Sept. 29, 1953 P. B. GREGER 2,653,582

FURNACE

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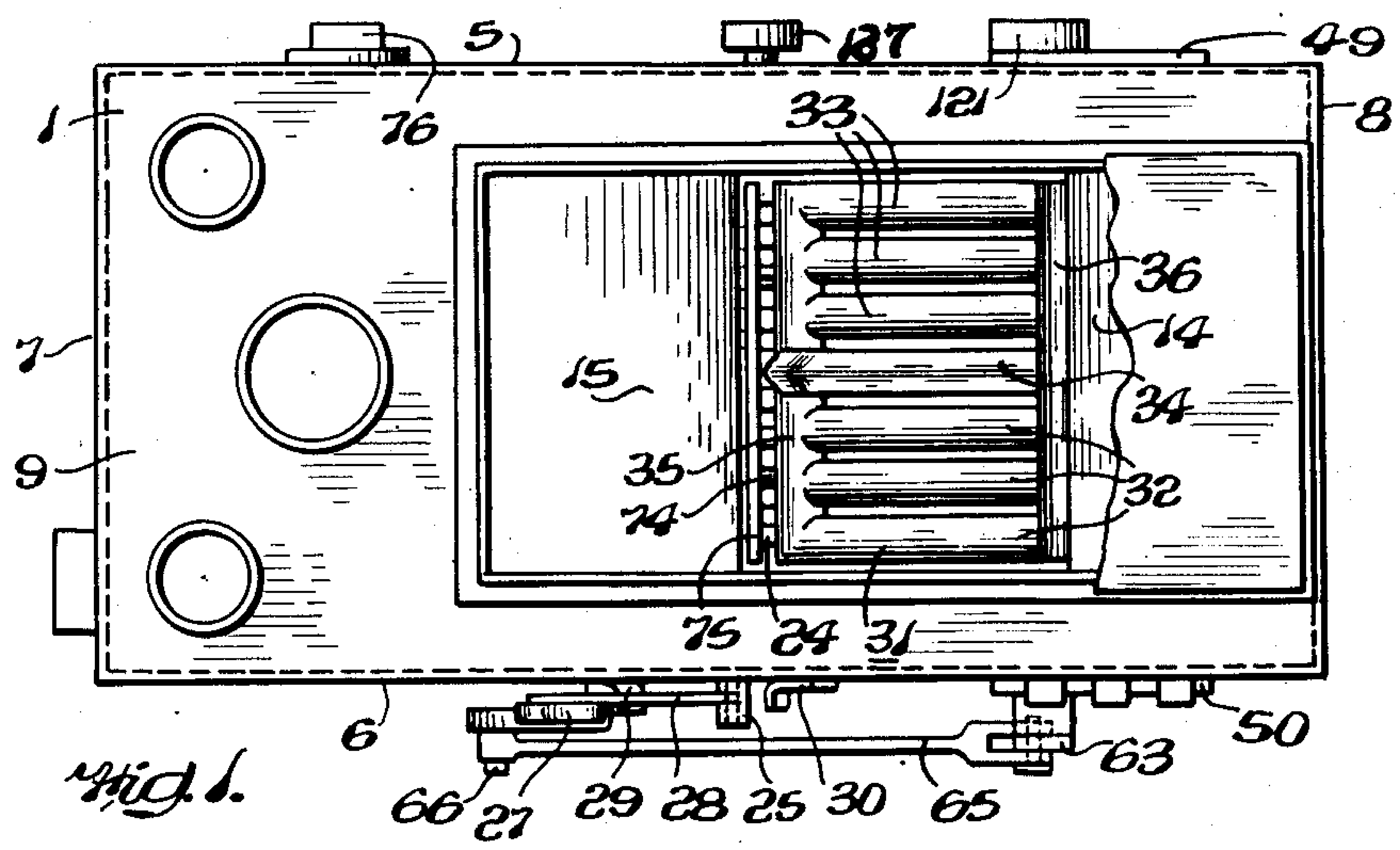

Fig. 1.

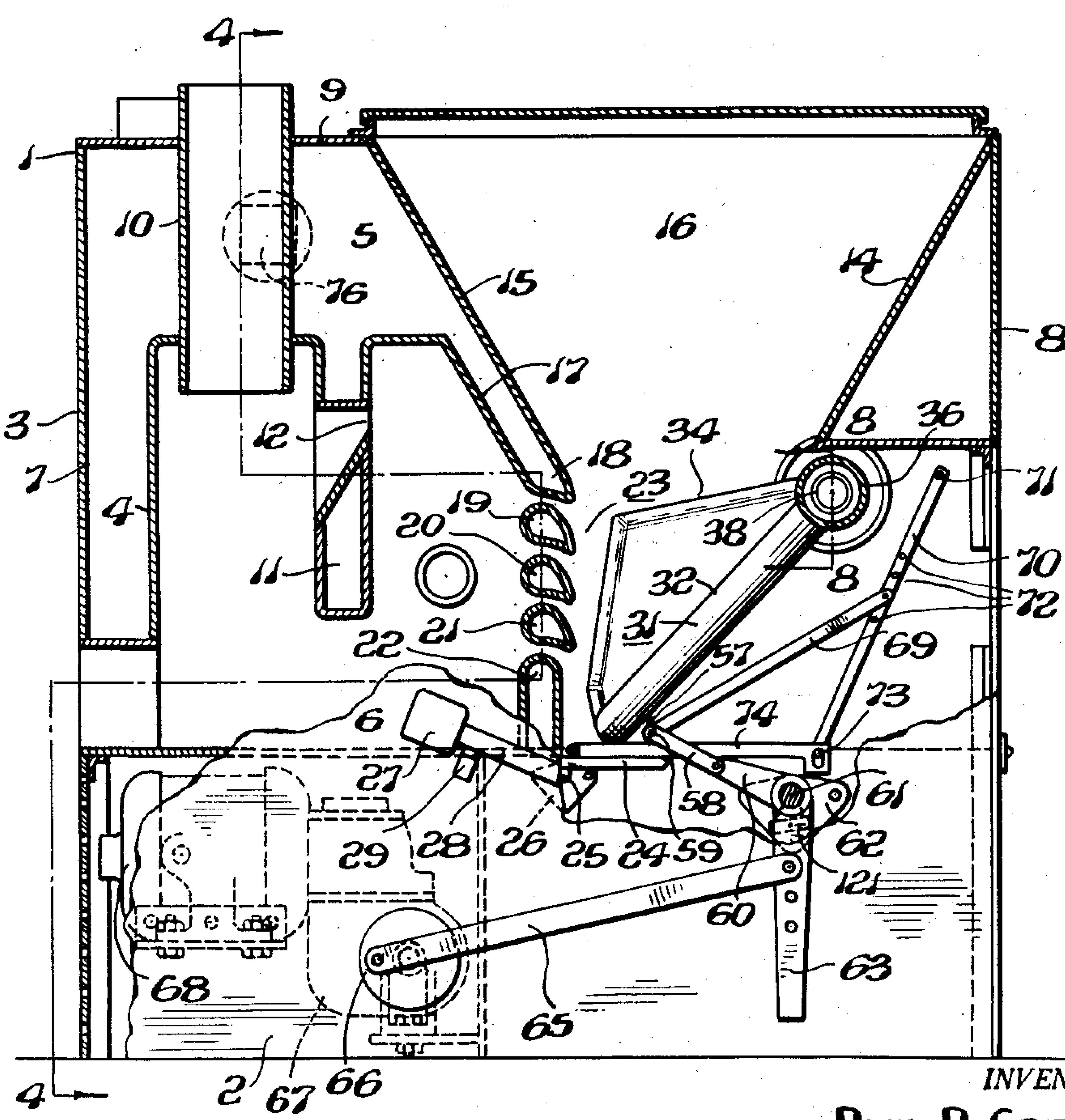

Fig. 2.

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Fig.3.

