May 9, 1933. A. L. STEVENS 1,907,892

ANNEALING FURNACE

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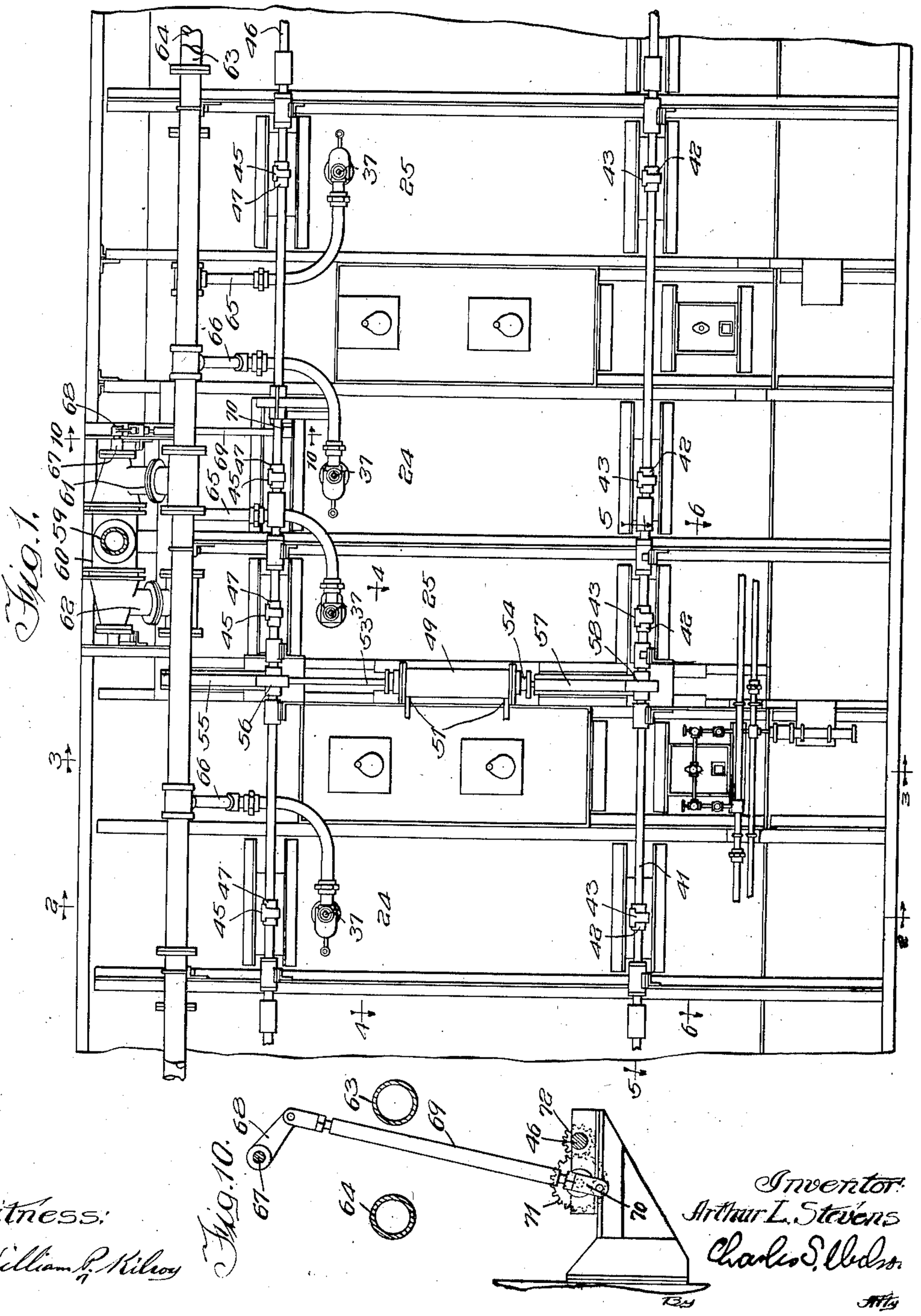

Fig. 1.

Fig. 10.

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ANNEALING FURNACE

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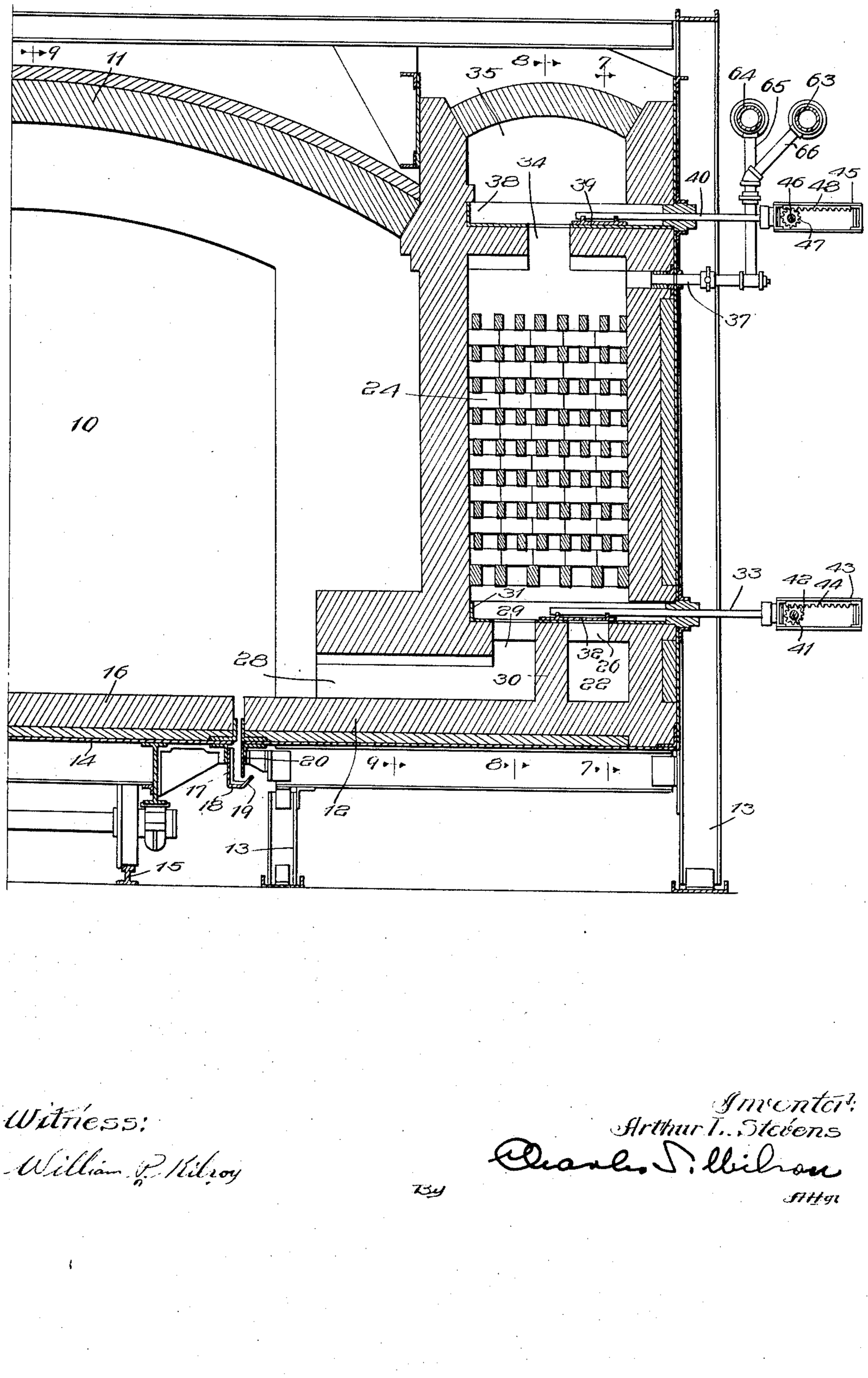
Fig. 2.



