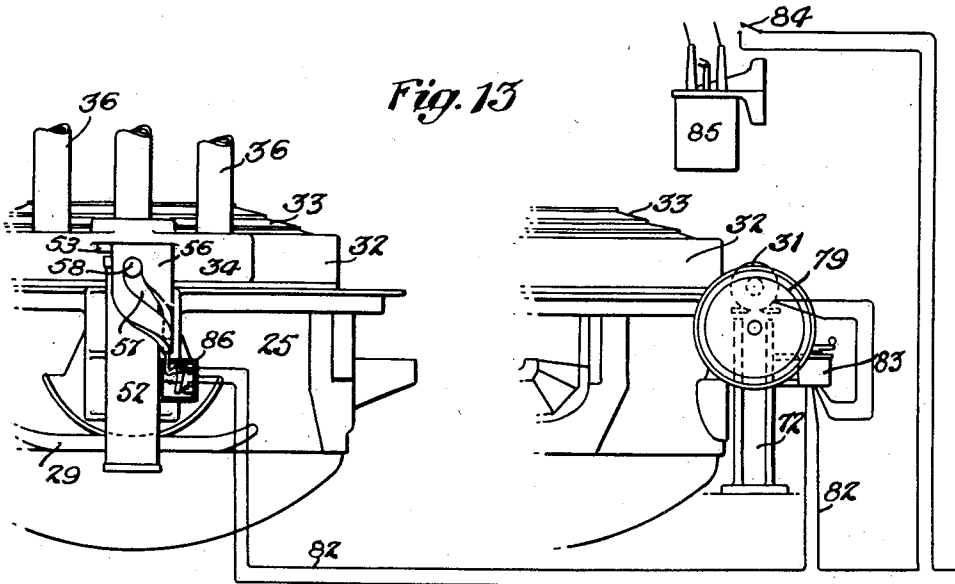
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ELECTRIC FURNACE

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7 Sheets-Sheet 4



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2,114,230

ELECTRIC FURNACE

Filed Dec. 22, 1933

7 Sheets-Sheet 5

Fig. 15

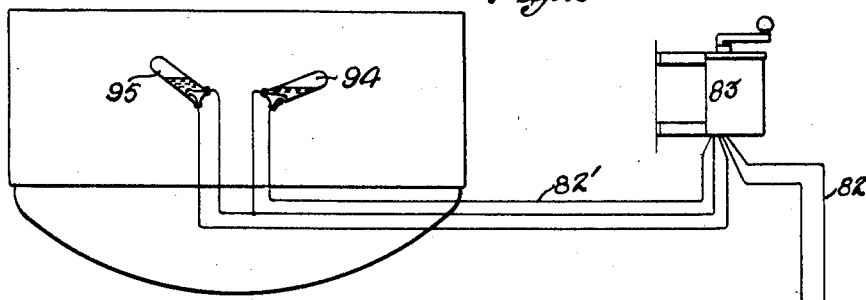


Fig. 16

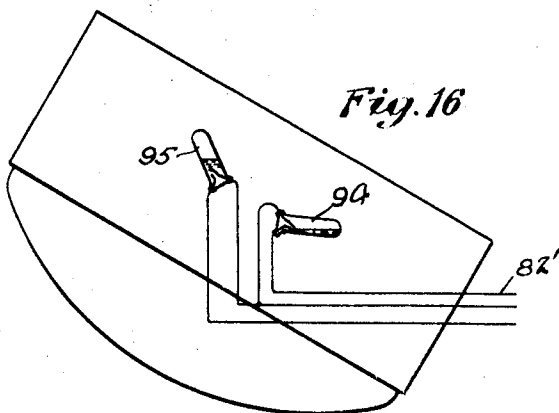


Fig. 17

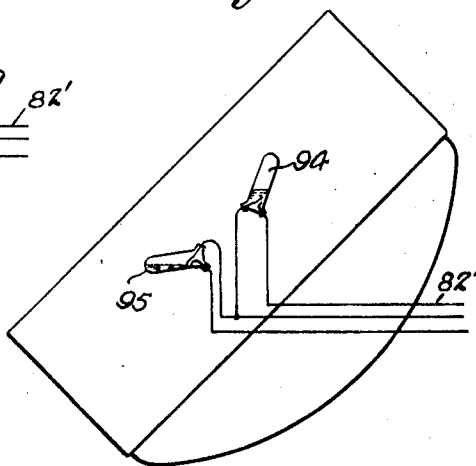
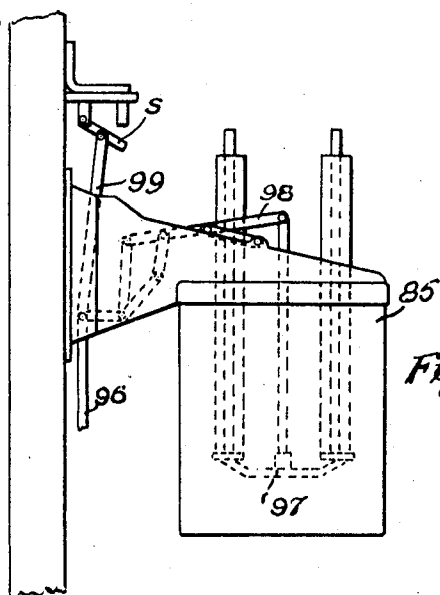