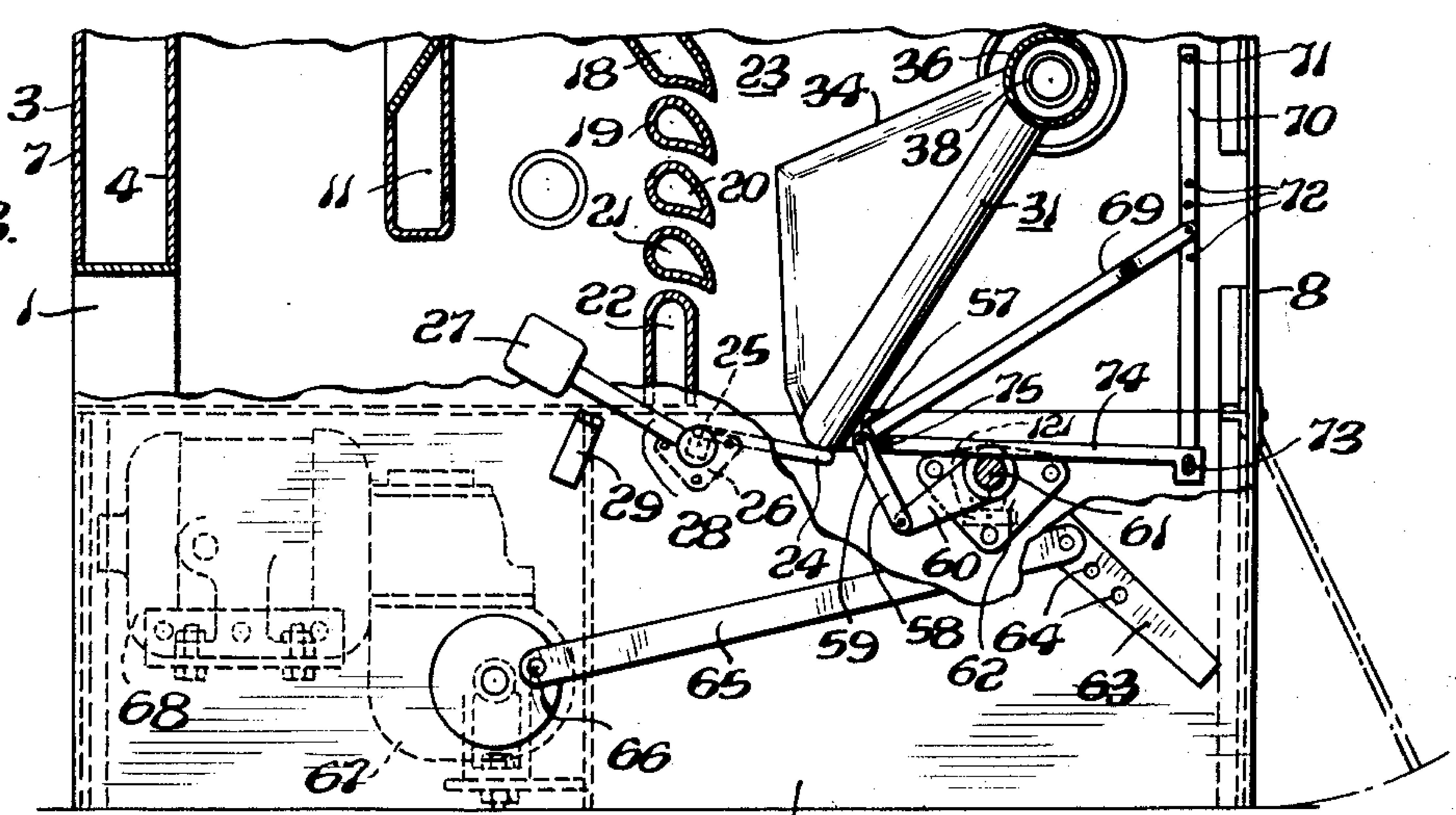

Fig.4.

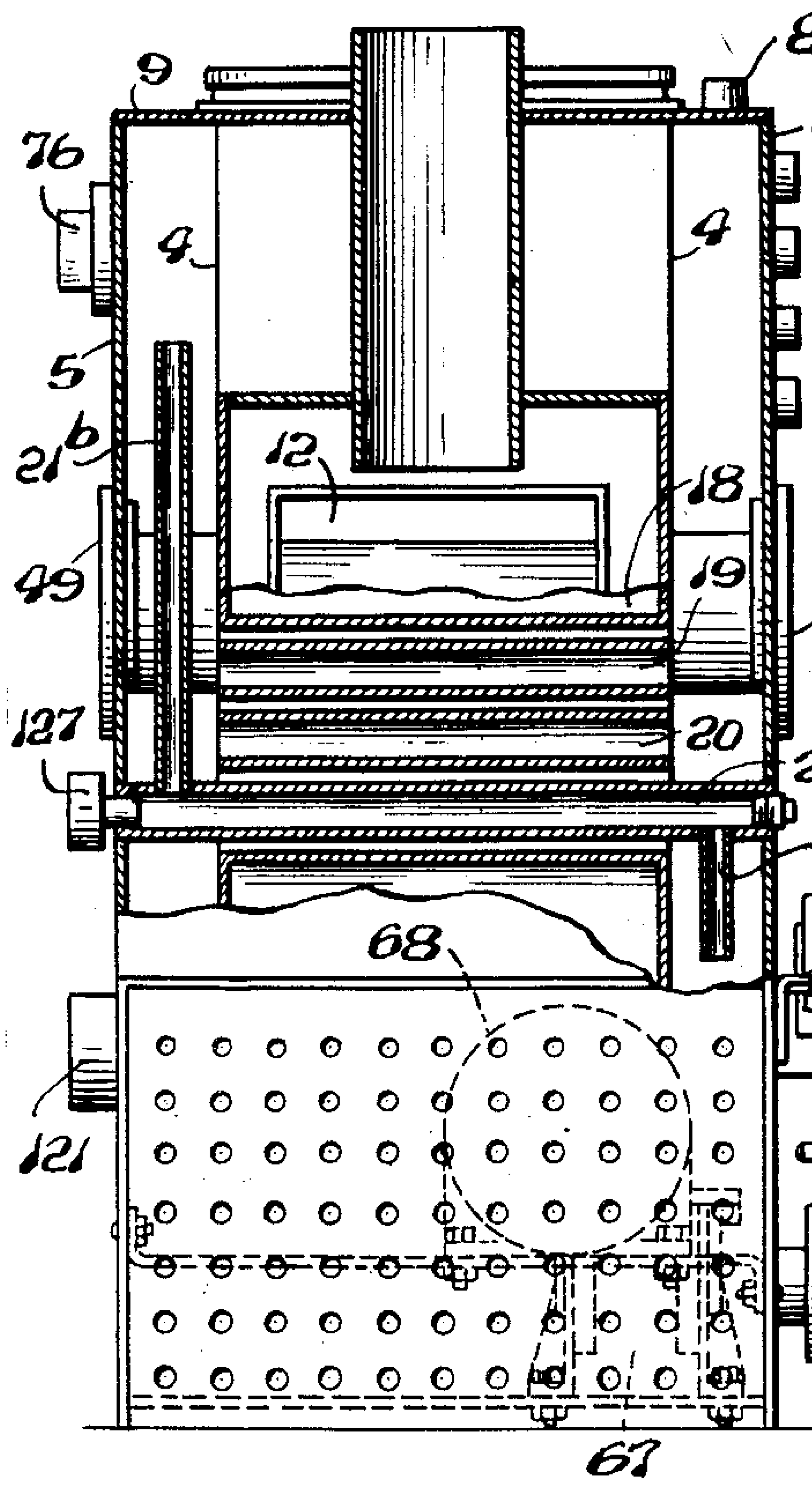

Fig.5.

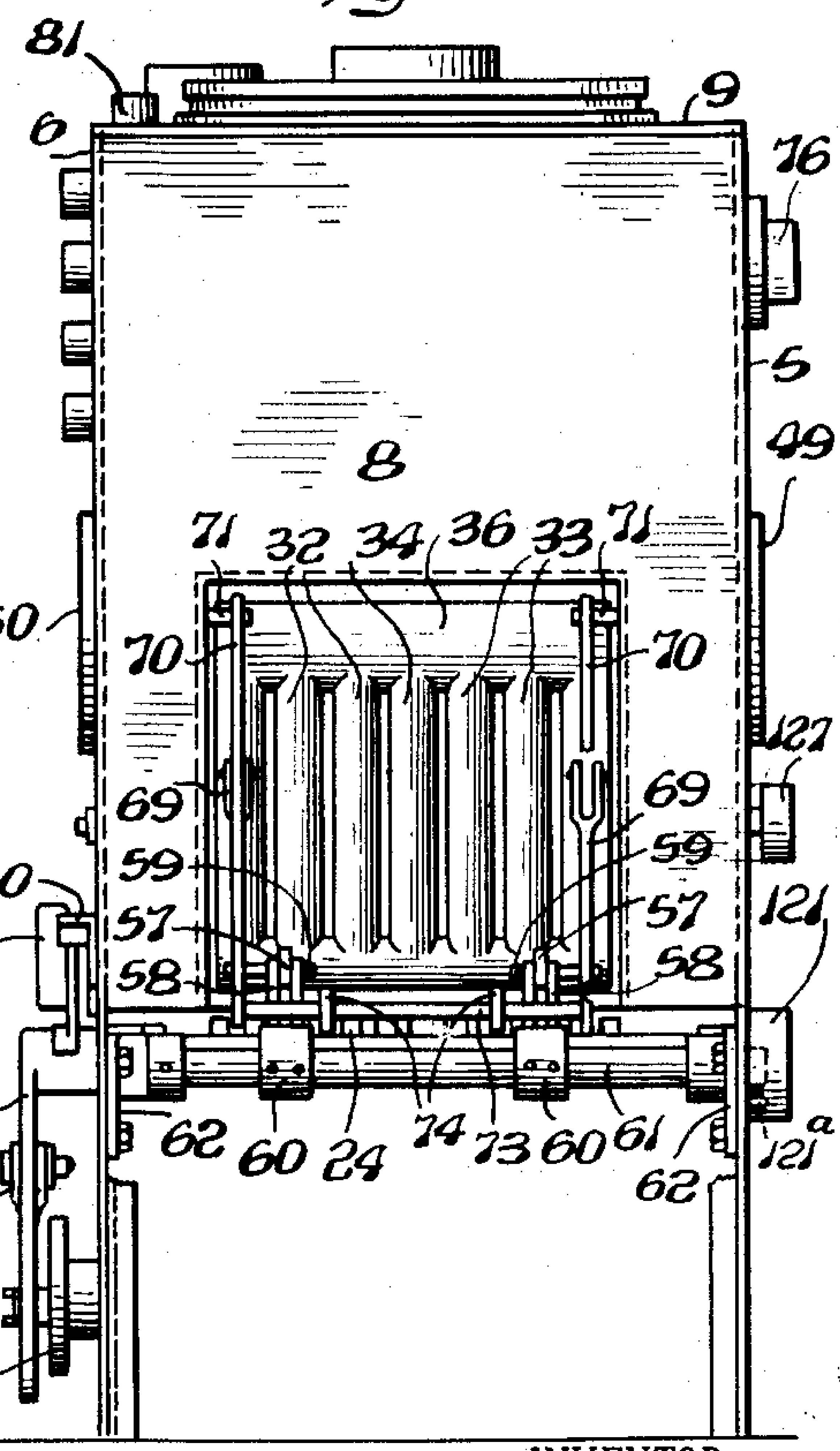

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Fig. 6.