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ANNEALING FURNACE

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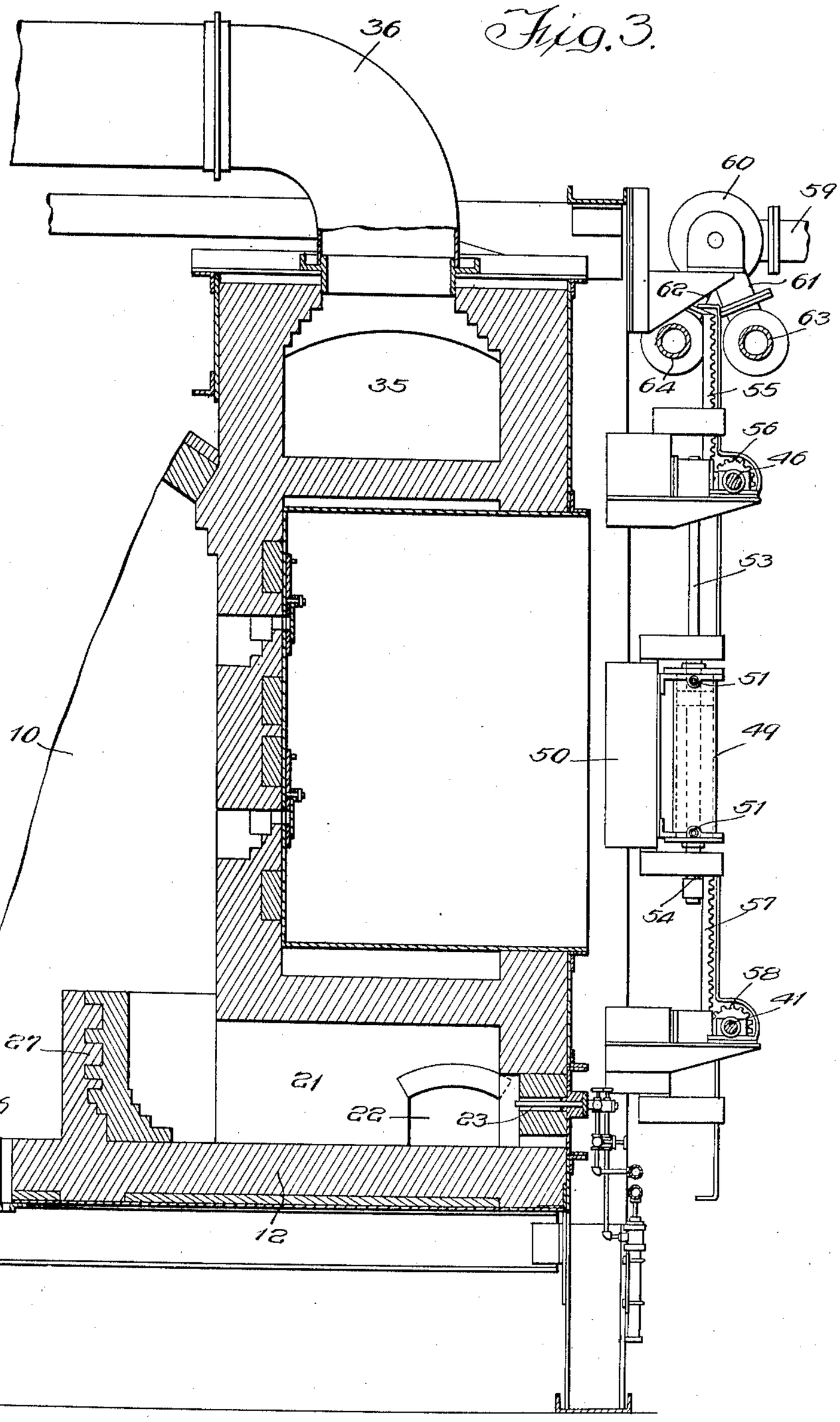
Fig. 3.



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ANNEALING FURNACE

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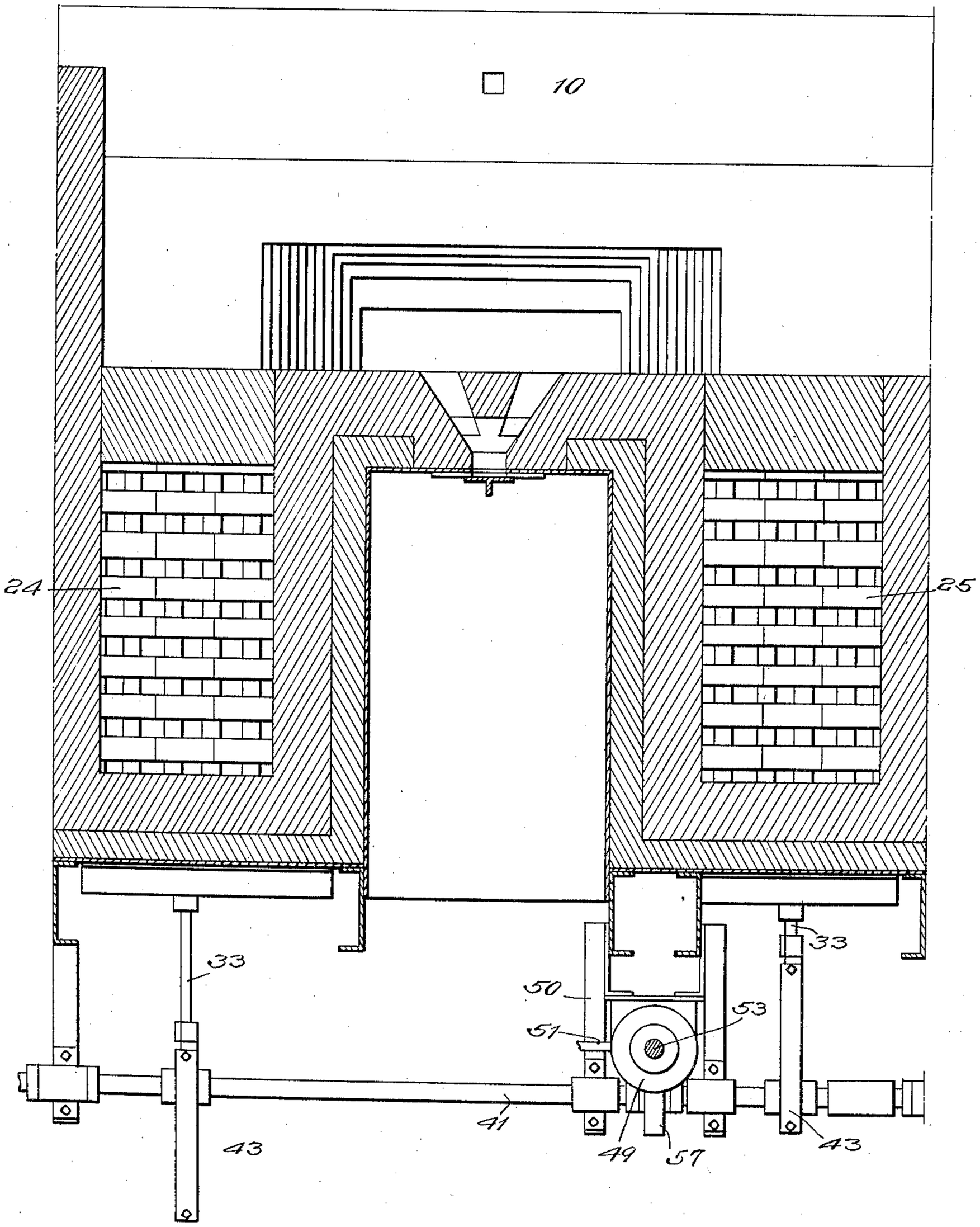
Fig. 4.



