S. A. REEVE & E. P. NOYES.

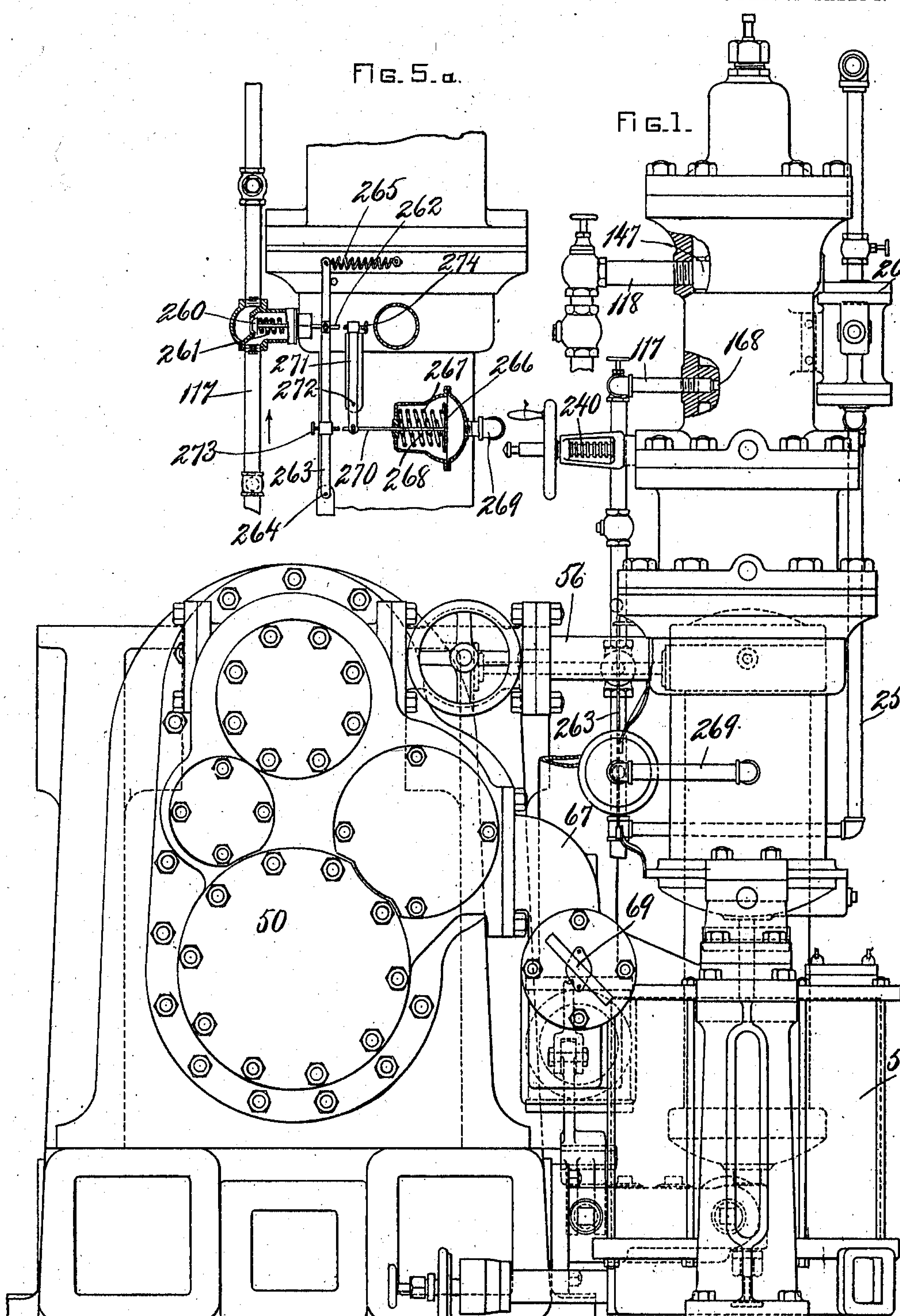
GENERATING APPARATUS.

APPLICATION FILED MAY 1, 1902.

982,871.

Patented Jan. 31, 1911.