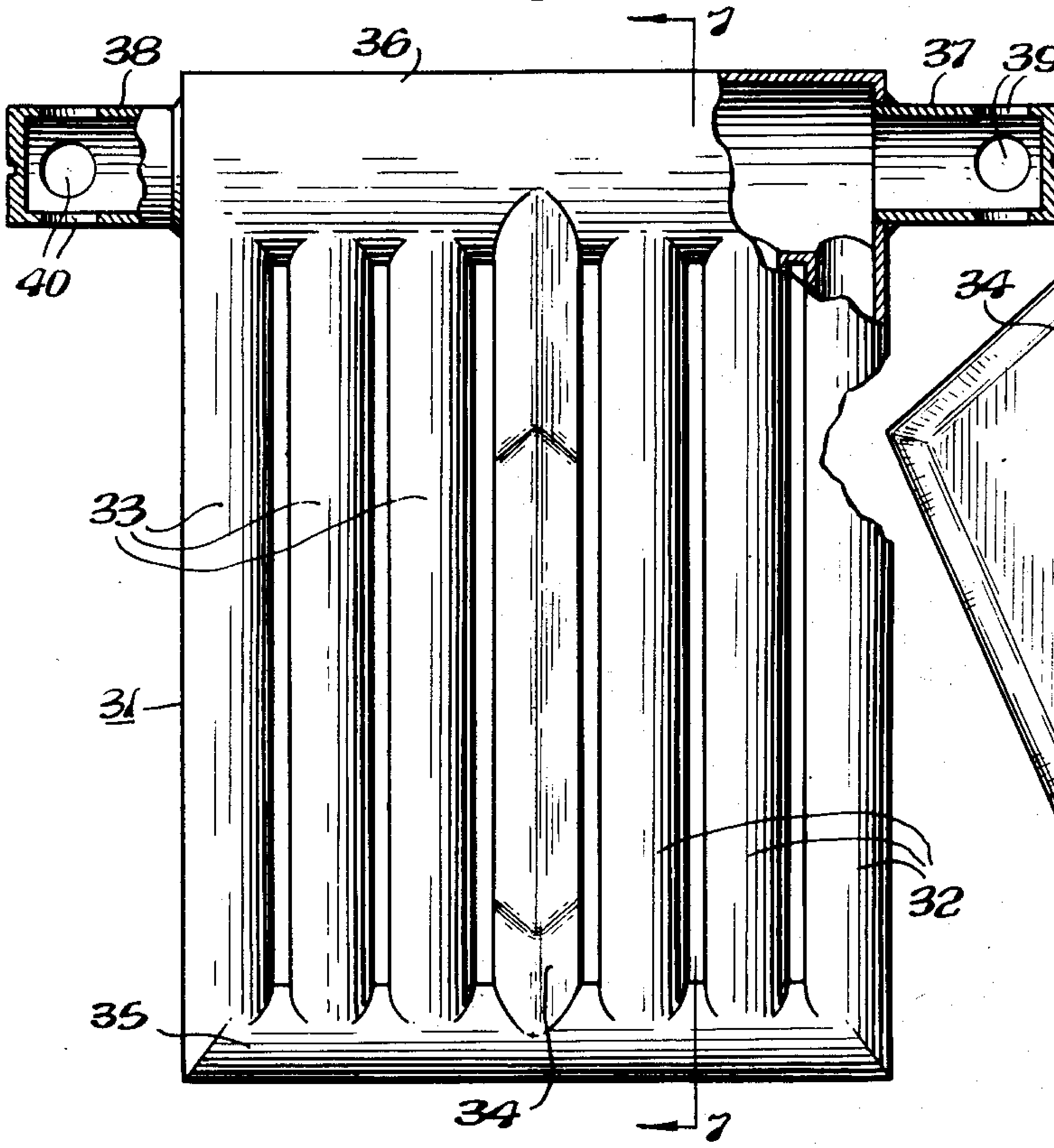


Fig. 7.

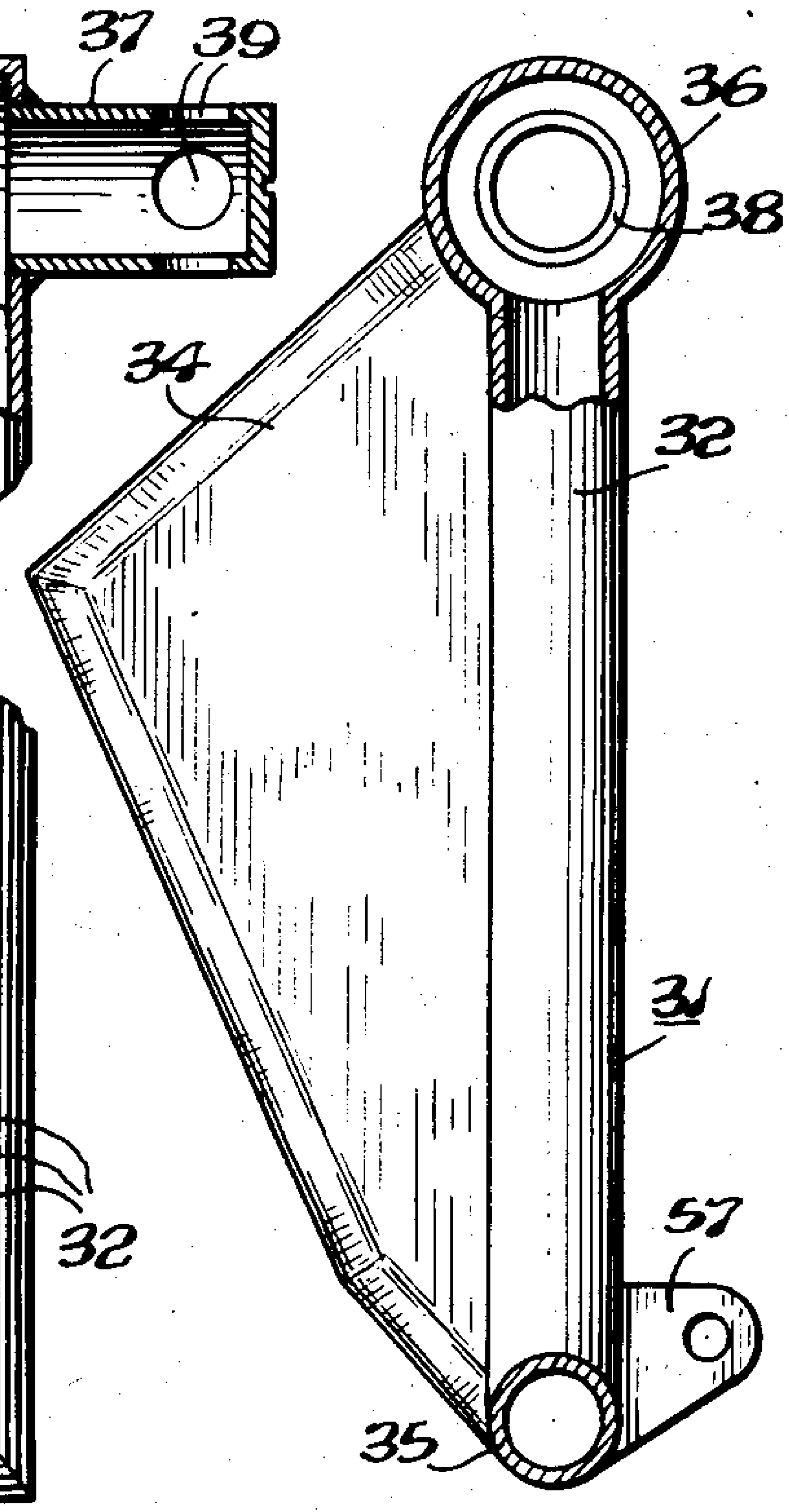


Fig. 9.

Fig. 8.