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ANNEALING FURNACE

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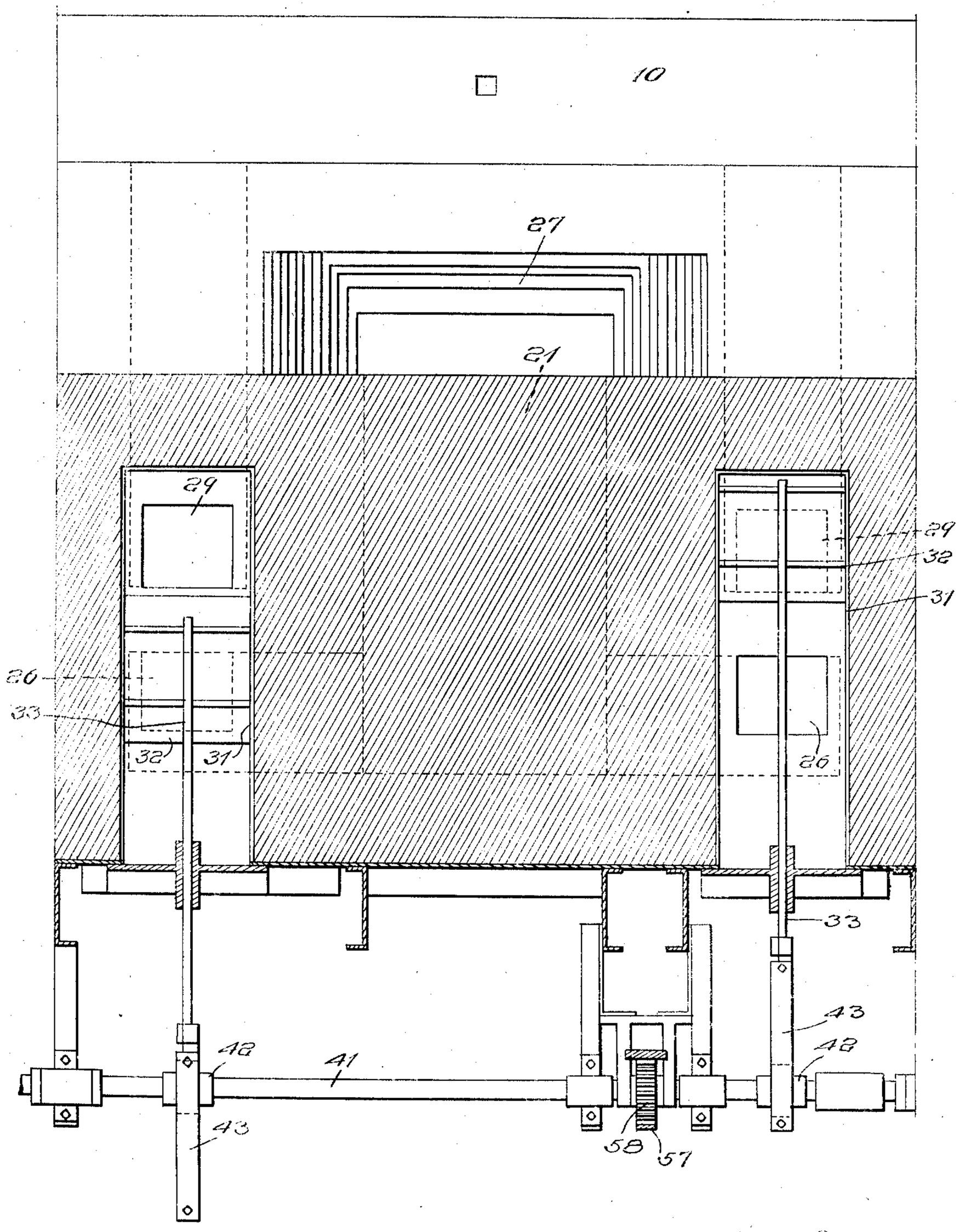
Fig. 5



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ANNEALING FURNACE

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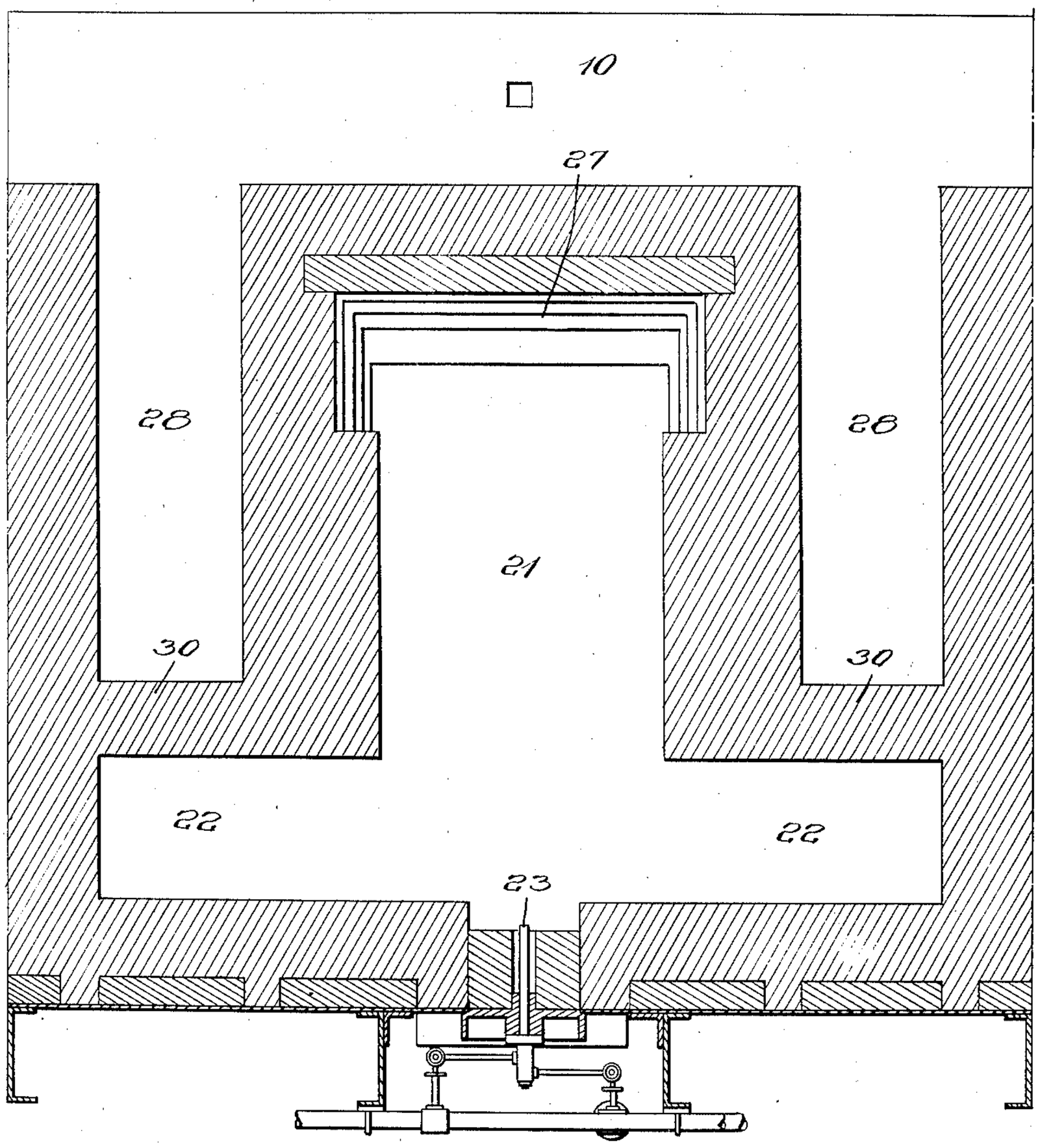
Fig 6.



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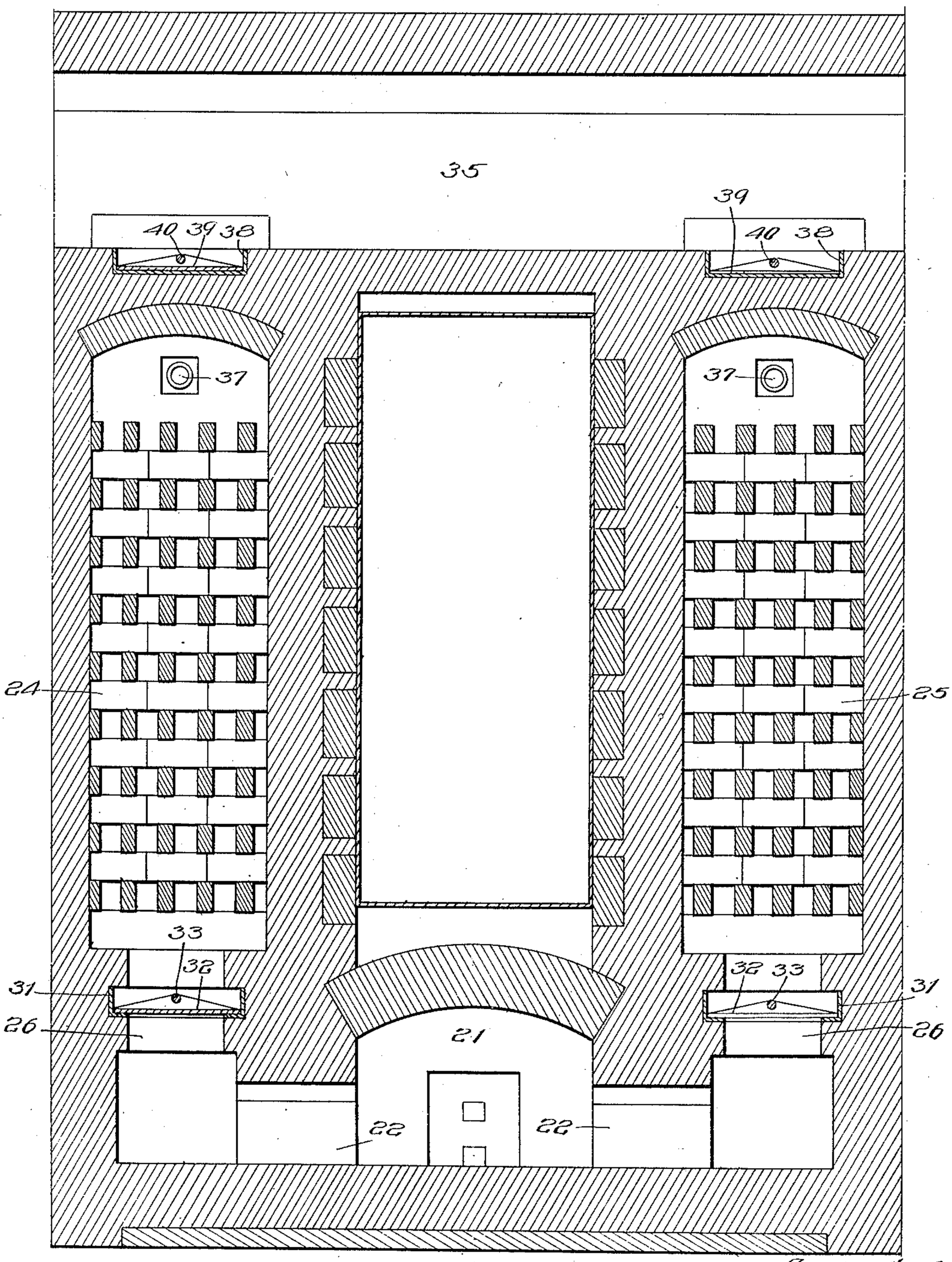
ANNEALING FURNACE