Fig. 18



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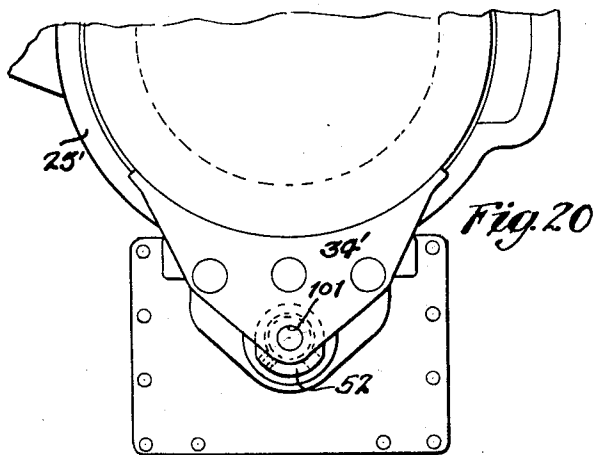
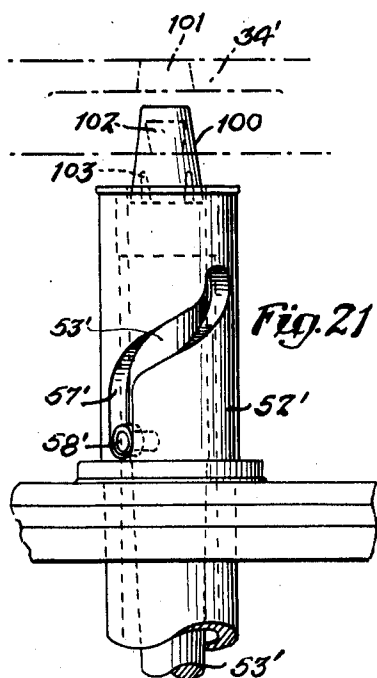
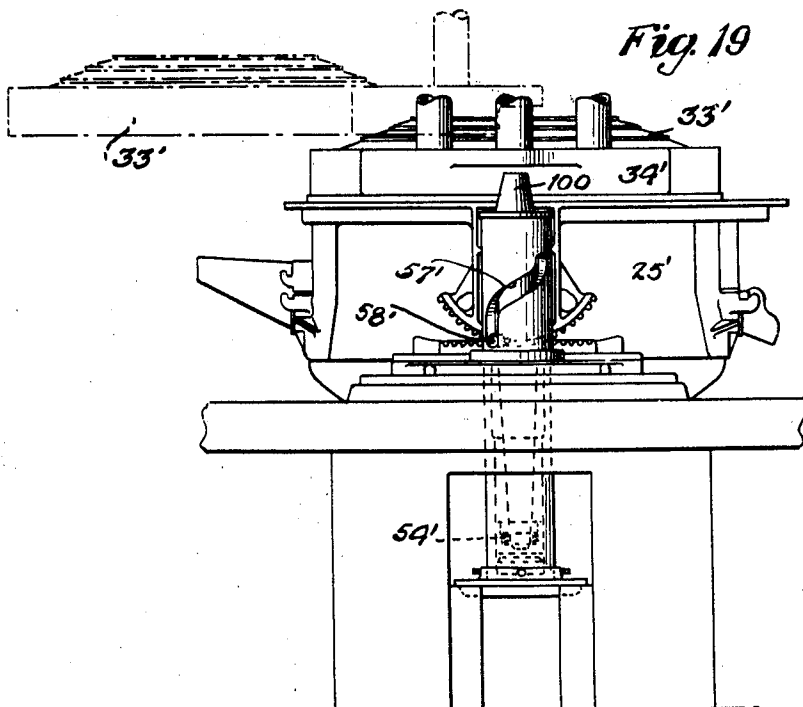
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ELECTRIC FURNACE