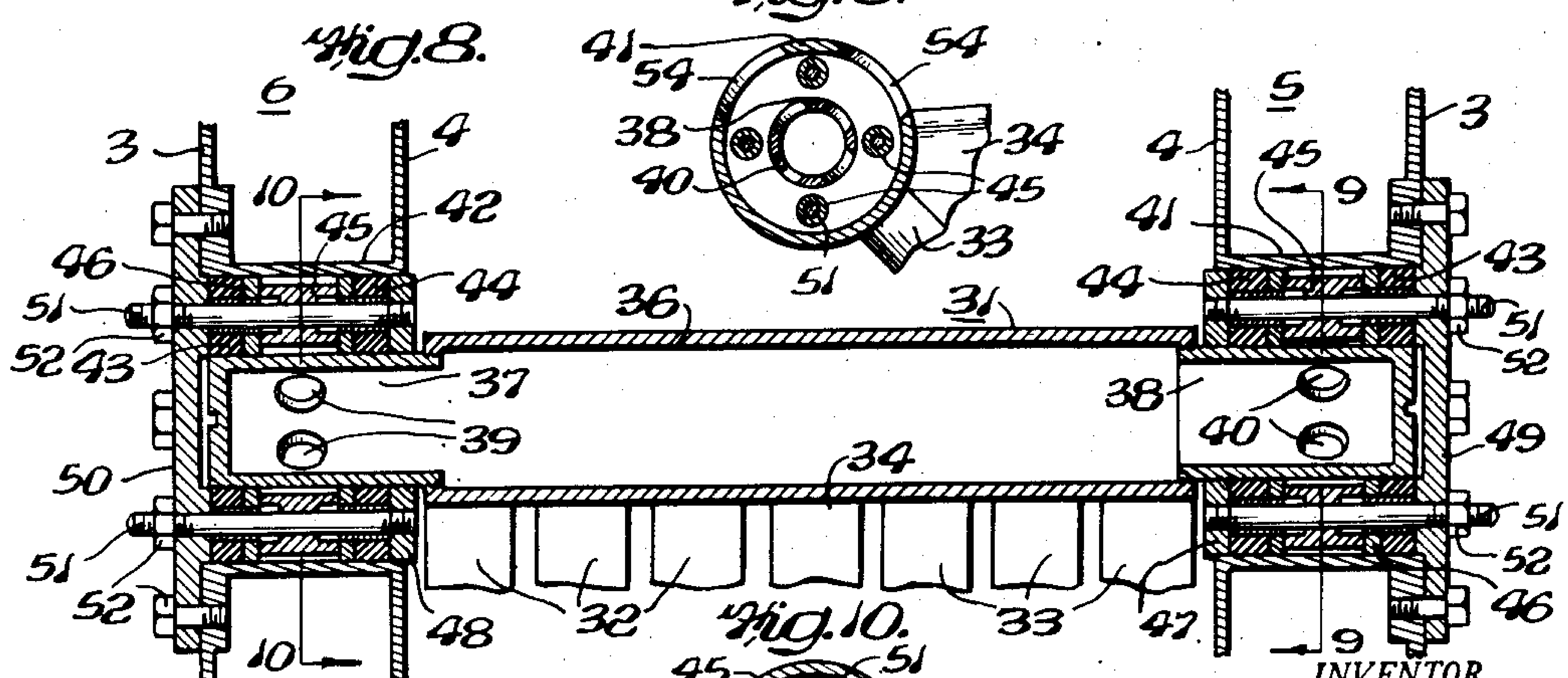
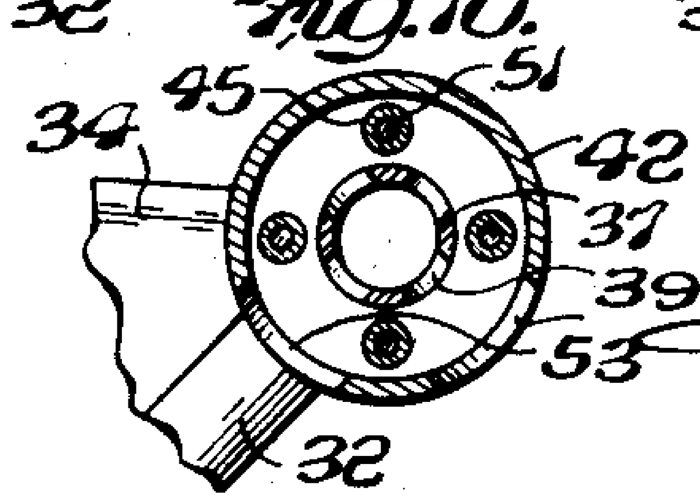


Fig. 10.



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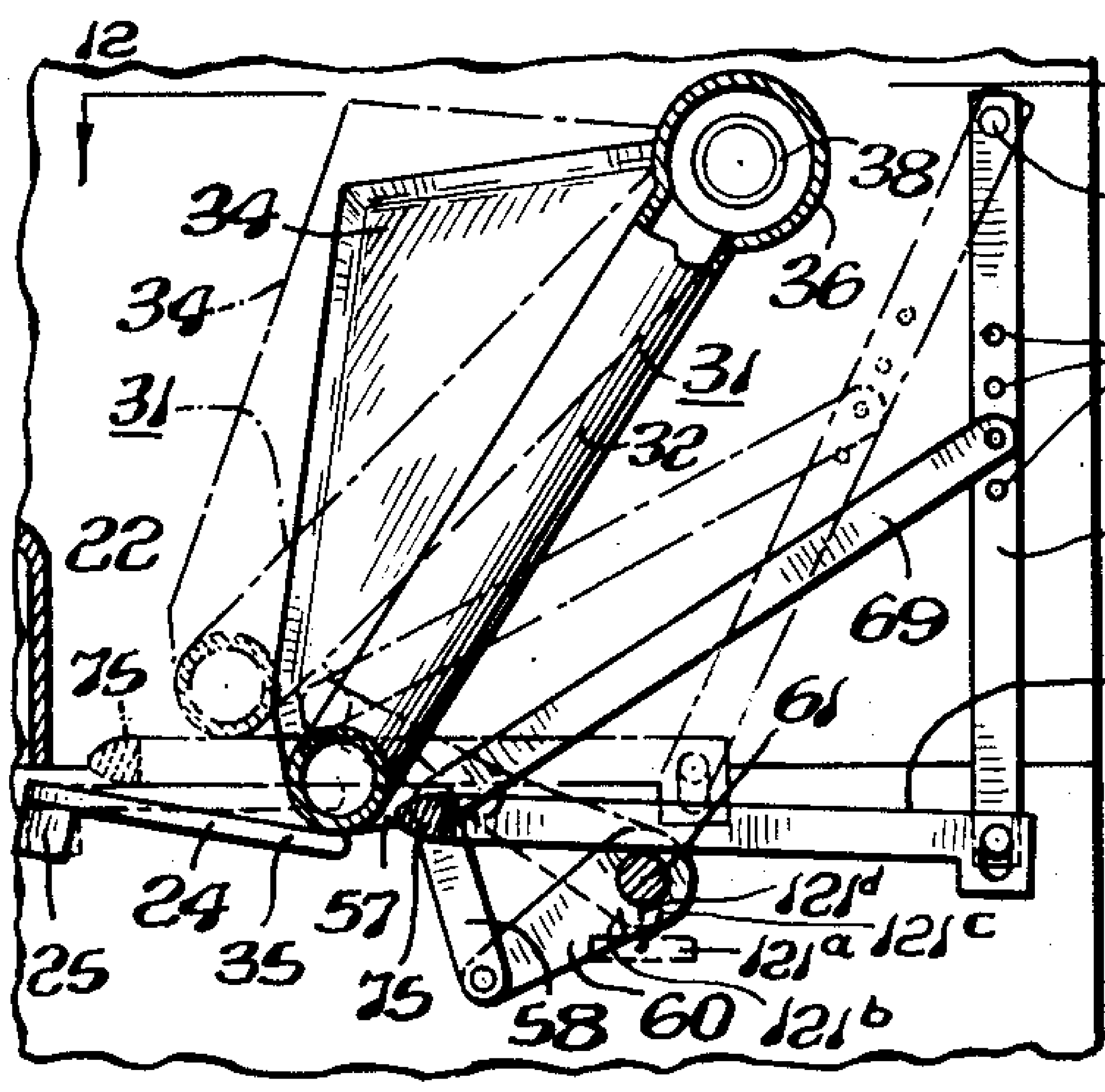


Fig. 11.