Filed March 28, 1931 9 Sheets-Sheet 7

Fig. 7.



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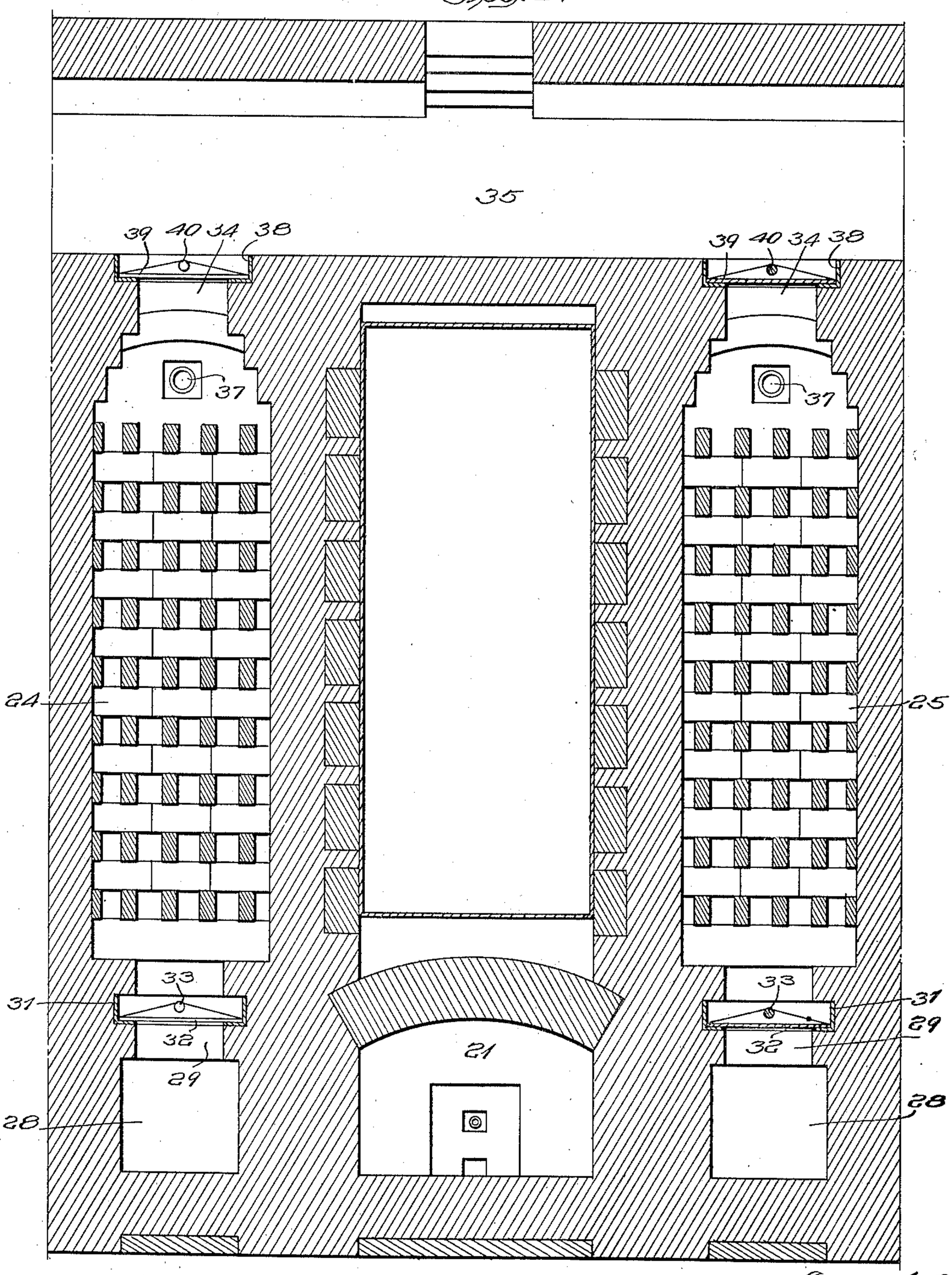
ANNEALING FURNACE

Filed March 28, 1931 9 Sheets-Sheet 8

Fig. 8.



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ANNEALING FURNACE

Filed March 28, 1931

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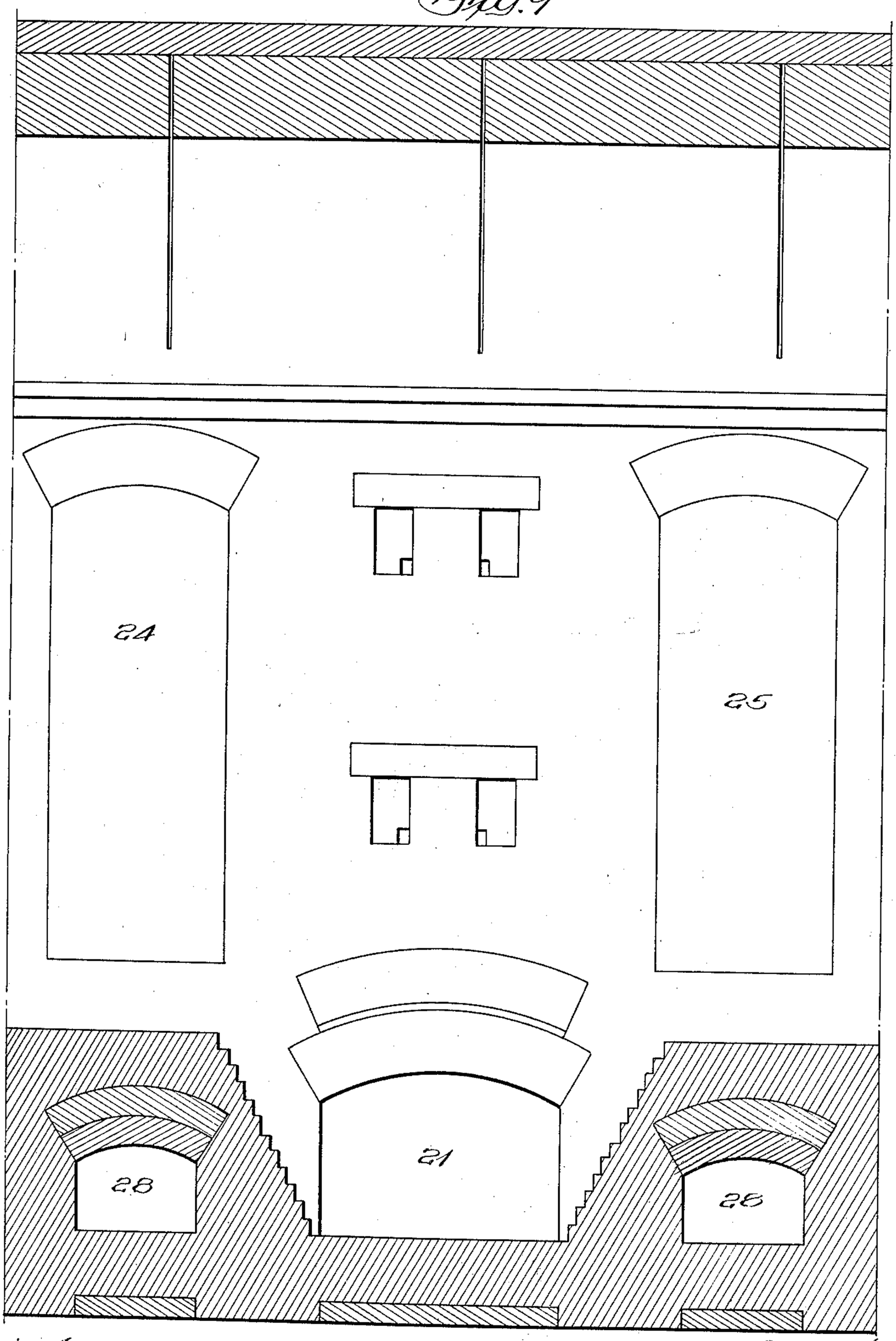
Fig. 9



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UNITED STATES PATENT OFFICE

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ANNEALING FURNACE

Application filed March 28, 1931. Serial No. 525,956.