8 SHEETS—SHEET 1.



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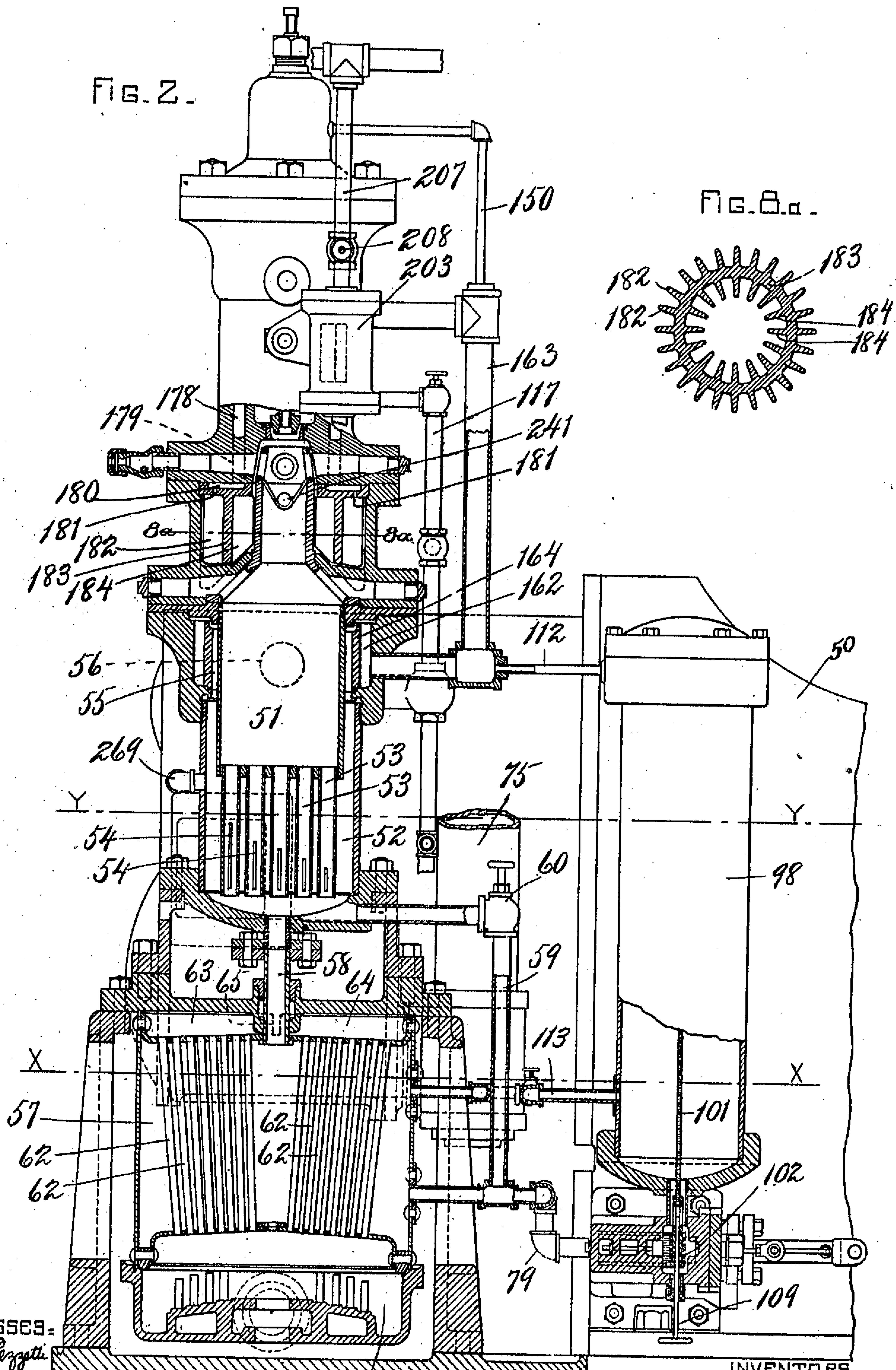
8 SHEETS—SHEET 2.

FIG. 2.



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8 SHEETS—SHEET 3.

FIG. 5.

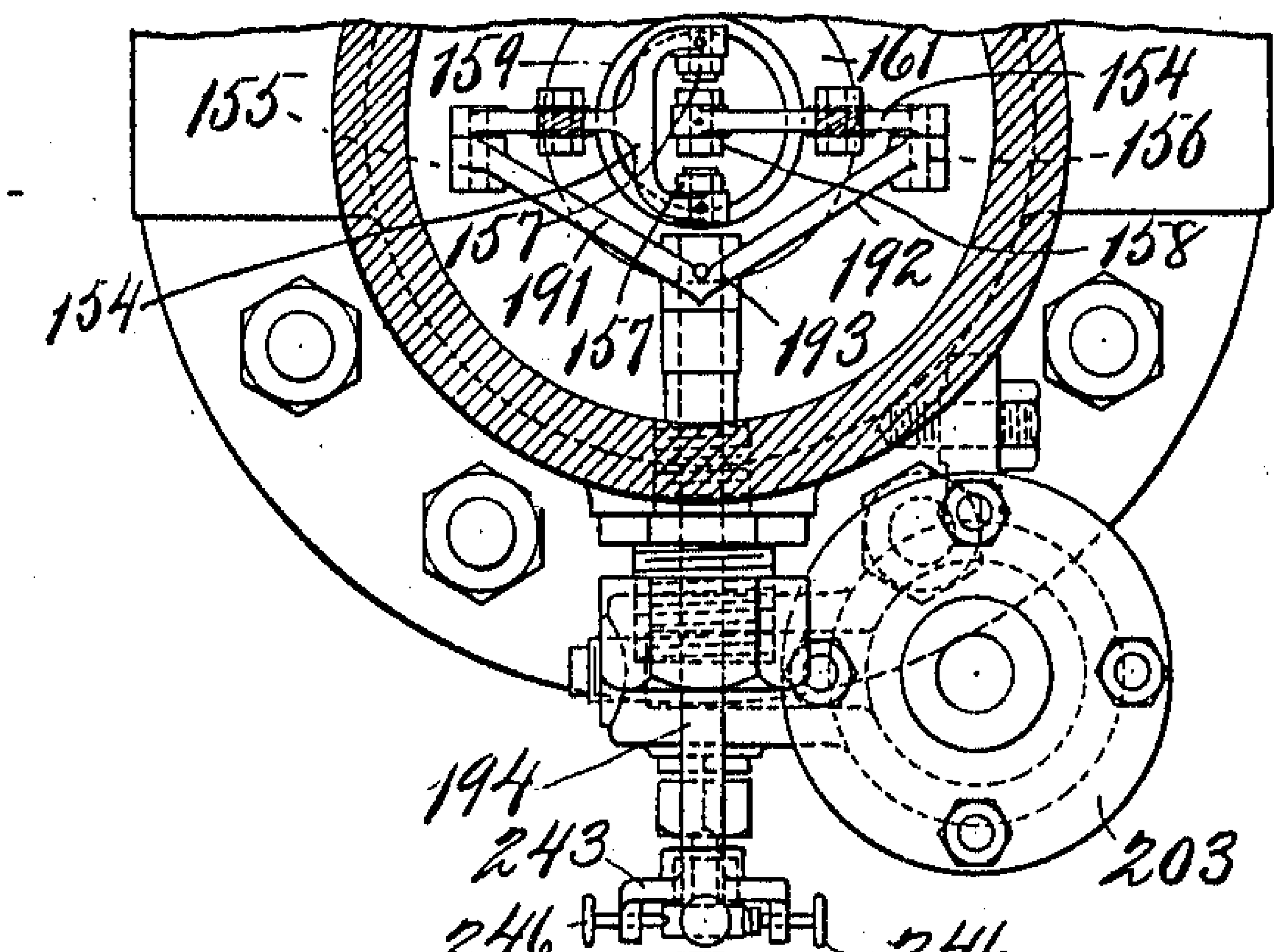


FIG. 3.