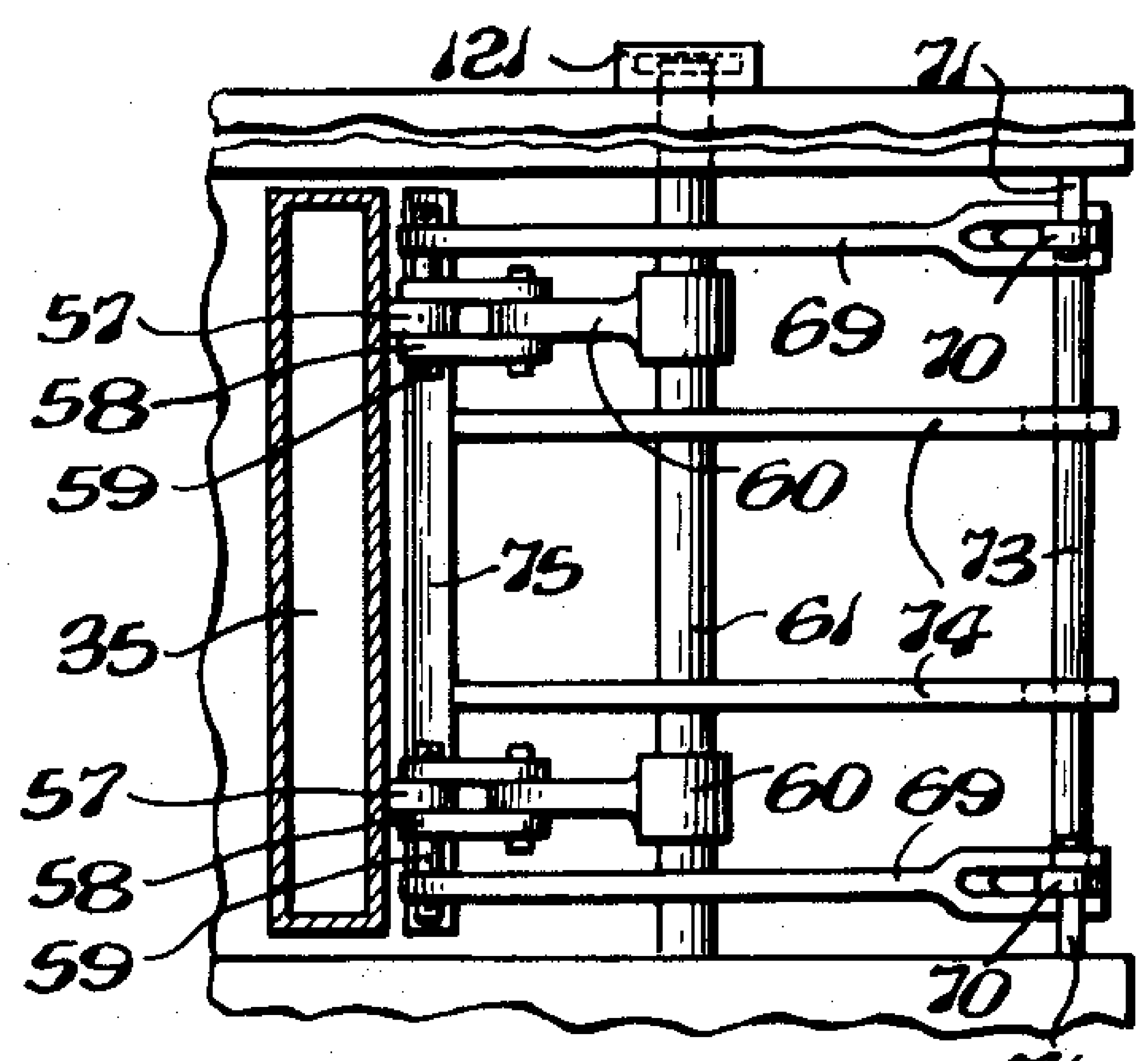
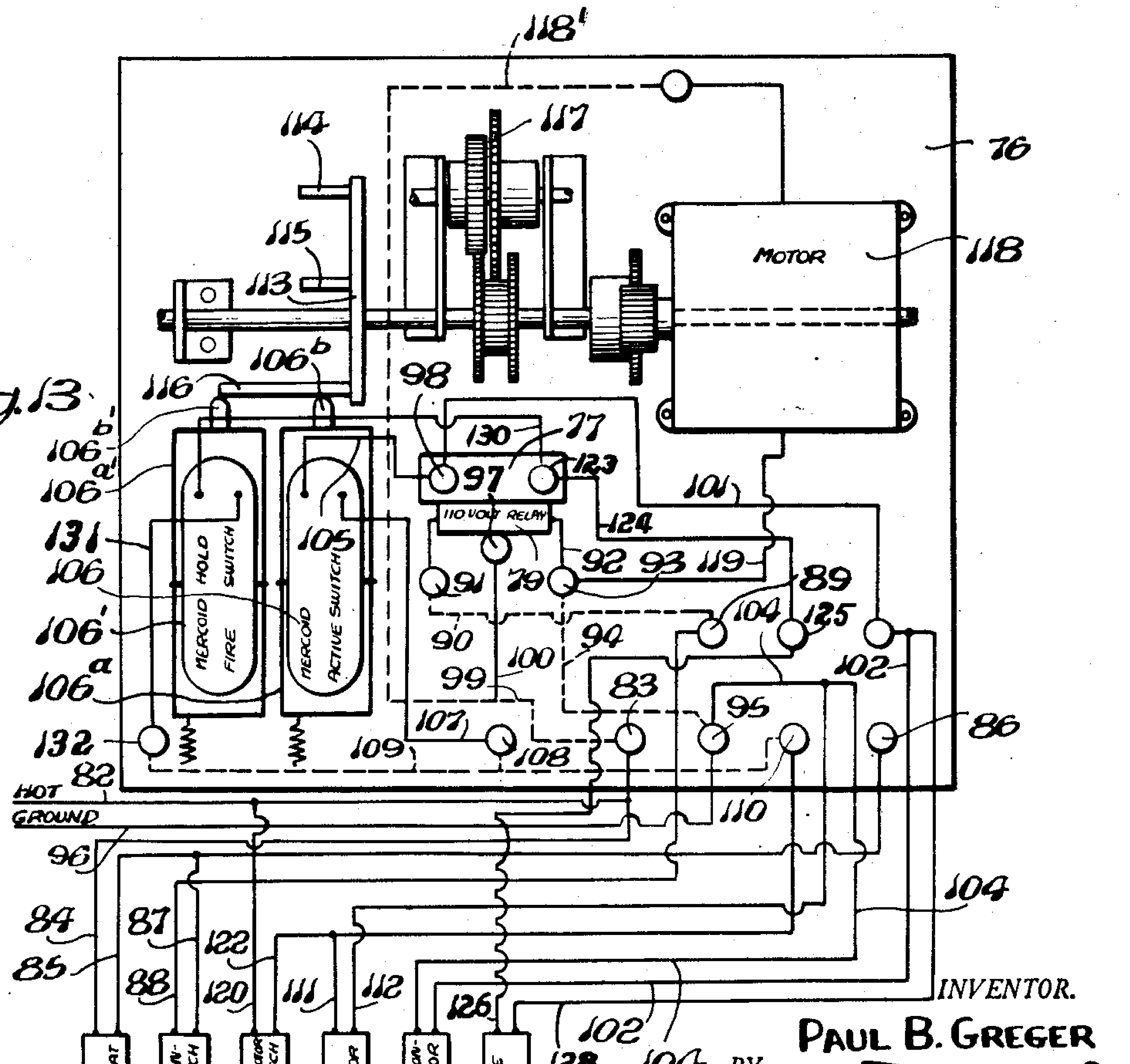


Fig. 12.

Fig. 13



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Patented Sept. 29, 1953 2,653,582

UNITED STATES PATENT OFFICE

2,653,582

FURNACE

Paul B. Greger, Reading, Pa.

Application August 16, 1946, Serial No. 691,114

13 Claims. (Cl. 122—30)

My invention is an improved furnace for and method of burning solid fuels, and particularly fuels which tend to clinker and arch, such for instance as coal, coke and briquettes.

When solid fuels are burned in a bed to which air of combustion is admitted laterally and a zone of combustion is maintained of substantial vertical depth relative to the thickness of the bed, the fuel tends to arch in the upper portion of the bed and cavities are formed below such arches by the contraction of the lower portion of the bed resulting from the conversion of the fuel to ash. Such cavities result in inequality of air flow through various portions of the bed, with consequent localized excessive temperatures tending to slag the fuel, or the impurities therein, and form clinkers reinforcing the arching of the bed and preventing a continuous feed of fuel to the combustion zone and the proper scavenging of the fire box.

The tendency of solid fuel to clinker is further accentuated by burning it in a mass so large that incandescent, interior portions thereof are substantially free from the cooling effect of heat absorbent surfaces confining the mass.

I have found that the distance through which heat absorbent surfaces are effective in retarding clinkering varies with the size of the fuel, and that no portion of an incandescent mass should be further from a heat absorbent surface than four or five times the maximum diameter of the average sized lumps of fuel composing the mass. Since each "size" of solid fuel is graded by its passage through the mesh of one screen and its passage over a screen of smaller mesh, the diameter of the average size lumps of any given "size" of solid fuel may, for convenience, be considered the diameter of the mesh through which it passes and is so considered herein. Hence, for maximum efficiency and minimum clinkering, fuel of such size should be burned in a bed having all incandescent portions thereof cooled by some heat absorbing surface disposed at a distance not exceeding five times the diameter of the larger mesh by which the fuel was graded.

My invention provides a method and apparatus by which solid fuels may be burned at a high rate and at high efficiency without arching or slagging and without generating localized excessive temperatures, and by which the fuel bed may be continuously maintained at a substantially constant density and depth.

These desiderata are attained primarily by periodically squeezing laterally a bed of burning fuel and maintaining heat absorbing surfaces in

relatively close proximity to all incandescent portions of the burning bed. The combustion zone of the bed preferably converges from the upper toward the lower regions thereof and the squeezing movement preferably increases progressively from the upper portion toward the lower portion of the combustion zone of the bed, which is preferably of relatively great depth both in proportion to its thickness and in proportion to the distance between heat absorbing elements in and around the fire box. The maximum distance between such heat absorbing elements preferably does not exceed ten times the larger of the mesh sizes used in grading the fuel for which the fire box of the furnace is designed or adjusted.