This invention relates generally to annealing furnaces, wherein each burner coacts with a pair of regenerators or checkers which alternate in admitting air for combustion and removing the products of combustion. It has for its object the provision of a mechanism for the control of the dampers or valves coacting with the air supply pipes and controlling the operation of the regenerators or checkers whereby a plurality thereof will operate in unison and in proper relation to each other.

With the above and other objects in view, as will be apparent, this invention consists in the construction, combination and arrangements of parts, all as hereinafter more fully described, claimed and illustrated in the accompanying drawings, wherein:

Fig. 1 is a fragmentary side elevation of a furnace constructed in accordance with the present invention, illustrating the general position and relative coaction of the mechanism for operating and controlling the air valves and the dampers cooperating with the checkers or regenerators;

Fig. 2 is a vertical section taken along line 2—2 of Fig. 1 through approximately one half of the furnace to illustrate one of the regenerators or checkers, the valves or dampers for the control thereof, the latter being shown positioned to permit the escape of the products of combustion from the furnace chamber through the regenerator and further showing the car in place together with the seal for the joint between the car and furnace hearth;

Fig. 3 is also a vertical section taken along line 3—3 of Fig. 1 to illustrate the combustion chamber together with the unitary control for the dampers opposite the ends of the regenerators;

Fig. 4 is a horizontal section along line 4—4 of Fig. 1 illustrating a combustion unit comprising a pair of complemental regenerators coacting with a single combustion chamber, and further showing in plan the unitary mechanism whereby the dampers or valves at the opposite ends of the regenerators are controlled and operated;

Fig. 5 is a horizontal section taken along line 5—5 of Fig. 1 and illustrates generally the dampers or valves coacting with the lower ends of the regenerators and the mechanism for operating the same;

Fig. 6 is a similar view taken along line 6—6 of Fig. 1 and shows the combustion chamber and burner which coacts with a pair of complemental regenerators together with the air passages leading from the combustion chamber to the respective regenerators;

Fig. 7 is a vertical section taken along line 7—7 of Fig. 2 and illustrates the relationship between the combustion chamber of one unit of the present furnace and the complemental regenerators cooperating therewith.

Fig. 8 is a similar view taken along line 8—8 of Fig. 2;

Fig. 9 is a staggered vertical section taken along line 9—9 of Fig. 2 and illustrates the general cooperation between the combustion chamber of a unit and its complemental regenerators and the passages by means of which the products of combustion are exhausted from the hearth; and

Fig. 10 is a vertical section taken along line 10—10 of Fig. 1 and illustrates the operating mechanism for controlling the valve by which air for combustion purposes is distributed and the operation thereof from the control for the dampers coacting with the regenerators.

This invention relates primarily to the construction of annealing furnaces and the economical firing thereof, accompanied by a positive universal control of the regenerators and the air for combustion. The present furnace is of a relatively long construction and is provided with a plurality of combustion or burner units along each side of the furnace which direct the flames and products of combustion inwardly toward the furnace chamber from each side of the hearth thereof. Each combustion unit comprises a combustion chamber and a pair of complemental or companion regenerators or checkers through one of which the air for combustion is admitted to the combustion chamber while the products of combustion are being exhausted through the opposed or comple-

mental regenerator. This operation is reversed from time to time so that the air for combustion is admitted to the combustion chamber through the regenerator which had previously conducted the hot products of combustion from the furnace, and the products of combustion are conducted from the furnace through the regenerator or checker through which the air for combustion was previously admitted. Each side of the furnace is provided with a series of these combustion units, each of which is independent of the remaining units, except that the present invention contemplates a unitary control whereby the combustion units aforesaid will be reversed, operated and controlled in unison. The products of manufacture, being treated in the furnace, are placed in cars which are inserted in the furnace after which the firing takes place from both sides of the furnace as above described.

Reference being had more particularly to the drawings, 10 designates the furnace chamber, having a roof 11 and a hearth 12. The hearth 12 of the furnace and the whole furnace structure is supported above the ground by suitable legs or supports 13, whereby ready access may be had to the bottom of the furnace. Suitable cars 14, carrying the articles of manufacture to be annealed, operate on tracks 15 which are so positioned that when the cars are located within the furnace the platforms 16 of the cars 14 are co-planer with the hearth 12 of the furnace structure. In order to seal the joint or narrow opening between the platform 16 of the car and the hearth 12 of the furnace on each side of the car 14, the sides of the car are provided with hangers 17 which terminate in a horizontal base 18. At the outer edge of the base 18 of the hanger 17 is an upwardly and outwardly sloping lip 19 which coacts with a vertical plate 20 extending downwardly from the adjoining edge of the hearth 12 of the furnace. The lengths of the plate 20 and the lip 19 are such that there is an overlapping thereof which at the same time permits of or creates a space between the edge of the plate 20 and the body of the lip 19. Thus as the car 14 is inserted in the furnace, the plates 20 at each side of the car are positioned above the horizontal bases 18 of the hangers 17 to the rear of the lips 19. After the cars 14 have been positioned in the furnace, operators may enter below the hearth 12 of the furnace by reason of its elevated position and pack the hangers 17 and lips 19 with sand or other suitable material, which will completely close and seal the space between the edge of the plates 20 and the lips 19. In this manner, the furnace chamber 10 is rendered substantially air tight and sealed insofar as the junctures between the cars 14 and the furnace structure hearth is concerned.

Inasmuch as there are a plurality of combustion units along each side of the furnace directing the productions of combustion toward the furnace chamber 10, the floor or hearth of which constitutes the platforms 16 of the cars 14 in conjunction with the side hearths 12, it will only be necessary to describe one of these units as all are duplicates one of the other.

Each of these combustion units comprises a combustion chamber 21 located adjoining the hearth 12 of the furnace and provided at its outer end, i. e., the end thereof remote from the hearth, with transverse passages 22, between the inner ends of which is positioned the burner 23. Disposed upon the sides of each combustion chamber are regenerators 24 and 25. The passages 22 terminate below the checkers or regenerators 24 and 25 and at the ends thereof remote from the combustion chamber 21 communicate with the regenerators through the ports 26. Thus the air for combustion is admitted through one or the other of the ports 26 from one or the other of the checkers or regenerators 24—25 to one or the other of the passages 22, and by such passage conducted to the burner 23 and combustion chamber 21. At the inner end of the combustion chamber 21 is a baffle wall 27 by means of which the products of combustion, generated in the combustion chamber 21, are directed upwardly and toward the furnace chamber 10.

The combustion chamber 21 is flanked by the exhaust passages 28 which parallel the combustion chamber 21 and terminate below the respective regenerators or checkers 24—25. A transverse port 29 connects the rear end of each exhaust passage 28 with the adjoining regenerators 24—25. By reference to Fig. 2 it will be observed that the ports 26—29 leading into the lower ends of the regenerators 24—25 and communicating respectively with the transverse passages 22 and exhaust passages 28 are substantially parallel and are completely separated one from the other by partition 30. In operation, the air for combustion purposes passes downwardly through one or the other of said regenerators 24—25 through the coacting port 26 to one of the passages 22 and enters the combustion chamber 21, from which products of combustion are conducted and directed upwardly into the furnace chamber 10 by the baffle 27. When this occurs, the port 29 of the regenerator 24—25 through which the air for combustion is passing is closed, while the port 26 of the companion or complemental regenerator 24—25 is also closed and the port 29 of that regenerator is open. Thus the products of combustion are conducted from the furnace chamber 10 through either passage 28, coacting with one of the ports 29, which is open, thence upwardly through the coacting regenerator or checker 24—25, and

at the same time the air for combustion passes downwardly through the complemental regenerator 24—25 through the port 26 thereof to the combustion chamber 21, and this operation is from time to time reversed.