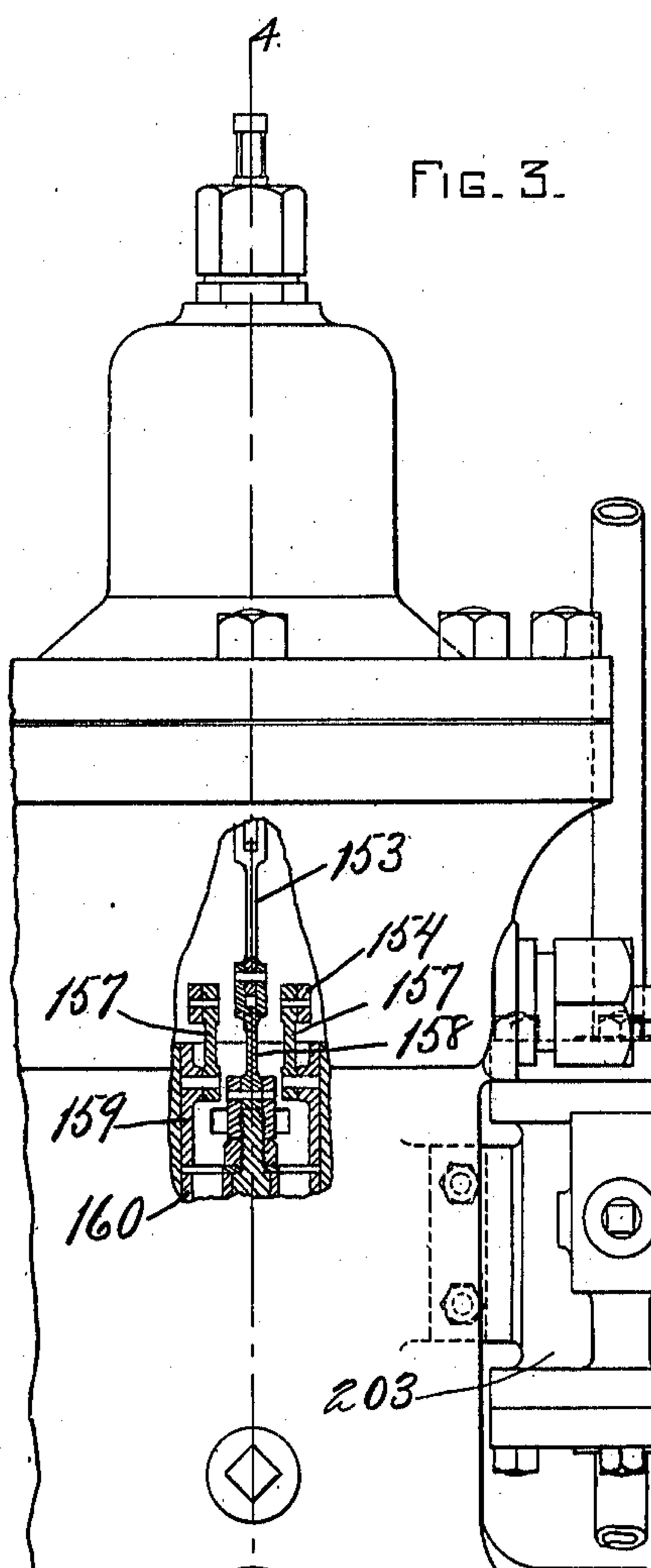
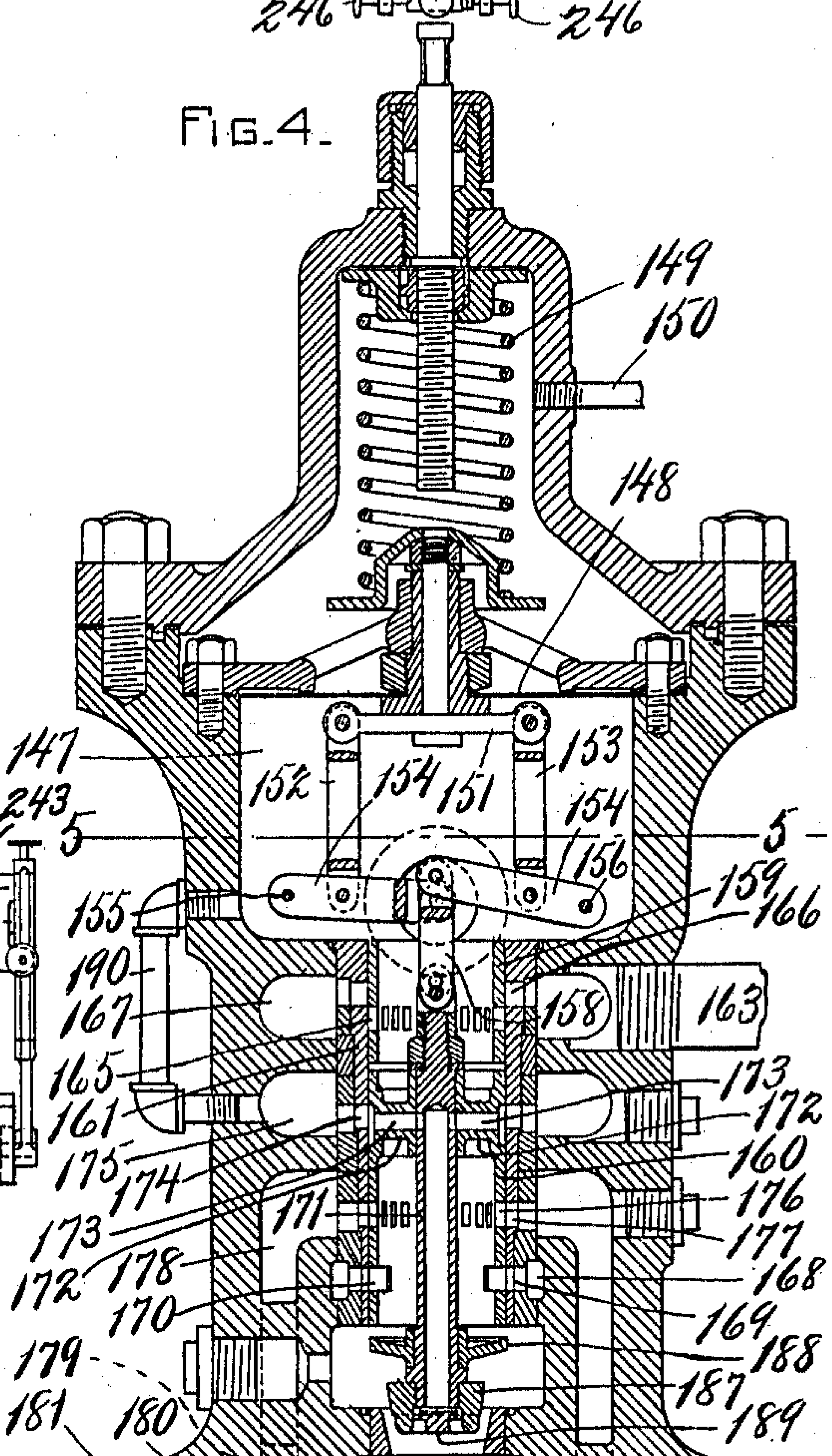