The lower portion of the combustion zone is preferably sliced or agitated during the squeezing thereof and immediately thereafter and where the fire box is of greater width than thickness the fuel bed therein is preferably sliced vertically during the squeezing thereof. The lateral squeezing and slicing of the bed not only breaks any arch or clinker that may be present but also tends to expel fine ash which may be present in the combustion zone at the various levels thereof, and the slicing of the lower zone tends to remove any clinker or fine ash that may accumulate on the grate or fuel bed support.

My improved furnace contains a fire box having a bottom grate or support of relatively small area for the fuel bed. The fuel bed is surrounded and confined by walls extending upwardly from the grate. Such walls are preferably cooled by the circulation therethrough of the water of a steam or hot water boiler forming a part of the furnace structure. The front and back walls of the fire box preferably diverge upwardly and one of them is rockable on an axis to periodically squeeze the combustion zone of the fire bed and reciprocate one or more slices therethrough.

The rocking wall preferably communicates with the hollow side walls of the fire box through bearings forming a tight joint for the admission and emission of cooling fluid during the movement of the rocking wall as well as during the rest periods thereof. The rocking wall preferably comprises a top header having at one end an inlet and at the other end an outlet for cooling fluid which circulates through the rocking wall between the admission and emission thereof.

Preferably the rockable wall comprises hollow tubular members projecting diagonally downward from the upper header and spaced from one another to form slots or air vents. The lower ends of the tubular members communicate with a bottom header and a hollow partition is fixed to and communicates with the top and bottom headers midway between the ends thereof and projects into the fire box to form a heat absorbing partition and vertical slice.

The rate of combustion may be controlled by varying the draft responsively to the action of a remote room thermostat subject to a safety control on the furnace, and also responsively to the action of a "hold fire" furnace thermostat which is responsive to a predetermined minimum temperature at the combustion zone. The draft is preferably variable by varying the action of an exhaust fan but may be varied by the movements of the damper or otherwise.

The movable water wall is automatically shaken at predetermined intervals under control of a timer switch when the room thermostat maintains the draft "on" and is automatically shaken at predetermined longer intervals when the draft is "off" or is briefly turned on by the "fire hold" thermostat mechanism.

A reset switch may be provided to insure the maximum outward movement of the movable wall at the end of any oscillation thereof.

The principles and characteristic features of my invention, and the manner of making, constructing and using my improved furnace will further appear from the accompanying drawings and the following description explaining the best mode in which I have contemplated applying such principles.

In the drawings, Fig. 1 is a top plan view of a boiler furnace embodying my invention, the hopper cover being partly broken away; Fig. 2 is a part side elevation and part longitudinal vertical sectional view of the boiler furnace shown in Fig. 1 with the movable wall of the fire box in fuel-compacting position; Fig. 3 is a fragmentary part side elevation and part longitudinal vertical sectional view of the boiler and furnace with the movable wall of the fire box and associated parts in normal burning position; Fig. 4 is a part sectional and rear end view taken on the line 4—4 of Fig. 2; Fig. 5 is a front end elevation of the boiler furnace with the end cover removed and parts broken away; Fig. 6 is a detached enlarged elevation of the movable wall of the fire box as viewed from the fire box and with parts broken away; Fig. 7 is a transverse sectional view of the movable wall of the fire box taken on the line 7—7 of Fig. 6; Fig. 8 is a fragmentary sectional view taken approximately on the line 8—8 of Fig. 2; Fig. 9 is a transverse sectional view taken on the line 9—9 of Fig. 8; Fig. 10 is a transverse sectional view taken on the line 10—10 of Fig. 8; Fig. 11 is a fragmentary, diagrammatic view illustrating the movements of the movable wall of the fire box and of the horizontal slice; Fig. 12 is a fragmentary top plan view of part of the mechanism for periodically operating the movable wall of the fire box and the horizontal slice; and Fig. 13 is a diagrammatic view of the control mechanism for regulating the operation of the furnace responsively to predetermined conditions.

The drawings illustrate the embodiment of my invention in a combined boiler and furnace 1 mounted on a rectangular base 2 and having inner and outer sheets or plates 3 and 4 connected with one another to form hollow communicating side walls 5 and 6, back and front walls 7 and 8 and top wall 9.

A tubular flue connection 10 projects through the top wall 9 between the rear wall 7 and a hollow water leg 11 formed by depending sections of the inner sheet 4 extending transversely of the furnace and containing a flaring gas vent 12. The bottom of the water leg 11 is spaced from the top of the base 2 to form a passage for the transit of products of combustion to the flue connection 10.

The inner sheet or plate 4 has downwardly converging sections 14 and 15 forming front and rear walls of a fuel hopper 16 bounded sidewise by the hollow walls 5 and 6. The bottom of the plate section 15 is connected through a downwardly tapering bend with an inclined section 17 of the inner sheet or plate 4 to form a diagonal water leg 18.

A series of spaced tubes 19, 20, 21 and 22, preferably of substantially airfoil cross section, extend transversely of the furnace beneath the water leg 18 and form therewith an apertured rear water wall for a fire box 23 to which the hopper 16 discharges. The downward taper of the bend of the plate 15 and the airfoil cross sections of the members 19, 20 and 21 provide depending watercooled fins acting as shields to prevent or minimize the deposit of ash between the tubes. The leg 18 and tubes 19, 20 and 22 have their ends set in the inner plates of the end walls 5 and 6 so as to permit free circulation through the leg and tubes. The tube 21 extends across the hollow walls 5 and 6 and communicates with the interiors thereof only through constricted ports of smaller cross section than the tube and preferably through the constricted inlet tube 21*a* extending downward toward the coolest water zone and the constricted outlet tube 21*b* extending upward toward the hottest water zone. By this construction the temperature of the water in the tube 21 is directly and promptly responsive to changes in the temperature of the fuel bed zone adjacent to the tube 21.

The tube 22 is preferably of greater height than the tubes 19—21 and forms a sill of substantial height preventing ingress of air or ashes from the grate 24 into the gas combustion chambers lying between the fire box 23 and the rear wall 7 of the furnace.

The grate 24 comprises a row of bars or fingers fixed to a shaft 25 journalled in brackets 26 in the sides of the base 2. A counterweight 27 is fixed to an arm 28 on the end of the shaft 25 and normally biases this shaft so as to turn the grate bars to substantially horizontal position, but permitting the shaft and grate bars to be tilted as hereinafter described. The throw of the counterweight is limited by the engagement of the arm 28 with the spaced stops 29 and 30.

The front of the fire box 23 is bounded by a hollow, water-circulating, inclined, aperture wall 31 which is movable periodically toward and from the rear wall of the fire box to compress and release the burning zone of the fuel bed bounded horizontally by the grate 24 and the bottom or exit port of the hopper 16.

The water wall 31 preferably comprises a plurality of sets of spaced tubes 32 and 33; the sets being spaced from one another by a hollow partition 34, preferably of trapeziform peripheral outline and having an upper point movable into or adjacent to the exit port of the hopper 16 to break up any arching therein.

The lower ends of the tubes 32 and 33 and of the hollow partition 34 are connected with and communicate with the interior of a lower header 35, and the upper ends of the tubes 32 and 33 and of the partition 34 are connected with and communicate with the interior of an upper header 36.

The ends of the header 36 have fixed therein hollow trunnions 37 and 38 containing peripheral ports 39 and 40; the trunnions having their outer ends closed by slotted end pieces and their inner ends communicating with the interior of the header 36.

The trunnions 37 and 38 are journalled in bearings in the water walls 5 and 6 immediately below and to the front of the exit port of the hopper 16. Such bearings preferably consist of sleeves 41 and 42 (Figs. 8–10) integral with the respective plates 3 and 4 or seated in apertures in such plates 3 and 4 and making tight joints with the edges thereof.

Compressible water-proof packings 43 and 44 are inserted between the respective trunnions 37 and 38 and sleeves 41 and 42; the packings being spaced from one another by spacers 45 and washers 46. Glands 47 and 48 are slidable axially in the inner ends of the sleeves 41 and 42, and the outer ends of these sleeves are sealed by caps 49 and 50 bolted to the plate 3. The glands 47 and 48 may be drawn toward the respective caps 49 and 50 by bolts 51 and nuts 52 to compress the packings and make water and steam tight joints between the trunnions and sleeves while permitting the oscillation of the trunnions on their common axis.

The sleeve 42 (Fig. 10) contains bottom apertures 53 between the packings 43 and 44 therein so as to permit ingress of water from the side wall 6 through the apertures 53 to the trunnion apertures 39 and therethrough to the header 36 and wall 31. The sleeve 41 (Fig. 9) contains top apertures 54 between the packings 43 and 44 therein to permit egress of water from the wall 31, header 36, trunnion ports 40 and sleeve ports 54 to the interior of the hollow wall 5.

The bottom header 35 has formed thereon ears 57 to which links 58 are pivotally connected by the pins 59 (Figs. 2, 3, 7, 12). The links 58 are pivotally connected with crank arms 60 on a shaft 61 journalled in bearings 62 on the ends of the base 2.

An end of the shaft 61 projects through an end wall of the base 2 and has fixed thereto a crank arm 63 (Figs. 1, 2, 3, 5). The crank shaft 63 contains a series of apertures 64 extending diagonally to a radius of the shaft 61. The crank 63 may be pivotally connected with a link 65 through any one of the apertures 64. The link 65 is pivotally connected with a crank 66 of a speed reducer 67 rotated by an electric motor 68.