For controlling the ports 26—29 a damper seat 31 is positioned over and coacts with each pair of said ports 26—29, and coacts with a damper 32, slidably mounted in such seat 31 under the control of a damper rod 33 which passes outwardly through the wall of the furnace. A single damper 32 coacts with each damper seat 31 and, consequently, with each pair of ports 26—29, and is always so positioned that it closes either the air port 26 or the cooperating exhaust port 29, for the products of combustion. Thus when the damper 32 is positioned as illustrated in Fig. 2, the products of combustion pass outwardly through one of the passages 28, upwardly through the port 29 and the regenerator 24, heating the bricks thereof previous to admitting air for combustion purposes upon the reversal of the firing operation. When the damper 32, coacting with the regenerator 24 is positioned as illustrated in Fig. 2, the damper 32, coacting with the companion regenerator 25, is positioned to close the port 29 of that regenerator so that air, admitted at the upper end of the regenerator 25, passes downwardly through the regenerator 25 and the port 26 to the cooperating passage 22, and thence to the combustion chamber 21, as illustrated in Fig. 5.

At the upper end of each regenerator 24—25, is a port 34 that communicates with a longitudinal exhaust passage 35, extending over all of the regenerators and communicating at a suitable point with the stack 36. Adjoining the exhaust port 34 and adjoining the upper end of each regenerator, the side wall of the furnace is pierced by an air inlet pipe 37 which, under certain conditions, as will be hereinafter pointed out, is designed to deliver air for combustion purposes to the upper end of the regenerator.

A damper seat 38 coacts with each port 34 and has a plate damper 39 operable thereon. Each of these damper plates 39 is operated by a damper rod 40 which passes through the furnace wall above the air inlet pipe 37 and provides a means for operating the damper 39. When the port 29 of one of the regenerators 24—25 is open, and the port 26 thereof is closed by the lower damper plate 32, the upper damper plate 39 is so positioned that the upper port 34 is open, whereby the products of combustion may pass through the passage 28 upwardly through the port 29, through the coacting regenerator and out through the port 34 into the exhaust passage 35 and thence to the stack 36. This condition is illustrated in Fig. 2, which shows the exhaust of the products of combustion through the regenerator 24. Consequently when dampers of the regenerator 24 are positioned as illustrated in Fig. 2, the dampers coacting with the companion or complemental regenerator 25 are in opposite position so that the ports 29 and 34 of the regenerator 25 are closed by their respective dampers 32—39, while the port 26 is open. As a result of this positioning of the dampers, coacting with the regenerator 25, the air from the pipe 37 is admitted into the upper end of the regenerator 25 and passes downwardly through the regenerator, the port 26, into the passage 22; while the products of combustion are leaving the furnace chamber 10 to pass upwardly through the companion or complemental regenerator 24.

From the foregoing, it is manifest that in conjunction with each regenerator (24—25), there are two damper operating rods, viz: 33—40 and an air inlet pipe 37, all of which must be operated and controlled in synchronization with the similar elements of the companion or complemental regenerator, and this is true in each combustion unit, made up of a combustion chamber 21 and two regenerators 24—25. Furthermore the operation of the dampers of one combustion unit should be simultaneous with the operation of corresponding dampers of the other units. Likewise, the dampers 32—39 coacting with each regenerator 24 must at all times operate in an opposite direction to that of the dampers 32—39 coacting with each regenerator 25. Therefore, the present invention contemplates the simultaneous operation and control of all of these elements upon each side of the furnace, and for that purpose the following mechanism is provided.

In order to operate dampers 32 cooperating with the ports 26—29 at the lower ends of the regenerators 24—25 an operating shaft 41 extends parallel to the outer wall of the furnace adjoining the outer ends of the operating rods 33 of the dampers 32 and in alignment with each rod 33 has a gear 42 fixed thereto. The outer end of shaft of each rod 33 carries a rectangular frame 43 which spans and embraces the gear 42 mounted on the shaft 41 in alignment with the rod 33. These frames contain racks 44 which coact with the gears 42 on the shaft 41. The position of these racks 44 within the frames 43 determine the direction of movement on the part of the rods 33 upon the oscillation of the shaft 41. Thus if the rack 44 of the frame 43 carried by the rod 33 operating the damper 32 which coacts with the regenerator 24 is on the upper side of the frame 43, as illustrated in Fig. 2, the rack 44 carried by the frame 43, carried by the rod 33 which controls the damper 32 of the complemental regenerator 25 is on the lower side of said frame. In this manner the pair of rods 33 and cooperating frames 44 which control the dampers of a pair of companion or complemental regenerators 24—25 are

upon opposite sides of the frames 43 and consequently always operate in opposite directions so that the dampers 32 are moved in opposed directions.

Therefore, as the shaft 41 oscillates the gears 42 thereon for each pair of companion or complemental regenerators 24—25 will oscillate and affect the rods 33 to move the same in opposite directions.

At the outer ends of the rods 40 operating the dampers 39 which coact with the ports 34 at the upper end of the regenerators 24—25 are carried frames 45 which in construction are similar to the frames 43. A shaft 46 parallels the shaft 41 and is adjacent the outer ends of the rods 40 and passes through the frames 45 carried by said rods. At each frame the shaft 46 is provided with a gear 47, which is positioned within the frame and is designed to coact with a rack 48, carried by the frame. For each combustion unit, made up of a combustion chamber 21 and a pair of complemental or companion regenerators 24—25, there are two rods 40, one controlling the damper 39 at the upper end of each regenerator. These dampers 39 of each unit operate in opposite directions, so that when one port 34 is open the port 34 of the companion regenerator is closed. Hence the racks 48 coacting with each pair of frames 45 are upon opposite sides of the frames. In this manner, as the shaft 46 oscillates, the rods 40 and their frames 45 will move in opposite directions. With reference to one combustion unit the positions of the racks 48 and the racks 44 in their respective frames 45—43 are such that when the port 29 of the regenerator 25 is opened the port 26 thereof will be closed and the exhaust port 34 open. The elements of the companion or complemental regenerator 24 will then be reversely positioned so that the ports 29 and 34 of that regenerator will be closed while the port 26 is open. The oscillation of the shafts 41 and 46 in acting upon the oppositely positioned racks 44—48 will cause an alternate reversal of these positions with respect to each individual combustion unit.

For the purpose of oscillating the shafts 41 and 46 a vertical cylinder 49 is positioned between the shafts 46 and 41 adjacent the outer furnace wall and is supported in a suitable bracket structure 50. The pipes 51 connect to the upper and lower ends of this cylinder 49 and are designed to admit fluid under pressure into either end of the cylinder 49. A piston (shown in dotted lines Fig. 3) is mounted in the cylinder and is provided with an upper piston rod 53 and a lower piston rod 54. The upper piston rod carries a rack 55 which meshes with a pinion 56 fixed to the upper shaft 46 and similarly the lower piston rod is carried to a rack 57, which in turn meshes with a pinion 58 connected to the lower shaft 41. When fluid pressure is admitted to the cylinder 49 through the lower pipe 51, the piston within the cylinder 49 is moved upwardly, moving the piston rods 53 and 54 and the racks 55 and 57 in a similar direction rotating the shafts 41 and 46 in a clockwise direction, and reversely when the fluid pressure is admitted to the cylinder 49 through the upper pipe 51, the piston of the cylinder 49 moves downwardly as to the piston rods 53 and 54 and racks 55 and 57, rotating the shafts 41 and 46 in a reverse or counter clockwise direction. This oscillation of these shafts 41 and 46 move the dampers 32 and 39 as above described dependent upon the direction of the rotation of said shafts.

In order to control the flow of air through the inlets 37 to the regenerator, an air supply pipe 59 is provided which opens into a valve 60. This valve 60 is provided with two outlets 61 and 62 which are controlled by the movement of the valve, so that the air from the supply pipe 59 is directed to and through one or the other of said outlets. The outlet pipe 61 communicates with an air distribution pipe 63 paralleling the outer wall of the furnace while the outlet 62 communicates with a similar pipe 64 which not only parallels the outer wall of the furnace but is coplaner with and parallels the first distribution pipe 63. Each of the regenerators 24—25, of each combustion unit is connected with either one or the other of the pipes 63 and 64. For this purpose the pipe 64 is connected by a series of leads or branches 65 to the air intakes 37 at the upper ends of the regenerators 25, while the pipe 63 is connected by the branches 66 to the air intakes 37 of the regenerators 24. Consequently the pipe 63 supplies air for combustion purposes to the air intakes 37 of all of the regenerators 24 on that side of the furnace and the pipe 64 supplies air for combustion purposes to the air intakes 37 of all of the regenerators 25 on that side of the furnace, irrespective of the number of the combustion units, made up of a combustion chamber 21 and a pair of regenerators 24—25.