FIG. 4.



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8 SHEETS—SHEET 4.

FIG. 8.

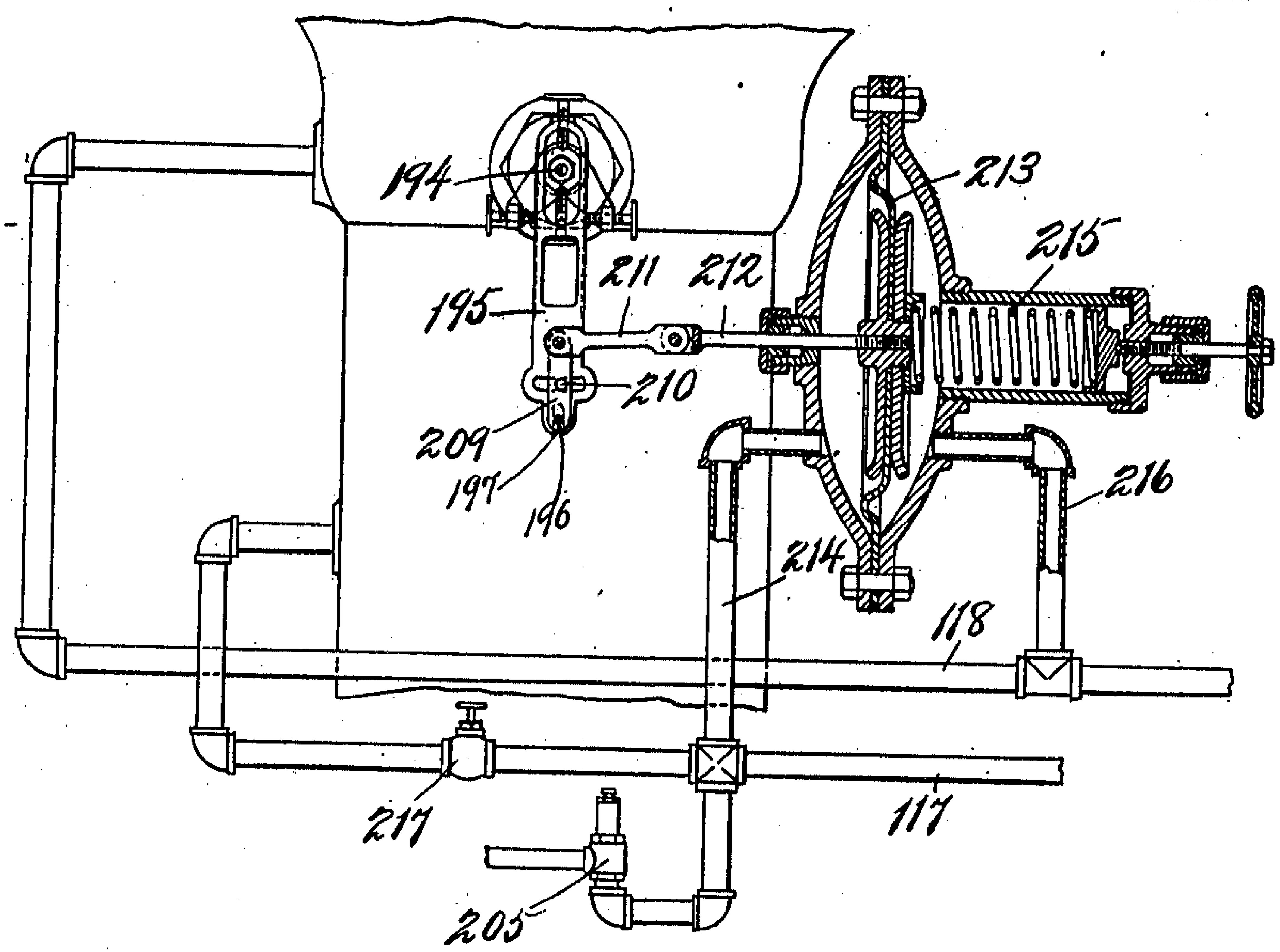


FIG. 7.