The pins 59 are pivotally connected, through bifurcated couplings or links 69, with hangers 70 (Figs. 3, 5, 11, 12) pivotally suspended from bosses or bearings 71 in front of the header 36. The hangers 70 contain a series of apertures 72 intermediate their ends so that the links 69 may be connected with the hangers 70 in various positions so as to vary the rate and extent of movement of the lower ends of the hangers 70 when the links 69 are moved as a result of the movements of the lower end of the water wall 31.

The lower ends of the hangers 70 are connected by a shaft 73 which support the outer slotted ends of rods 74 which slide over and are supported by the shaft 61. A horizontal slice 75 is fixed to the inner ends of the bars 74 and preferably has a tapered nose and flat back.

Normally, as shown in Fig. 3, the bottom header of the water wall 31 lies near and above the front ends of the relatively short, spaced bars of the grate 24; the horizontal slice 75 lies below or in front of the lower part of the water wall 31, viz., outside the fire box; and the vertical slice formed by the partition 34 is spaced somewhat from the rear wall of the fire box and its top lies adjacent to but preferably slightly below the exit orifice of the hopper 16.

The normal horizontal spacing of the water wall header 35 from the sill 22 may be adjusted for different sizes of fuel by connecting the link 65 in apertures 64 of the crank 63 at greater or lesser distances from the axis of the shaft 61.

When the link 65 is reciprocated, through the action of the motor 68 and speed reducer 67, the arm 63 is rocked to rock the shaft 61 and straighten or break the toggle-like joint formed by the arms 60 and bifurcated links 58. The straightening of the joint moves the header 35 backward toward the sill 22. The movement of the header 35 is transmitted through the links 69 to the hangers 70 approximately midway of their lengths. The hangers 70 are thereby turned on their bearings 71 and move the shaft 73, bars 74, and slice 75 backward, viz., toward the sill 22, at a rate faster than the movement of the header 35. The slice 75 therefore passes beneath the slowly inwardly and upwardly moving header 35 and slices the portion of the fuel bed adjacent to the bars of the grate 24. If the movement of the slice 75 is resisted by obstructions, such as slate, debris, or the like on the grate 24, the resulting pressure on the grate bars overcomes the normal biasing action of the counterweight 27, and tilts the grate bars 24 so as to drop the obstruction and permit the inward movement of the slice 75 until it has neared the rear of the bed on the grate, as shown in Fig. 11 by the dotted lines.

When the continued movement of the crank 66, through the connections described, breaks the joints formed by the arms 60 and links 58, the header 35 is rocked downward and frontward, and such movement is transmitted through the linkage 69, 70, 73 and 74 to cause the rapid retraction of the slice 75, whose flat face carries with it ash and refuse which lay immediately above the grate bars 24. The grate bars are tilted thereby sufficiently for the material being withdrawn to pass beneath the header 35 and be discharged into a receptacle or into the base 2.

The inward and upward movement of the water wall 31 moves the vertical slice formed by the partition 34 toward the rear wall of the fire box and moves the upward edge of the slice into or adjacent to the exit port of the hopper 16 to agitate the fuel therein.

The periodical compression and releasing of the burning zone of the fuel bed by the lateral movement of the wall 31 and the horizontal and vertical slicing thereof by the slices 34 and 75 effectively breaks any arches or unconsumed products and fills any voids that may have tended to form, and sifts any fine ash in the burning zone through the slots between the tubes 32 and 33 and partition 34 as well as through the slits between the grate bars 24.

A uniform density of fuel bed and uniform flow of air is thus maintained through the burning zone of the fuel bed, which tapers in thickness between the wall 31 and the wall formed by the tube 19, 20, 21 and 22 relatively to the extent of burning and consequent degree of compaction of the bed at different depths in the combustion zone.

The heat produced by the combustion of the fuel is absorbed by the water cooled heat absorption surfaces formed by the walls of the parts 5, 6, 19, 20, 21, 22, 31 and 34, in close proximity to all portions of the bed to secure the most efficient and uniform results. No portion of the incandescent fuel should be more distant from a water cooled heat absorptive surface than five times the diameter of the apertures in the screen over which the fuel used was graded. Consequently when small size fuel is used, the link 65 should be connected with the arm 63 through an aperture 64 at a sufficient distance from the axis of the shaft 61 to normally position the header 35 closer to the sill 22 than its normal position when fuel of larger size is being consumed. Likewise when fuel of small size is burned in a fire box of greater width than that indicated, a greater number of partitions 34 should be provided so as to maintain the desired relationship between the heat absorption surfaces and the incandescent fuel.

The movements of the wall 31 and the slice bars 34 and 75 connected therewith, as well as the draft supplied to the fire, are preferably regulated automatically by mechanism diagrammatically illustrated in Fig. 13.

The bulk of the control mechanism may be conveniently mounted in a housing 76 mounted on the furnace wall or other convenient support. The housing 76 contains a relay 77. The relay 77 has a usual electromagnetic coil 79 adapted to be energized by the flow of current therethrough under control of a usual form of room thermostat 80 and a usual form of safety control switch 81 on the furnace (Fig. 13). The safety control switch 81 may be any usual form of pressure switch, aquastat or vaporstat depending upon the type of heating employed. The room thermostat 80 closes a switch when the room temperature drops below a desired minimum and the safety switch 81, which is in series with the room thermostat, opens, to break the circuit, whenever the steam pressure, water temperature or vapor temperature in the boiler reaches the maximum compatible with safety and good practice.

When the room thermostat 80 and safety switch 81 are both closed, current flows from a source or hot wire 82 (connected with the terminal 83) through the shunt conductor 84, room thermostat 80, conductor 85, conductor 87, safety switch 81, conductor 88, terminal 89, conductor 90, terminal 91, relay coil 79, return conductor 92, terminal 93, conductor 94, terminal 95, and conductor 96 to ground.

The energizing of the coil 79 of the relay 77 causes the relay to close the circuit between the contacts 97 and 98 thereof to permit the flow of current from the terminal 83 through conductors 99, 100, contacts 97, 98, conductors 101, 102, draft control 103 and return conductor 104 to the grounded terminal 95.

The draft control may be an induced fan motor connected with the flue connection 10 or may be a motor-operated damper for controlling the draft applied to the furnace through the flue connection 10. But whatever form the draft control 103 may take, it causes the maximum draft to be applied to the fire so long as the thermostat 80 and safety control 81 are both closed.

The contact 98 is connected through the conductor 105 with one side of a usual form of "Mercoid" switch 106 comprising a mercury-containing tube mounted on a usual spring biased, tiltable frame 106*a* having a nose 106*b* for the engagement of a tilting member. The other side of the "Mercoid" switch 106 is connected through a conductor 107, terminal 108, conductor 109, terminal 110, conductor 111 with one side of the motor 68, the other side of which is grounded through the conductors 112 and 104 on the ground terminal 95.

When the contacts 97 and 98 are closed and the "Mercoid" switch 106 is tilted to closing position, current will flow through the motor 68 and the operation of the motor 68 will vibrate the water cooled wall 31 through the intermediate mechanism above described.

The time and duration of tilting of the switch 106 is governed by a timer comprising a disk 113 having axially extending pins 114, 115 and 116 adjustably, but usually equi-distantly, fixed around the periphery thereof. These pins 114, 115 and 116 rotate in the path of the nose 106*b* of the frame 106*a*, the nose being adjustable to vary the duration of the engagement of the pins with the nose.

The disk 113 is rotated at a constant rate through the speed reducing mechanism 117 by the motor 118. The motor 118 may be spring driven but is preferably an electric telechron type motor which is energized by current flowing from the conductor 99 through the conductor 118' to the telechron motor and from the telechron motor through the conductor 119 to the grounded terminal 93.

Each time the switch 106 is thrown by the timer while the circuit is closed through the draft control 103, the motor 68 is operated to shake the wall 31 a predetermined number of times which may be regulated by the adjustment of the duration of the engagement between the timer pin and the nose 106*b* of the switch frame 106*a*.

To avoid the interruption of current to the motor 68 while the wall 103 is displaced from its outermost position, a shunt circuit from the line 82 to the shaking motor 68 is provided comprising a conductor 120, a switch 121 and a conductor 122 connected with the conductor 111. The switch 121 is closed whenever the shaft 61 is so positioned that the water wall 31 is away from its frontwardmost position and is open only when the wall 31 is in its frontwardmost position.

The switch 121 may be of any conventional type, such, for instance, as a "Mercoid" type tilting mercury tube 121*a* (Fig. 11) having arms 121*b* and 121*c* adapted to be engaged by a tongue 121*d* fixed on the end of the shaft 61 between the tube arms. The parts are so positioned that when the shaft 61 begins to turn about its axis to move the water wall 31 rearward, the tongue 121*d* fixed to the end thereof engages the arm 121*b* of the "Mercoid" tube to rock the mercury tube 121*a* and close a circuit through the conductors 120 and 122. The mercury tube 121*a* remains in tilted position until the reverse rotation of the shaft 61 causes the tongue 121*d* to engage the arm 121*c* and rock the tube 121*a* to open the circuit.