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7 Sheets-Sheet 6



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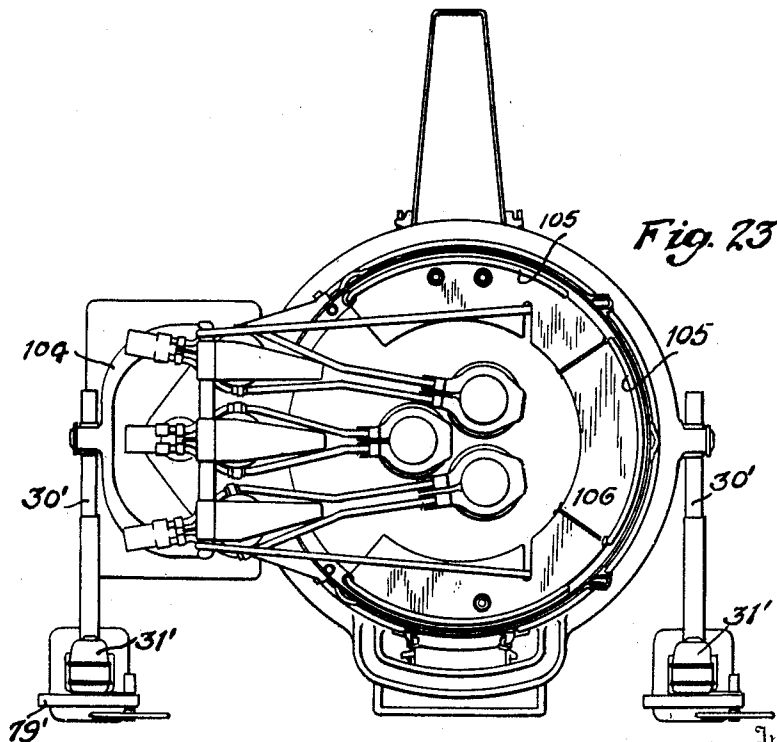
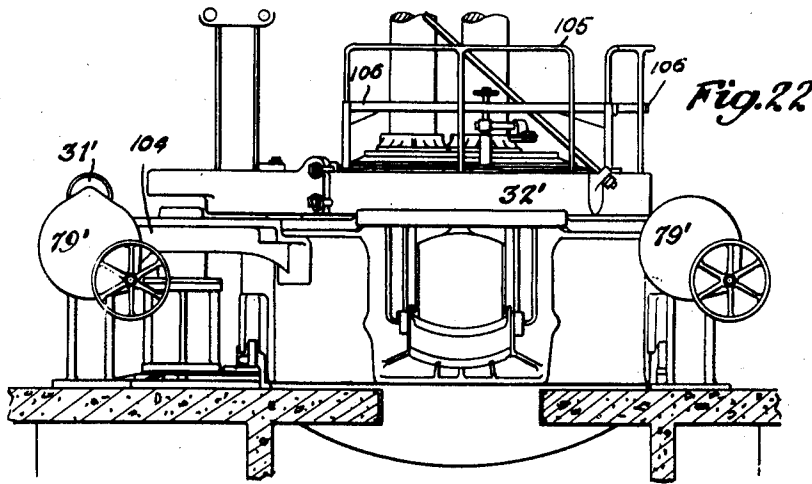
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ELECTRIC FURNACE

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UNITED STATES PATENT OFFICE

2,114,230

ELECTRIC FURNACE

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Application December 22, 1933, Serial No. 703,639

18 Claims. (Cl. 13—1)

My present invention relates to improvements in electric furnaces and more particularly to furnaces of the type used in metallurgical operations.

5 One important object of my invention is to provide a furnace which may be charged through its top by moving the furnace roof away from the furnace shell.

10 Another object of my invention is the provision of a top charge furnace with a removable roof having the electrode columns and operating winches mounted thereon.

15 A further object of my invention is to provide improved tilting mechanism to tilt the furnace shell for slagging and pouring operations.

Still another object of my invention is the provision of automatic electrical control mechanism for controlling the roof raising and furnace tilting operations.

20 Yet another object of this invention is to provide means for raising the furnace roof and swinging it away from the furnace shell in a single operation.

25 A still further object of my invention is to provide a platform about the furnace electrodes which will support workmen above the furnace roof.

Another object of my invention is the provision of a novel electrode arm and clamp.

30 Other objects and advantages of my invention will be apparent during the course of the following description.

35 In the accompanying drawings which form a part of this specification and wherein like characters of reference denote like parts throughout the same,

Figure 1 is an elevation of an electric metallurgical furnace embodying my invention,

Figure 2 is a top plan view thereof,

40 Figure 3 is a detail side elevation of my improved electrode clamp,

Figure 4 is a top plan view thereof,

45 Figure 5 is a fragmentary vertical sectional view through the electrode clamp,

Figure 6 is a detail fragmentary sectional view through the water circulating connection between the bus bar and electrode clamp,

50 Figure 7 is a vertical sectional view through the electrode winch,

Figure 8 is an end elevation of the fiber bushing for the winch drum,

Figure 9 is a fragmentary side elevation thereof,

55 Figure 10 is a longitudinal sectional view

through the universal joint of the tilting mechanism,

Figure 11 is a transverse sectional view thereof,
Figure 12 is a detail sectional view of the hydraulic ram piston and cylinder showing the connection of the ram plunger and piston,

Figure 13 is a diagrammatic view illustrating the interlocking control of the roof lifting mechanism and the tilting mechanism,

Figure 14 is a similar view illustrating the furnace leveling control,

Figure 15 is a diagrammatic view illustrating the tilting limit control switches,

Figure 16 shows the operation of the control switches at the slagging tilting limit,

Figure 17 illustrates the operation of the switches at the limit of the pouring tilt,

Figure 18 is a detail view of the interlocking connection between the main circuit breaker and the main control switch,

Figure 19 is a side elevation of a furnace embodying a slightly modified roof lifting mechanism,

Figure 20 is a fragmentary top plan view thereof,

Figure 21 is a detail elevation of the roof lifting mechanism,

Figure 22 is an elevation of a furnace embodying my improved tilting mechanism and roof platform, and,

Figure 23 is a top plan view thereof.