The valve 60 controls the admission of air into one or the other of the pipes 63—64 so that when air is admitted to the pipes 63 it will be fed through the branches 66 and air intakes 37 into all of the regenerators 24 and no air will be admitted into the distribution pipe 64 or the regenerators 25. When the valve 60 is shifted the air will be shut off from the distribution pipe 63 and admitted into the distribution pipe 64, which in turn will supply all of the regenerators 25 through the medium of the several branches 65 and the air intakes 37.

As the admission of air into the regenerators 24—25 must be timed to synchronize with positions and adjustments of the dampers 32 and 39, the mechanism for the control of the position of the valve 60, is driven or op-

erated by the means which operates and controls the dampers 32—39.

To this end the valve 60 is controlled by the movement of the upper shaft 46 and the valve spindle 67 thereof is provided with a crank arm 68 at its end which is connected to a pitman 69. The lower end of the pitman is connected to a crank 70 carried by a gear 71 which in turn meshes with a gear 72 secured to the shaft 46 (see Fig. 10). Thus as the shaft 46 oscillates to regulate the positions of the dampers 39 the gear 71 will be similarly oscillated and through the medium of the pitman 69 and the crank 68 the position of the valve 60 will be adjusted. If the distribution pipe 63 is receiving air through the valve 60 and delivering air to the regenerators 24, the shaft 46 will be so adjusted that the ports 34 of the regenerators 24 will be closed by the dampers 39 while the ports 34 of the checkers 25 will be open to permit the products of combustion to escape into the flue 35 and reversely, if the pipe 64 is receiving air for delivery to the regenerators 25, the ports 34 of the regenerators 24 will be open while the similar ports of the regenerators 25 will be closed.

From the foregoing it will be observed that the present furnace construction provides a plurality of combustion units each made up of a combustion chamber in conjunction with a pair of complemental or companion regenerators, having a unitary control whereby certain of the checkers are used for the admission of air, while the remainder thereof are used for the exhausting of the products of combustion and the reversal of such uses may be simultaneously accomplished and accompanied by the proper and simultaneous control of the delivery of air for combustion purposes.

What is claimed is:

1. In a furnace the combination with a plurality of combustion units, each unit comprising a combustion chamber in combination with a pair of complemental regenerators including passages connecting the lower ends of said regenerators with the combustion chamber and separate passages connecting the lower ends of said regenerators with the body of the furnace, of an outlet flue connected by ports with the upper ends of said regenerator, dampers coacting with the ports at the upper end of said regenerators, a damper coacting with the passages between the lower end of each regenerator and the body of the furnace and the combustion chambers to close one or the other of said passages, and means for simultaneously operating all of said dampers whereby the ports connecting with the flue and with the passages connecting with the furnace body of certain of said regenerators are opened and the passages connecting with the combustion chamber of those regenerators are closed, while the complemental regenerators have the ports connecting with the flues and the passages connecting with the body of the furnace closed, and the passages to the combustion chamber open.

2. In a furnace a combination with a plurality of combustion units, each unit comprising a combustion chamber and a pair of complemental regenerators including passages connecting the lower ends of said regenerators with the combustion chamber and separate passages connecting the lower ends of said regenerators with the body of the furnace, of an outlet flue connected by ports with the upper ends of said regenerators, dampers coacting with the ports at the upper end of said regenerators, a damper coacting with the connections between the lower ends of each regenerator and the body of the furnace and its combustion chamber to close one or the other of said connections, means for simultaneously operating said dampers whereby the ports connecting with the flue and the passages connecting with the furnace body of alternate regenerators open and the passages thereof connecting with the combustion chambers close while the ports connecting with the flue and the passages connecting with the body of the furnace of the remaining regenerators close, the passages to the combustion chambers open, and means for supplying air to the upper ends of the regenerators having the connections with the passage leading to the combustion chambers open.

3. In a furnace a combination with a plurality of combustion units, each unit comprising a combustion chamber and a pair of complemental regenerators including passages connecting the lower ends of said regenerators with the combustion chamber and separate passages connecting the lower ends of said regenerators with the body of the furnace, of an outlet flue connected by ports with the upper ends of said regenerators, dampers coacting with the ports at the upper end of said regenerators, a damper coacting with the connections between the lower ends of each regenerator and the body of the furnace and its combustion chamber to close one or the other of said connections, means for simultaneously operating said dampers whereby the ports connecting with the flue and the passages connecting with the furnace body of alternate regenerators open when the passages thereof connecting with the combustion chambers close while the ports connecting with the flue and the passages connecting with the body of the furnace of the remaining regenerators close, the passages to the combustion chambers open, an air intake to deliver air for combustion to said regenerators, independent means for directing air to the alternate intake, and means for controlling the air supply whereby

air is delivered to the intakes of all regenerators having their flue ports closed and the connections with the passages leading to the combustion chambers open.

4. In a furnace a combination with a plurality of combustion units, each unit comprising a combustion chamber and a pair of complemental regenerators including passages connecting the lower ends of said regenerators with the combustion chamber and separate passages connecting the lower ends of said regenerators with the body of the furnace, of an outlet flue connected by ports with the upper ends of said regenerators, dampers coacting with the ports at the upper end of said regenerators, a damper coacting with the connections between the lower ends of each regenerator and the body of the furnace and its combustion chamber to close one or the other of said connections, means for simultaneously operating said dampers whereby the ports connecting with the flue and the passages connecting with the furnace body of alternate regenerators open when the passages thereof connecting with the combustion chambers close while the ports connecting with the flue and the passages connecting with the body of the furnace of the remaining regenerators close, the passages to the combustion chambers open, an air intake to deliver air for combustion to said regenerators, independent means for directing air to the alternate intake, means for controlling the air supply whereby air is delivered to the intakes of all regenerators having their flue ports closed and the connections with the passages leading to the combustion chambers open, and unitary means for controlling the effective positions of said dampers and simultaneously changing the delivery of air whereby the aforesaid conditions may be reversed.

5. In a furnace a combination with a plurality of combustion units, each unit comprising a combustion chamber and a pair of complemental regenerators including passages connecting the lower ends of said regenerators with the combustion chamber and separate passages connecting the lower ends of said regenerators with the body of the furnace, of an outlet flue connected by ports with the upper ends of said regenerators, dampers coacting with the ports at the upper end of said regenerators, a damper coacting with the connections between the lower ends of each regenerator and the body of the furnace and its combustion chamber to close one or the other of said connections, means for simultaneously operating said dampers whereby the ports connecting with the flue and the passages connecting with the furnace body of alternate regenerators open when the passages thereof connecting with the combustion chambers close while the ports connecting with the flue and the passages connecting with the body of the furnace of the remaining regenerators close, the passages to the combustion chambers open, an air intake to deliver air for combustion to said regenerators, independent means for directing air to the alternate intake, means for controlling the air supply whereby air is delivered to the intakes of all regenerators having their flue ports closed and the connections with the passages leading to the combustion chambers open, and unitary means for controlling the effective positions of said dampers and simultaneously changing the delivery of air whereby the aforesaid conditions may be reversed.

6. A combustion unit for a furnace, comprising a combustion chamber and a pair of complemental regenerators, each regenerator having a plurality of passages leading therefrom and a pair of ports, one of which communicates with a passage leading to the combustion chamber and the other of which communicates with a passage leading to the body of the furnace and at the opposite end thereof an exhaust port, a damper for each regenerator coacting with the ports communicating with the passages leading to the furnace and to the combustion chamber to close one or the other thereof, a damper coacting with the exhaust port of each regenerator, and unitary means for alternately operating the dampers of the complemental regenerators whereby the opening of the exhaust port and port leading to the furnace of one regenerator will result in the closing of such ports in the complemental regenerators and the opening of the port thereof leading to the combustion chamber.

7. A combustion unit for a furnace, comprising a combustion chamber and a pair of complemental regenerators, each regenerator having a plurality of passages leading therefrom and a pair of ports, one of which communicates with a passage leading to the combustion chamber and the other of which communicates with a passage leading to the furnace, and at the opposite end thereof an exhaust port, a damper coacting with the ports of each regenerator communicating with the passages leading to the furnace and to the combustion chamber to close one or the other thereof, a similar damper coacting with the exhaust port of each regenerator, operating rods for controlling the positions of said dampers, a shaft for the operation of the dampers coacting with the ports leading to the furnace and the combustion chamber aforesaid, a second shaft coacting with the operating rods of said dampers coacting with the exhaust ports of said regenerators, a connection between said shafts and the operating rods, and means for oscillating said shafts for the operation of said rods.