It will thus be seen that so long as the room thermostat 80 calls for heat and the safety switch 81 is closed, the draft control 103 will constantly provide a predetermined draft to the furnace, which draft, however, may be adjusted for different types of fuel in any usual manner, as, for instance, by changing the speed of the induced draft motor or the throw of the draft damper. So long as the draft is on, the ashes will be removed from the fire box periodically by the movements of the water wall 31, slice 34 and slice 75, and these movements may be so synchronized with the draft as to maintain substantially constantly a bed of incandescent fuel of substantial uniform density on the grate **24** and extending upwardly therefrom toward the exit port of the hopper **16**.

Should there be any appreciable accumulation of dead ash on the great **24**, the switch **106** and its timer are readjusted to increase the frequency or duration of the operation of the shaking motor **68**. Should incompletely burned fuel be discharged from the fire box, the switch **106** and its timer are reset to decrease the frequency or duration of the operations of the shaker motor **68**. By synchronizing the operation of the shaker motor **68** with the draft control motor **103**, a large volume of fuel may be rapidly burned in a fire box of small grate area without clinkering or arching, and with the production of a minimum amount of ash. For example, a furnace embodying my invention will burn without clinkering sufficient solid fuel to provide an output of approximately 400,000 B. t. u.'s per square foot of grate area per hour.

My invention further provides means to prevent the fire from dying out completely for lack of draft and scavenging when the room thermostat **80** or the safety control **81** are open for a long period and the relay coil **79** thereby deenergized.

The de-energizing of the coil **79** permits the automatic closure of the relay contacts **97** and **123**. The contact **123** is connected through conductor **124**, terminal **125**, conductor **126**, with the line side of a minimum temperature switch or "hold fire" switch **127**, whose ground side is connected through the conductors **128** and **102** with the line side of the draft control motor **103**.

The switch **127** may be a conventional type of minimum temperature switch having a thermal element in the tube **21** and responsive to the temperature of the water therein which varies quickly responsively to changes in the temperature in the fuel bed zone adjacent thereto. Hence when the fuel bed becomes cool at the level of the tube **21** the temperature of the water in the tube **21** falls below the temperature for which the switch **127** is set. The latter is thereby closed and current is supplied therethrough to the draft control motor **103** to supply draft to the fire until the fire is revived in the zone of the tube **21** sufficiently to heat the water in the tube **21** to a high enough temperature to cause the switch **127** to open and break the circuit.

The terminal **123** is also connected through a conductor **130** with one side of a Mercoid switch **106'**, whose other side is connected, through the conductor **131**, terminal **132**, conductor **109**, terminal **110**, and conductor **111** with the line side of the motor **68** for shaking the wall **31**.

The Mercoid switch **106'** is similar to the Mercoid switch **106** and is mounted on a spring biased tilting frame **106a'** having an adjustable nose **106b'** projecting into the path of the adjustable long trip pin **116** on the disk **113** of the timer **117**. Since the nose **106b'** is not engaged by the shorter trip pins **114** and **115**, the tube **106'** is tilted only one-third as often as the tube **106**. Hence the wall **31** is shaken only one-third as often when the relay contacts **97** and **123** are closed as when the relay contacts **97** and **98** are closed.

It will further be noted that the shaking of the wall under control of the switch **106** is directly related to and dependent upon maintenance of the draft through closure of the circuit through the control motor **103**, whereas the operation of the shaking wall **31** under control of the switch **106'** is independent of the draft and the circuit of the control motor **103**.

Having described my invention, I claim:

1. A furnace containing a fire box enclosing a chamber for burning solid fuel and comprising water cooled sidewalls, a movable grate and walls opposite to each other projecting upwardly from said grate between said sidewalls and having lower portions in close proximity to said grate, said walls confining a burning fuel bed on said grate and each of said opposite walls containing ports for respectively supplying air to burning fuel on said grate and permitting the discharge of gaseous products of combustion therefrom, said opposite walls each containing water circulating passages communicating with said sidewalls, one of said opposite walls being movable relatively to the other and to said grate and having a water circulating partition projecting therefrom substantially parallel with and intermediate said sidewalls and across a substantial portion of said chamber to divide it into communicating compartments.

2. A furnace containing a fire box enclosing a chamber for burning solid fuel and comprising water cooled sidewalls, a movable grate, and walls opposite to each other projecting upwardly from said grate between said sidewalls and having lower portions in close proximity to said grate, said walls confining a burning fuel bed on said grate, and each of said opposite walls containing ports and water circulating passages, one of said opposite walls being oscillatable relatively to the other end to the grate about an axis adjacent to the upper portion of said oscillatable wall, said osillatable wall having an inlet communicating with one of said sidewalls and an outlet communicating with the other of said sidewalls adjacent to said axis of oscillation, and said oscillatable wall having a water circulating partition projecting therefrom intermediate said sidewalls and across a substantial portion of said chamber to divide it into communicating compartments.

3. A furnace containing a fire box enclosing a chamber for burning solid fuel and comprising water cooled sidewalls, a movable grate, and walls opposite to each other diverging upwardly from said grate between said sidewalls and having lower portions in close proximity to said grate, said walls confining a burning fuel bed on said grate, and each of said opposite walls containing ports and water circulating passages, one of said opposite walls having a water circulating partition of trapeziform peripheral outline projecting therefrom, with an edge approximately parallel with the other of the opposite walls and dividing said chamber into communicating compartments.

4. A furnace containing a fire box enclosing a chamber for burning solid fuel and comprising water cooled sidewalls, a movable grate and walls diverging upwardly from said grate between said sidewalls and having lower portions thereof adjacent to said grate, one of said diverging walls containing ports and water circulating passages and having a water circulating slice projecting normally from an intermediate portion of said wall and along a major portion of the height thereof and extending therefrom toward and adjacent to the complementary wall.

5. A furnace containing a fire box forming a fuel chamber and having a movable wall and a grate, a slice movable beneath said wall into said

fuel chamber, and linkage connecting said slice and wall so that the rate of movement of said slice is different from the rate of movement of said wall, said linkage including a pivoted arm connected with said slice and a link pivotally connected with said wall and arm at different distances from the pivot of said arm.

6. A furnace containing a fire box forming a fuel chamber and having a grate and a water-cooled wall oscillatable about an axis, a slice extending vertically and along a major portion of said wall and movable thereby in said fire box, and a second slice normally lying adjacent to a point of juncture between the bottom of said wall and said grate, and mechanism for moving said second named slice across said grate below said first named slice and transversely thereto.

7. A furnace containing a fire box having a grate, a water-cooled wall oscillatable about an axis over said grate and having its lower edge in juxtaposition to said grate, a water-cooled upright partition projecting into said fire box transversely to the axis of said wall and extending across a major portion of said fire box, a slice having a bar substantially parallel to said axis and normally positioned adjacent to the juncture between said wall and grate, mechanism for moving said bar across said fire box beneath said partition and in a plane in close juxtaposition to said grate to scrape from the fire box ashes below the plane of movement of said partition.

8. A furnace containing a fire box having hollow end walls provided with sleeves containing radial apertures communicating with the interiors of said end walls, a movable wall between said end walls and having radially apertured trunnions housed in said sleeves, and sealing means between said sleeves and trunnions and bounding passages through which said trunnion apertures communicate with said sleeve apertures.

9. A furnace containing a fire box having a grate and an oscillatory side wall, slice mechanism comprising a slice bar normally positioned adjacent to the bottom of said wall and above said grate, an oscillatory hanger movable about an axis and supporting an end of said slice mechanism, a coupling pivotally connected with the lower portion of said wall and pivotally connected with said hanger between its axis and said end of said slice mechanism; the movement of said wall effecting the movement of said coupling and hanger to move said slice.

10. A furnace containing a fire box having a tilting grate and an oscillatable wall, a slice normally disposed adjacent to the bottom of said movable wall and movable across said grate, a pivotally supported hanger pivotally connected with said slice and moving it across said grate, a link pivotally connected with said wall and with said hanger between its connection with the slice and its pivotal support.

11. A furnace containing a fire box forming a combustion chamber and having a grate forming a fuel support, a wall for said combustion chamber having its lower portion adjacent to said grate and containing gas ports, said grate being tiltable about an axis adjacent to the lower portion of said wall, a water-cooled wall for said combustion chamber oscillatable on an axis parallel with said axis first named and having its lower edge adjacent to said grate and spaced substantially the width of the grate from said axis first named, said second named wall containing air supply ports, and means including a motor operably connected with said second named wall for moving it across said grate for compressing fuel in the combustion chamber during combustion thereof.

12. A furnace having a fire box, a counterweighted tilting grate at the bottom of said fire box, a hopper discharging fuel to said box to maintain a fuel bed therein, said box having a water circulating wall containing air supply openings for supplying air for combustion of said fuel bed, and means including a motor for rapidly and repeatedly squeezing and releasing a burning fuel bed in said box throughout a major portion of the depth of said burning bed to unify the density thereof.

13. A furnace having a fire box having water walls and a series of water circulating tubes extending across the fire box and communicating with the interiors of said walls, one of said tubes having a more restrictive orifice than the others and retarding flow through said tube to render the water therein more responsive than the water in said walls to the temperature of said fire box, and combustion control mechanism having a thermal element responsive to the temperature of the water of said tube.

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