In the drawings, wherein for the purpose of illustration is shown a preferred embodiment of my invention the numeral 25 designates the furnace shell provided with the usual side doors 26 and having trunnion frames 27 at its sides which are provided with rockers 28 supported upon horizontal supports 29. Tilting of the furnace shell is effected by means of shaft 30 operated by tilting motor 31. The furnace so far described is similar to that shown and described in my prior Patents 1,444,980 and 1,532,599 and need not be described in detail.

The roof arch ring 32, holding the removable refractory roof 33 is detachably connected to the spectacle casting 34 by means of suitable bolts or other securing means 35. The spectacle casting 34 carries the electrode guide columns 36 and may be quickly detached from the roof ring for repairs. The roof ring 32 is further supported by means of guy rods 37 which are latched into suitable slot blocks 38 on the exterior face of the ring 32. A suitable cross bar or rod 39, having hook like ends which pivotally engage the upper ends of the guy rods 37 is carried by the upper

ends of the columns 36. Electrode arms 40 are slidable vertically on guide columns 36 and have clamps 41 which engage the electrodes 42.

The electrode arms 40 are of the usual cast cross head construction with adjustable guide rollers engaging the columns 36, and clamp about extensions on electrode clamps 41. The clamps 41 are of the continuous ring type and are provided on their forward sides with tapered slots 43 to receive clamping wedges 44 which directly engage the electrodes to wedge them in the clamping rings 41. The wedges 44 have their upper ends provided with projections or turned over portions to facilitate raising the wedges, and set screws 45 lock the wedges in position in the clamping ring, and further add to the clamping action of the wedges on the electrodes.

The electrode clamping rings 41 are each provided with a cast in loop of fluid circulating pipe 46. The rings 41 are copper casting while the pipes 46 are preferably of steel to strengthen the clamping rings. The loops of pipes 46 encircle the electrodes and form cooling coils for circulating cooling water through the clamping rings and around the electrodes. While only a single loop 46 is shown for each clamping ring it is obvious that any number of cooling loops may be used.

Copper bus tubes 47 are of sufficient size to conduct the desired power to the electrodes and two such hollow tubes are provided for each electrode clamp so that they may also be used as cooling water conductors. The bus tubes 47 are supported in insulated non-magnetic brackets 48 mounted on the electrode arm cross heads. The other ends of the bus tubes fit into contact shoes 49 bolted to the upper surfaces of the electrode clamps 41. A vertical passage 50 extends through each contact shoe 49 and clamping ring 41 to connect each bus bar with cooling pipe 46. This passage is enlarged or counterbored adjacent the juncture of the contact shoe and clamping ring to receive a pipe tube 51 which is enlarged or barreled slightly at each end so that when it is forced into the enlarged portion of the passage 50 in the clamping ring 41 and shoe 49 it will be sealed against leakage. The relieved central portion of pipe tube 51 between the enlarged ends will also permit a slight misalignment of the passages in the shoe and clamp without destroying the seal.

In order to charge the furnace through its top it is necessary to raise the furnace roof vertically until it clears the furnace shell, and then to swing it away from the furnace shell to uncover the shell. In my prior Patent No. 1,818,239 I provided a lifting ram arranged independently of the furnace shell and roof and which raised and swung the roof away from the shell in two operations. In Figures 1, 2 and 13 I have shown mechanism for raising and swinging the furnace roof in a single operation. A hydraulic cylinder 52 is mounted on the furnace shell and receives a hydraulic ram plunger 53 bolted or otherwise securely fastened to the underside of the spectacle casting 34. The ram 53 tapers to its lower end which rests in an anti-friction roller bearing 54 arranged in the piston 55, as indicated in Figure 12 and in dotted lines in Figure 1. Consequently the ram plunger is free to rotate independently of the piston 55. An arcuate cam skirt 56 is secured to the upper end of the ram plunger above cylinder 52 and extends downwardly in concentric spaced relation thereto, and exteriorly of the cylinder 52. The skirt 56 is provided with a cam slot 57 extending

about the skirt through an arc of 90° and the shape of this slot is indicated in Figures 1 and 13 and in the modification shown in Figures 19 and 21. A roller 58 is secured to the stationary cylinder 52 adjacent the top thereof and extends into the slot 57 and engages the sides thereof.