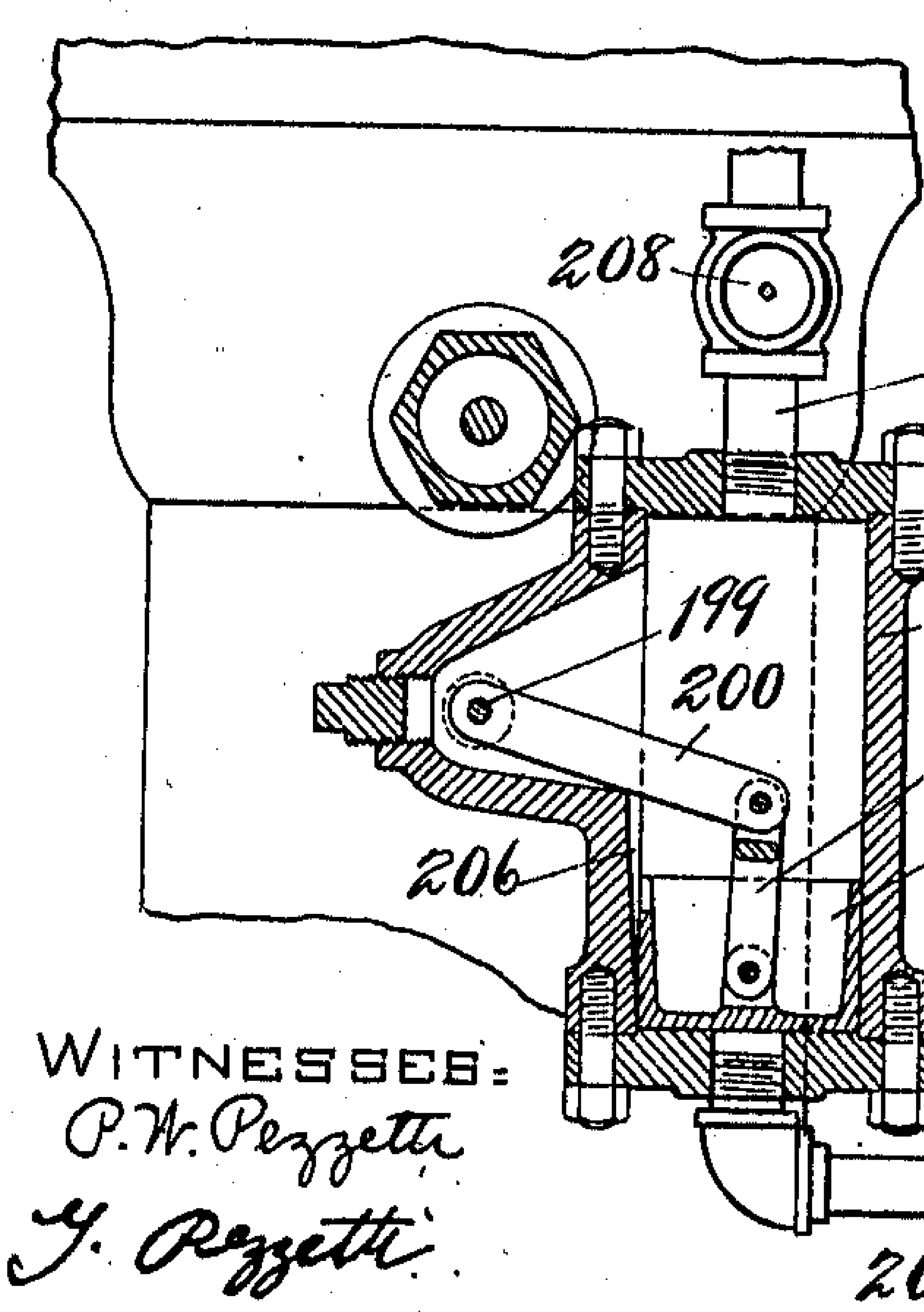
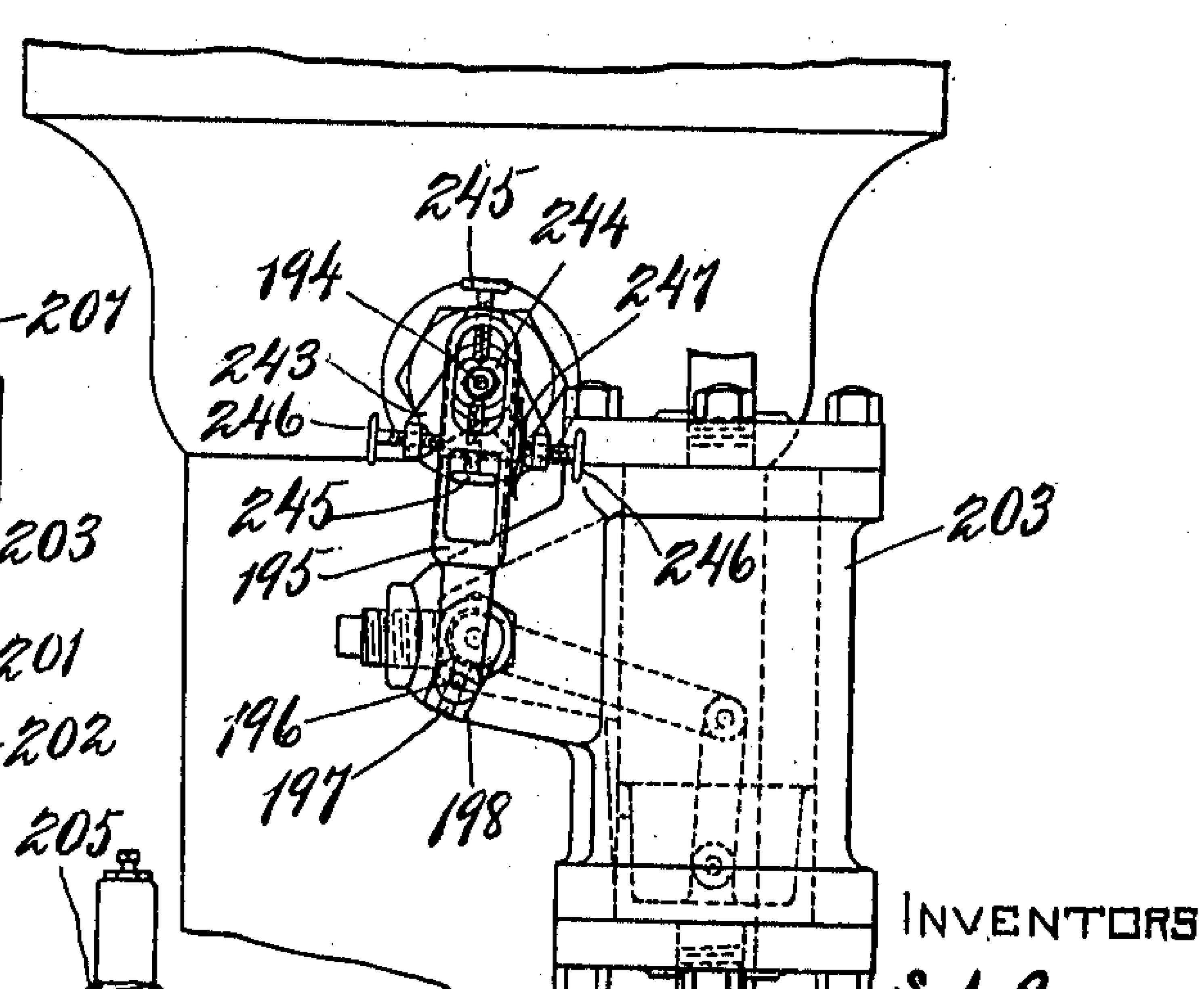