8. A combustion unit for a furnace, comprising a combustion chamber and a pair of complemental regenerators, each regenerator having a plurality of passages leading there-

from and a pair of ports, one of which communicates with a passage leading to the combustion chamber and the other of which communicates with a passage leading to the furnace, and at the opposite ends thereof each being provided with an exhaust port, a damper coacting with the ports leading to the furnace and the combustion chamber to close one or the other thereof, a similar damper coacting with the exhaust port, operating rods for controlling said dampers, a shaft for the operation of the dampers coacting with the ports leading to the furnace and to the combustion chamber aforesaid, a second shaft for the operation of said dampers coacting with the exhaust ports of said regenerators, a gear on each of said shafts adjacent the terminal of each damper rod, means for oscillating said shafts, and racks carried by said damper rods and meshing with the gears on said shaft.

9. A combustion unit for a furnace, comprising a combustion chamber and a pair of complemental regenerators, each regenerator having a plurality of passages leading therefrom and a pair of ports, one of which communicates with a passage leading to the combustion chamber and the other of which communicates with a passage leading to the furnace, and at the opposite end thereof each being provided with an exhaust port, a damper coacting with the ports of each regenerator leading to the furnace and to the combustion chamber to close one of the other thereof, a similar damper coacting with the exhaust port of each regenerator, operating rods for controlling said dampers, a shaft for the operation of the dampers coacting with the ports leading to the furnace and the combustion chamber aforesaid, a second shaft for the operation of the dampers coacting with the exhaust ports of said regenerators, a gear on each of said shafts adjacent the terminal of each damper rod, means for oscillating said shafts and racks carried by said damper rods, and cooperating with said gears, said racks being so positioned on the rods that the alternate racks cooperate with the opposite sides of the cooperating gears whereby the alternate rods will move in opposite directions upon the oscillation of the shafts aforesaid.

10. A combustion unit for a furnace, comprising a combustion chamber and a pair of complemental regenerators, each regenerator having a plurality of passages leading from the base thereof and a pair of ports, one of which communicates with a passage leading to the combustion chamber and the other of which communicates with a passage leading to the furnace, and at the opposite end thereof an exhaust port, of a damper coacting with the ports of each regenerator leading to the furnace and to the combustion chamber to close one or the other thereof, a similar damper coacting with the exhaust port of each regenerator, individual operating rods for controlling said dampers, a shaft for the operation of the dampers coacting with the ports leading to the furnace and the combustion chamber aforesaid, a second shaft for the operation of the dampers coacting with the exhaust ports of said regenerators, a gear on each shaft adjoining the terminal of each rod, a frame carried at the end of each rod embracing the coacting shaft, a rack carried by said frame and meshing with the adjacent gear, the rack of one rod coacting with the upper side of its gear while the rack of the complemental rod cooperates with the opposite side of its gear, and means for oscillating said shafts.

11. In a combustion unit, the combination with a combustion chamber and a pair of complemental regenerators, each regenerator having a pair of ports, one of which communicates with the combustion chamber and the other of which communicates with a furnace, and at the opposite end thereof with an exhaust port, of a damper coacting with the ports of each regenerator communicating with a furnace and with the combustion chamber to close one or the other thereof, a similar damper coacting with the exhaust port of each regenerator to close the same when the port of that regenerator communicating with the combustion chamber is open, operating rods for controlling said dampers, a shaft for the operation of the dampers coacting with the ports leading to the furnace and to the combustion chamber aforesaid, a second shaft coacting with the operating rods of said dampers coacting with the exhaust ports of said regenerators, a plurality of gears on said shafts, one for each rod, a frame carried at the end of each rod, a rack carried by each frame and meshing with the adjoining gear, the rack of one rod coacting with the upper portion of its gear while the rack of the complemental rod cooperates with the opposed portion of its gear, a cylinder positioned between said shafts having a piston thereon, piston rods extending from both sides of said piston and projecting from the opposite ends of said cylinder, a rack secured to the end of each rod, and a gear on each shaft meshing with one of the piston rod racks whereby the movement of the piston from one end of the cylinder to the other and return causes an oscillation of said shaft.

12. In a combustion unit, the combination with a combustion chamber and a pair of complemental regenerators, each regenerator having a pair of ports in one end, one communicating with the combustion chamber and the other with a furnace, and at the opposite end an exhaust port, of a damper coacting with the ports of each regenerator leading to the furnace, and to the combustion chamber to close one or other thereof, a similar damper

coacting with the exhaust port of each regenerator, operating rods for controlling said dampers, a shaft for the operation of the dampers coacting with the ports leading to the furnace and to the combustion chamber aforesaid, a second shaft for the operation of the rods of the dampers coacting with the exhaust ports of said regenerators, a plurality of gears on each shaft, one gear being provided for each rod, a rack carried at the end of each rod and meshing with the adjacent gear, the rack or one rod cooperating with the upper periphery of its gear while the rack of the complemental rod cooperates with the opposite periphery of its gear, a cylinder positioned between said shafts having a piston thereon, piston rods extending from both sides of said piston and projecting from the opposite ends of said cylinder, a rack secured to each rod, a gear on each shaft meshing with the adjoining rack whereby the movement of the piston from one end of the cylinder to the other and return causes an oscillation of said shaft, air intakes at the upper ends of said regenerators, and means under the control of one of said shafts for supplying air to alternate of said intakes.

13. The combination with a plurality of combustion units, each comprising a combustion chamber and a pair of complemental regenerators, the latter being provided with ports at the opposite ends thereof, of dampers for the control of said ports, a shaft for the operation of the dampers at one end of the regenerators, and connections between said shaft and said dampers whereby a portion of the dampers operate in one direction while the remainder operate in the opposite direction.

14. The combination with a plurality of combustion units, each comprising a combustion chamber and a pair of complemental regenerators, the latter being provided with ports at the opposite ends thereof, of dampers for the control of said ports, a shaft for the operation of the dampers at one end of the regenerators, connections between said shaft and said dampers whereby a portion of the dampers operate in one direction while the remainder operate in the opposite direction, and means for oscillating said shaft.

15. The combination with a plurality of combustion units, each comprising a combustion chamber and a pair of complemental regenerators, the latter being provided with ports at the opposite ends thereof, of dampers for the control of said ports, a shaft for the operation of the dampers at one end of the regenerators, connections between said shaft and said dampers whereby a portion of the dampers operate in one direction while the remainder operate in the opposite direction, a second shaft for the operation of the dampers at the opposite ends of said regenerators, connections between said last mentioned shaft and dampers whereby a portion thereof operate in one direction while the remainder operate in the reverse direction, and means for oscillating said shafts in unison.

16. The combination with a plurality of combustion units, each comprising a combustion chamber and a pair of complemental regenerators, the latter being provided with ports at the opposite ends thereof, of dampers for the control of said ports, a shaft for the operation of the dampers at one end of the regenerators, means whereby the oscillation of said shaft will move alternate dampers in opposite directions to open and close said ports, a second shaft for the operation of said dampers at the opposite ends of the regenerators, means whereby the oscillation of said second shaft will move alternate dampers in opposite directions to open and close the ports at those ends of the regenerators, and a unitary means for oscillating said shaft in unison.

17. The combination with a plurality of combustion units, each comprising a combustion chamber and a pair of complemental regenerators, the latter being provided with ports at the opposite ends thereof, of dampers for the control of said ports, a shaft for the operation of the dampers at one end of the regenerators, means whereby the oscillation of said shaft will move alternate dampers in opposite directions to open and close said ports, a second shaft for the operation of said dampers at the opposite ends of the regenerators, means whereby the oscillation of said second shaft will move alternate dampers in opposite directions to open and close the ports at those ends of the regenerators, a unitary means for oscillating said shaft in unison, comprising a cylinder, having a piston therein and rods extending from said piston out of the ends of the cylinder, racks on said rods, and gears on the said shafts meshing with said racks.

18. In a furnace, a chamber having its roof and hearth substantially coplanar with the respective upper and lower extremities of the body of the furnace, a series of combustion units arranged adjacent and completely external to the perpendicular limits of the chamber aforesaid, each unit comprising a combustion chamber in combination with a pair of complemental regenerators, means for supplying air for combustion to the upper end of said regenerators, and means for so controlling the flow of air that alternate regenerators receive air.

19. In a furnace, a chamber having its roof and hearth substantially coplanar with the respective upper and lower extremities of the body of the furnace, a series of combustion units arranged adjacent and completely external to the perpendicular limits of the chamber aforesaid, each unit comprising a

combustion chamber and a pair of complemental regenerators, ports at opposite ends of said regenerators, dampers for the control of said ports, a shaft for the operation of the dampers at one end of the regenerators, connections between said shaft and said dampers whereby a portion of the dampers operate in one direction while the remainder operate in the opposite direction, and means for oscillating said shaft.

ARTHUR L. STEVENS.