When it is desired to raise the roof, fluid under pressure is admitted into the lower end of cylinder 52 through port 59 and the ram 53 moves upwardly, carrying with it the spectacle casting, furnace roof and skirt 56. As the skirt 56 moves upwardly the roller 58 engages the vertical portion of the cam slot and the roof moves vertically from the furnace shell until the shell is cleared. The stationary roller then reaches the curved portion of the cam slot 57 and causes the skirt 56 to rotate, carrying with it the ram plunger 53 and the roof and spectacle casting which are secured thereto. Due to the roller bearing 54 the piston 55 does not rotate with the plunger and roof but moves in a vertical direction only, thereby preventing excessive wear of the piston packing.

The cam slot 57 raises the roof and swings it through an arc of substantially 90° about the plunger axis as a center in a single operation of the plunger. The top of the furnace shell is completely uncovered by the roof and the charging operation may be effected readily without interference from the furnace roof. When the furnace is completely charged, pressure beneath the piston 55 is relieved, and the plunger is allowed to lower under the weight of the roof. The cam slot and roller swing the roof back over the furnace shell and then drop it vertically into position on the shell to which it is then secured by latches 59 which are of the quick acting type.

With this construction of the ram, no pit or trough beneath the ram is required, and as the ram is secured directly to the spectacle casting, the roof is supported even before the hold down latches 59 engage the roof ring. Attachment of the ram directly to the spectacle casting allows the use of a shorter ram and cylinder than is required when the ram is independent of the cylinder as in my prior Patent 1,818,239, and the ram travel is also less than in my prior patent.

It is customary to mount the electrode operating winches at a distance from the furnace, or directly upon the furnace shell. Either of these locations is disadvantageous with a removable roof furnace, however, and I therefore propose to mount these winches upon the top of the electrode supporting columns 36 as shown in Figure 1. The electrode winches 60 may be of the usual motor driven construction, such as shown in Figure 7 but the cable drums 61 are each preferably provided with a somewhat flexible sleeve 62 of fiber or the like, slit longitudinally as seen in Figures 8 and 9. The inner surface of the sleeve 62 is provided with a plurality of circumferentially extending grooves 63 which terminate in openings 64 at points adjacent but spaced from the longitudinal slit in the sleeve. Rings or bands 65 of spring wire fit into the grooves 63 and have their ends extending into openings 64. The springs wires 65 tend to expand the split sleeve 62.

Electrode operating cables 66 are attached to the cross heads of the electrode arms 40 and are wound about the drums 61 and sleeves 62. The opposite ends of the cables 66 are attached to counterbalance weights 67 which are arranged to slide in the hollow columns 36. Normally the weight of the counterbalances 67 and electrode

arms 40 on the cables 66 compresses the fiber sleeves against the tension of springs 65 into intimate engagement with the drums 61 so that the sleeves rotate therewith. When the weights 67 ground on stops 68, or when the electrode arms contact with the furnace roof through the spring buffers 69, the weight on the cables is relieved thereby allowing springs 65 to expand sleeve 62 and permit drum 61 to rotate within the split sleeve. Consequently limit switches to prevent stalling of the winch motors are not required.

As the entire electrode operating mechanism is mounted upon the furnace roof, it may be moved with the roof as a unit and will not interfere with movement of the furnace roof. Flexible electrical and water supply connections to the bus bars or tubes 47 will be used which will not prevent movement of the roof.

The furnace tilting mechanism shown in Figures 1 and 2 may be of the usual construction but I prefer to mount the driven end of the tilting shaft 30 in a universal swivel such as shown in Figures 10 and 11. The swiveling action is obtained by the use of a trunnion casting or body 70 having diametrically opposed trunnions 71 pivotally mounted in the tilting column 72 permitting the casting 70 to swivel about a horizontal axis. Casting 70 has a central cylindrical bore to rotatably receive a cylindrical vertically arranged trunnion pin 73. A removable cap 74 is secured to the under side of the casting 70 to close the lower end of the cylindrical bore. The upper portion of the trunnion pin 73 is enlarged at 75 to form a shoulder which rests upon the top of casting 70. A platform 76 is formed on the enlargement 75 and supports tilting motor 31 which is bolted thereto, as seen in dotted lines in Figure 10.

Diametrically opposed bosses 77 are supported from the platform 76 extending downwardly therefrom, and are preferably integrally cast therewith. The bosses 77 fit closely about the exterior of casting 70. The tilting screw cover 78 fits into one of the bosses 77 while the tilting gear guard 79 is mounted on the other boss. A horizontal central bore extends through trunnion pin 73 and receives the end of tilting screw shaft 30 which extends therethrough and is preferably journaled in suitable anti-friction bearings.

Diametrically opposed openings 80 in the trunnion casting 70 are in substantial alignment with the trunnion pin bore and permit the insertion of screw shaft 30 therein. The openings 80 however are of greater diameter than the shaft 30 and consequently allow a small swiveling motion of the shaft 30 and trunnion pin 73.