FIG. 6.



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8 SHEETS—SHEET 5.

FIG. 10.

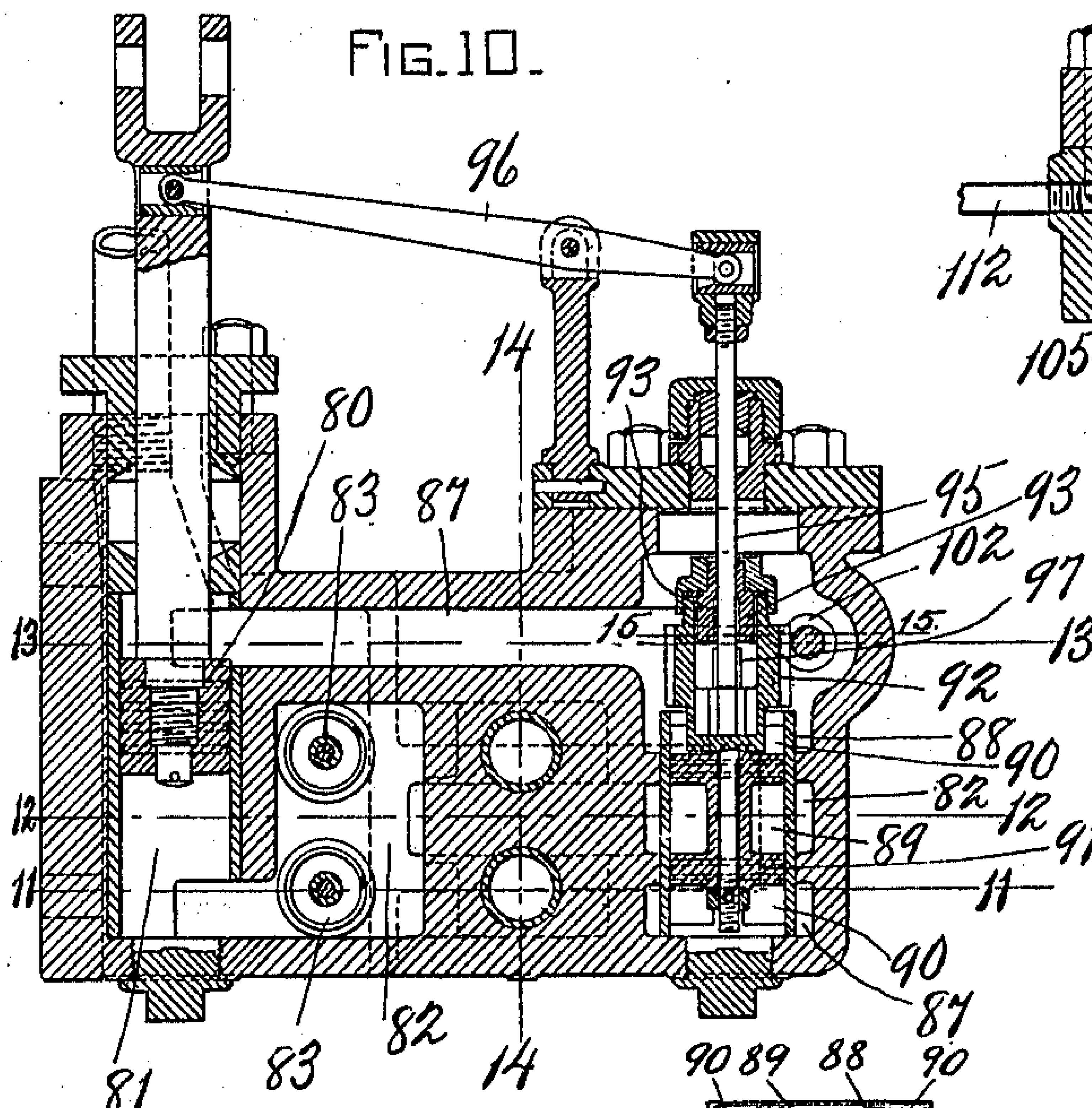


FIG. 9.