The shaft 30 extends completely through the pin 73 and has a reduced end portion to which a gear wheel 81 is secured. Gear 81 is driven by motor 31 through any suitable means such as a pinion drive and in turn drives screw shaft 30 in the usual manner.

It will be seen that the screw shaft 30 is free to swivel about the horizontal center line of vertical trunnions 71 and also has a limited swiveling motion about the vertical center line of vertical trunnion pin 73, thereby assuring complete freedom of movement for the screw shaft to prevent binding thereof due to misalignment caused by warpage, expansion or the like. The tilting motor, tilting gears and guard are all mounted on the vertical trunnion pin 73 and maintain their relative positions at all times.

In the operation of the furnace it is essential that the power be cut off before the roof is re-

moved or the furnace tilted. It is also important that the furnace only be tilted when the roof is in place thereon. It is also important that the roof lifting mechanism be operated only when the furnace is in a level position. In Figures 13 to 18 I have illustrated the control mechanism regulating the operation of the furnace.

Referring to Figure 13 it will be seen that the tilting motor circuit 82 acting through tilting regulator 83 is opened and closed by means of the tilting motor switch 84. Switch 84 is mechanically connected to main circuit breaker 85 in a manner to be hereinafter described, so that when the main circuit breaker is closed, the switch 84 is automatically opened, and when the breaker 85 is open the switch 84 will be automatically closed. A second switch 86 is interposed in the circuit 82 and is mounted on the roof lifting cylinder 52 adjacent the lowest point on cam skirt 56. Switch 86 is normally held open by means of a spring or other suitable means but when the skirt 56 moves to its lowest position it engages switch 86 as indicated in Figure 13 and closes the same. It will therefore be seen that the tilting motor circuit is interrupted at all times except when the main circuit breaker is open and skirt 56 is in its lowermost position. Therefore operation of tilting motor 31 may only be effected when the power to electrodes 42 is shut off and when the roof is in position on the furnace. Of course, actual operation of the tilting motor is controlled through regulator 83.

In Figure 14 I have shown the circuit 87 for operating the motor 88 for pumping fluid under pressure into the hydraulic ram cylinder 52. The pump motor switch 89 is interconnected with main circuit breaker 85 so that when the breaker is open the switch is closed and when the breaker is closed the switch is open. The pump circuit 87 is manually controlled through regulator or controller 90.

A switch 91 is arranged in pump circuit 87 and is located beneath the tilting block 92 at the side of the furnace shell. The switch 91 is pivoted and normally held open by means of a spring or the like. A portion of the switch 91 extends into the path of a roller 93 arranged on the center line of the tilting block. When the furnace is tilted, switch 91 is held open by its spring. When the furnace is exactly level the roller 93 engages the switch 91 and closes it. It will be seen therefore that circuit 87 is open except when the furnace is level and the circuit breaker 85 is open, and that only when switches 89 and 91 are closed can pump 88 be operated by means of controller 90.

In order to prevent overtilting of the furnace in either direction I provide tilting limit switches 94 and 95 of the mercury type. These mercury switches are connected to tilting circuit 82 through controller 83 by means of suitable wiring 82'. Switch 94 controls the slagging operation while switch 95 controls the charge pouring operation. In Figure 15 the furnace is level and both switches are closed. In Figure 16 the furnace has just reached the maximum slagging tilt which is at an angle of about 30°. In this position switch 95 is closed but the contacts of switch 94 are just being uncovered by the mercury and the furnace tilting mechanism will be automatically stopped by the opening of this switch. Figure 17 shows the furnace in its maximum pouring position at an angle of about 45° with the mercury of switch 95 just uncovering the switch contacts.

While I have shown mercury switches for the purpose of illustration it is to be understood that

other types of limit switches may be employed. Switches 94 and 95 are shown arranged in parallel so that opening of either switch will interrupt the tilting motor circuit while permitting the operation of the tilting motor in the opposite direction.

In Figure 18 I have shown one method of inter-connecting the main circuit breaker with the tilting or pumping switch S. The breaker operating rod 96 is connected by the usual linkage 98 to the contact bridge 97. An insulating link 99 connects the rod 96 to switch S. It will be seen that upward movement of rod 96 to open circuit breaker 85 will automatically close switch S through action of link 99 while downward movement of rod 96 to close circuit breaker 85 will automatically open switch S. Any number of switches S may be operated in this manner.

In Figures 19, 20 and 21 I have shown a modified form of roof lifting mechanism in which the hydraulic ram plunger and cylinder are normally independent of both the furnace shell and furnace roof. The furnace 25' is of the tilting type and has the removable roof 33' supported on the spectacle casting 34'. A hydraulic cylinder 52' is secured in the floor independently of the furnace and extends below the floor level. The ram plunger 53' rests in a roller bearing 54' in the piston, as in the preferred form of my invention, and the upper end of the plunger is provided with a substantially frusto-conical head 100. A similarly shaped opening 101 is arranged in the spectacle casting to receive the head 100. The cam groove 57' is located in the cylinder wall and the roller 58' is secured directly to the ram plunger. When the plunger is forced upwardly by hydraulic pressure, the head 100 enters opening 101 in spectacle casting 34'. Further upward movement of the plunger raises the roof vertically from the furnace and then the roller 58' engages the curved portion of cam groove 57' and rotates the roof away from the furnace as indicated in dotted lines in Figure 19.