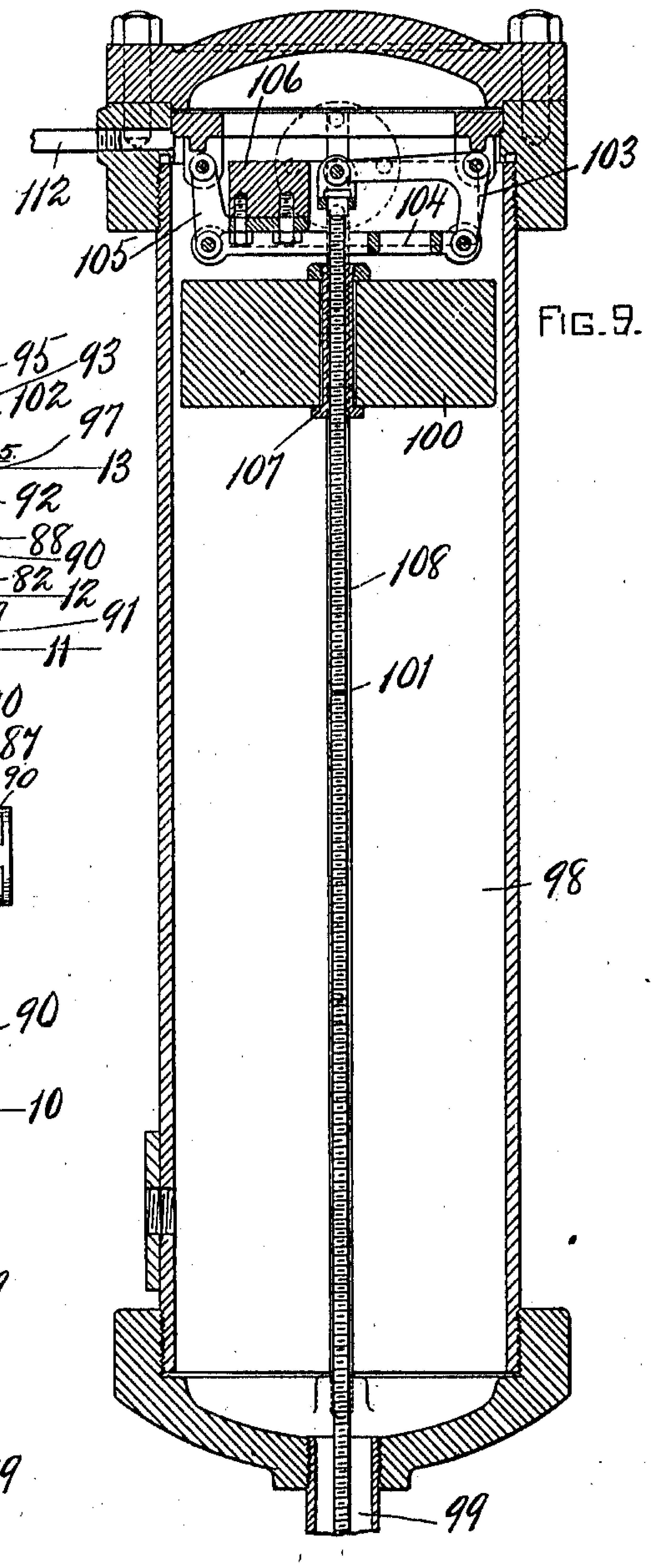


FIG. 16.

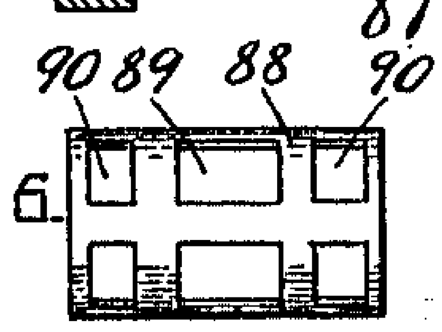


FIG. 11.