In order to insure rotation of roof 33' with the ram plunger I provide a key 102 on the spectacle casting to fit between spaced ribs 103 on the plunger when the plunger is raised into engagement with the spectacle casting. When the ram plunger is lowered out of engagement with the casting 34' the furnace is free to be tilted without interference from the roof lifting mechanism.

In Figures 22 and 23 I have shown a furnace embodying a modified form of tilting mechanism and a platform for workmen arranged above the furnace roof.

In tilting furnaces by means of a single tilting mechanism arranged on one side of a furnace, difficulties are experienced due to twisting strains and distortion, and excessive wear of the rockers and rocker teeth, especially in large furnaces. I therefore propose to apply the tilting force at two sides of the furnace to produce an even tilting of the furnace while maintaining the furnace alignment. The tilting mechanism comprising motors 31', tilting gears 19' and screw tilting shafts 30' are duplicated at each side of the furnace. In order to clear the roof lifting mechanism, however, a relatively large yoke 104 is secured to the furnace shell and extends around the tilting mechanism as seen in Figures 22 and 23. One of the tilting screws 30' is connected to this yoke. Either form of roof lifting mechanism may be used with this form of tilting mechanism and because of the yoke 104 the roof lifting mechanism will not interfere with the tilting operation.

The universal swivel shown in Figures 10 and 11 is also used with the double tilting motors. This form of swivel is desirable because of the misalignment due to warpage and expansion and contraction of the furnace parts. The universal action of the swivel insures a smooth thrust without binding at any time. The tilting screws are shown as on the slagging side of the furnace, but they may obviously be arranged on the other side of the furnace. It is intended that the tilting mechanism be arranged on the side of the furnace opposite to the side towards which the roof is swung.

The two electric tilting motors 31' may be operated in any suitable manner. For example they may be of the compound type, controlled through a single controller. The compounding can be adjusted so that the motors will tend to equalize the pull and overcome any inequality in thrust. The motors may, however, be of the series type, with the two armatures connected in series. Both the roof lifting mechanism and tilting mechanism shown in Figures 22 and 23 are used in conjunction with the control system shown in Figures 13 to 18.

The roof of the furnace is provided with spaced arcuate frames 105 mounted on the metal roof ring 32' and extending around the furnace roof through an arc of about 270°. An arcuate platform 106 is supported by frames 105 in spaced relation above the furnace roof and surrounding the electrodes. The platform is preferably arranged in sections as shown, and the frames 105 extend a substantial distance above the platform to provide hand rails for workmen on the platform. It will be seen that workmen may mount the platform 106 to make adjustments and repairs to the electrodes and electrode mechanism.

While I have shown and described the preferred embodiment of my invention it is to be understood that various changes in the size, shape and arrangement of parts may be resorted to without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described my invention what I desire to claim and protect by Letters Patent is:

1. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a roof lifting member adapted to lift said roof, means to operate said roof lifting member, and means operated by a single movement of said roof lifting member to raise the furnace roof vertically and then swing it horizontally away from the furnace shell.

2. An electric arc furnace comprising a furnace shell, a roof detachably secured thereto, a roof lifting member adapted to lift said roof, means to move said roof lifting member axially to raise the roof from the furnace shell, and means operated by the axial movement of said roof lifting member to rotate the roof lifting member about its longitudinal axis to swing the roof away from the furnace shell.

3. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a pressure fluid cylinder, a plunger adapted to lift said furnace roof and extending into said cylinder, a piston element in said cylinder and engaging said plunger, means to move the piston in said cylinder to impart an axial movement to said plunger to raise the roof from the shell, and means operated by the axial movement of said plunger to rotate said plunger about its longitudinal axis and swing the roof away from the furnace shell.

4. An electric furnace comprising a furnace

shell, a roof detachably secured thereto, a pressure fluid cylinder, a plunger adapted to lift said furnace roof and extending into said cylinder, means to impart an axial movement to said plunger to raise the roof from the shell, and means comprising a cam groove and roller to rotate said plunger about its longitudinal axis and swing the roof away from the furnace shell.

5. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a pressure fluid cylinder secured to the furnace shell, a piston in said cylinder, a plunger secured to said furnace roof and connected with the piston, whereby upward movement of the piston in the cylinder raises the roof from the furnace shell, and means operated by the upward movement of the piston to rotate the plunger about its longitudinal axis to swing the roof away from the furnace shell.

6. An electric furnace comprising a tilting furnace shell, a roof detachably secured thereto, a pressure fluid cylinder, a plunger in said cylinder adapted to lift the removable roof, means to move the plunger to raise the roof from the shell, and a cooperating cam surface and roller connecting said cylinder with the plunger to rotate the plunger and swing the roof away from the furnace shell.

7. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a pressure fluid cylinder secured to said shell, a piston in said cylinder, a plunger connecting the piston with the removable roof, a member secured to said plunger and having a cam groove therein, and a roller on said cylinder and extending into the cam groove, whereby upward movement of said piston in the cylinder will raise the roof and swing it away from the furnace shell.

8. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a hydraulic cylinder secured to said shell, a piston in said cylinder, a plunger connecting the piston with the removable roof, an arcuate skirt secured to said plunger and arranged in proximity to said cylinder, said skirt having a cam groove therein, the cam groove having a substantially vertical portion terminating in a curved portion, and a roller secured to said cylinder and extending into said cam groove whereby upward movement of the piston will raise the roof vertically from the shell and then swing it away from said shell.

9. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a hydraulic cylinder secured to said shell, a piston in said cylinder, a plunger connecting the piston with the removable roof, an arcuate skirt secured to said plunger and arranged in proximity to said cylinder, said skirt having a cam groove therein, the cam groove having a substantially vertical portion terminating in a curved portion, and a roller secured to said cylinder and extending into said cam groove whereby upward movement of the piston will raise the roof vertically from the shell and then swing it away from said shell, there being an anti-friction swiveling connection between the plunger and piston.

10. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a hydraulic cylinder secured to the furnace shell, a piston in said cylinder, a plunger adapted to lift said furnace roof and connected with the piston, whereby upward movement of the piston in the cylinder raises the roof from the furnace shell, and means operated by the upward movement of the piston to rotate the plunger about its longitudinal axis to swing the roof away from the furnace shell, there being an anti-friction swiveling connection between the plunger and piston.

11. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a pressure fluid cylinder and roof lifting member located adjacent said furnace and independent of said furnace shell and roof, means to move said roof lifting member vertically to engage the roof and raise it from the shell, and means operated by the vertical movement of the roof lifting member to rotate the roof lifting member and swing the roof away from the furnace shell.

12. An electric arc furnace comprising a furnace shell, a roof detachably secured thereto, a hydraulic cylinder and plunger located adjacent said furnace and independent of said furnace shell and roof, means to move said plunger vertically to engage and raise the roof from the shell, and means comprising a cooperating cam surface and roller connecting the cylinder with the plunger to rotate the plunger and swing the roof away from the shell.

13. An electric furnace comprising a tilting furnace shell, a roof detachably secured thereto, a hydraulic cylinder and plunger located adjacent said furnace and independent of said furnace shell and roof, said cylinder being provided with a cam groove comprising a vertical portion terminating in a curved portion, a roller secured to said plunger and extending into said cam groove, and means to raise the plunger vertically to engage and raise the roof and swing it away from the furnace shell.

14. An electric furnace comprising a furnace shell, a roof detachably secured thereto, a hydraulic cylinder and plunger located adjacent said furnace but independent of said shell and roof, said cylinder being provided with a cam groove comprising a vertical portion terminating in a curved portion, a roller secured to said plunger and extending into said cam groove, and a piston in said cylinder and swiveled to said plunger, whereby upward movement of the piston in the cylinder moves the plunger into engagement with the roof and raises the roof from the shell and swings it away from the shell.

15. An electric furnace comprising a tilting furnace shell, a standard located in proximity to said furnace shell, a trunnion body having horizontal trunnions journaled in said standard and having a central vertical bore, a trunnion pin rotatably supported in the vertical bore of the trunnion body, an electric motor supported on said trunnion pin, a tilting screw shaft rotatably supported in said trunnion pin and extending through openings in the trunnion body having larger diameter than the diameter of the screw shaft, said screw shaft operatively engaging the tilting furnace shell, and a driving connection between the electric motor and the screw shaft.

16. An electric furnace comprising a tilting furnace shell, a roof detachably secured thereto, roof lifting mechanism arranged at one side of the furnace shell and adapted to raise the roof from the shell, a tilting mechanism operatively engaging the furnace shell at a point opposite the roof lifting mechanism, a yoke secured to the furnace shell and straddling the roof lifting mechanism, and a tilting mechanism operatively engaging said yoke, the tilting mechanisms being adapted to operate in unison.

17. An electric arc furnace comprising a furnace shell having a removable roof, a roof lifting member, means carried by said furnace shell

to operate said roof lifting mechanism and raise the roof from the shell, and mechanism operatively engaging said roof lifting member to swing the roof away from the furnace shell.

- 5 18. An electric arc furnace comprising a furnace shell, a roof detachably secured thereto, a

roof lifting member adapted to lift the roof from the furnace shell, and automatic means associated with and operated by said roof lifting member to swing the roof away from the furnace shell.

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