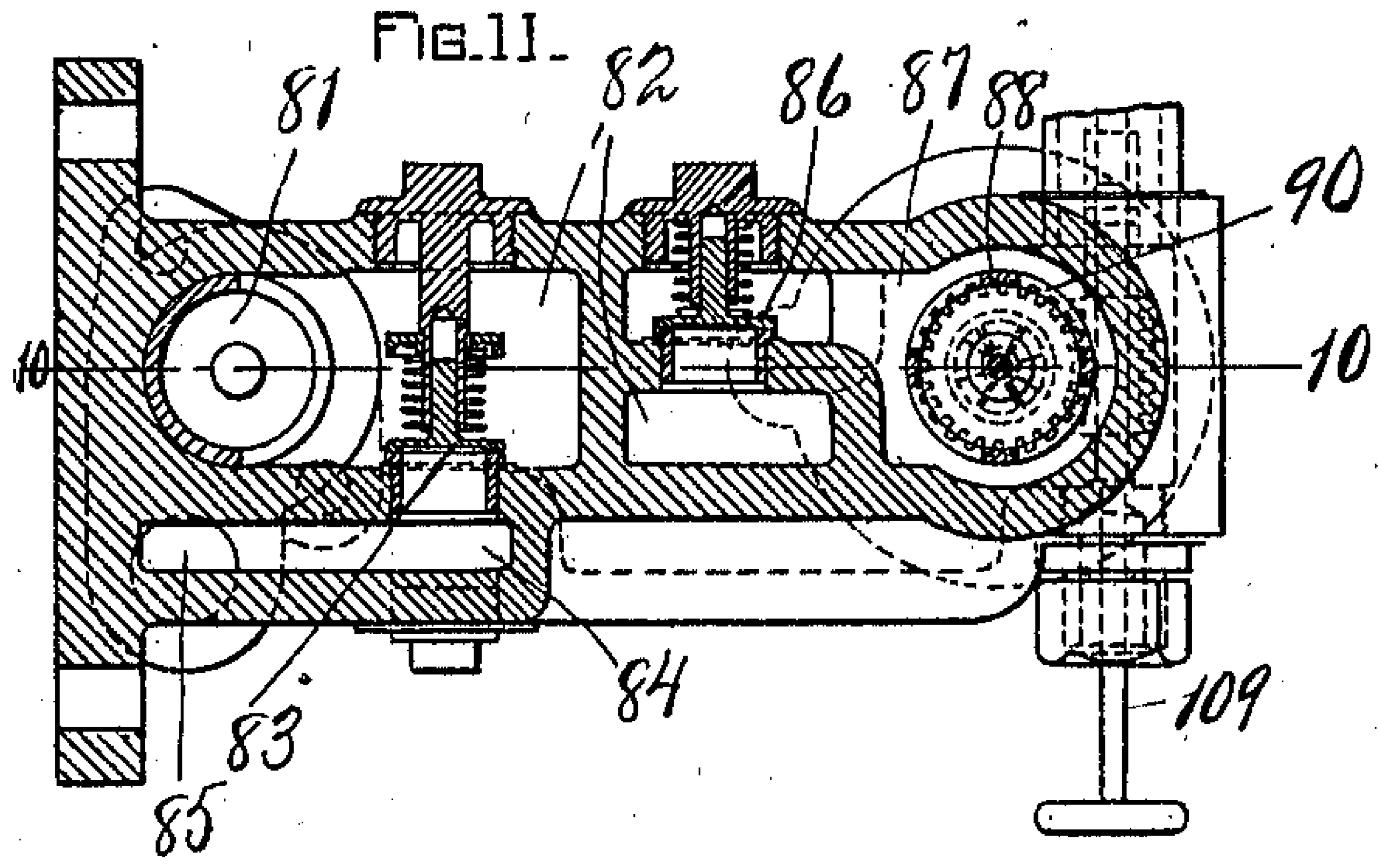


FIG. 12.

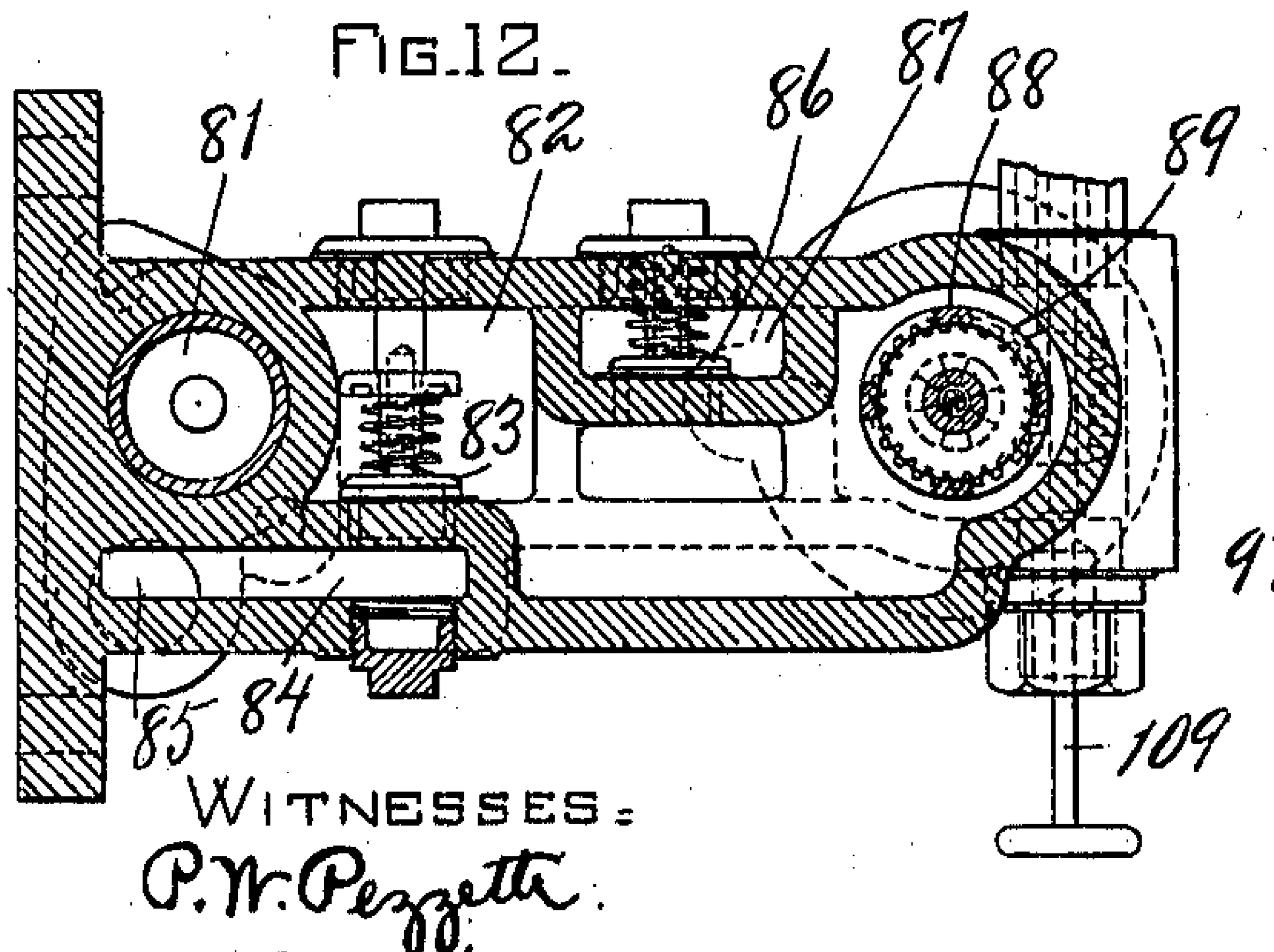
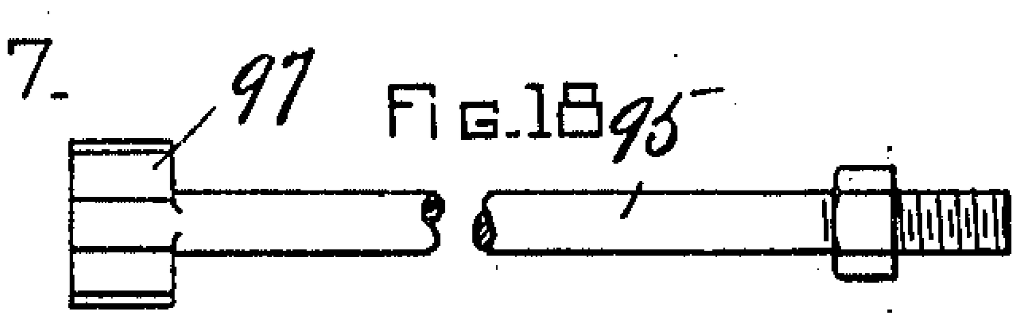


FIG. 17.

FIG. 18.



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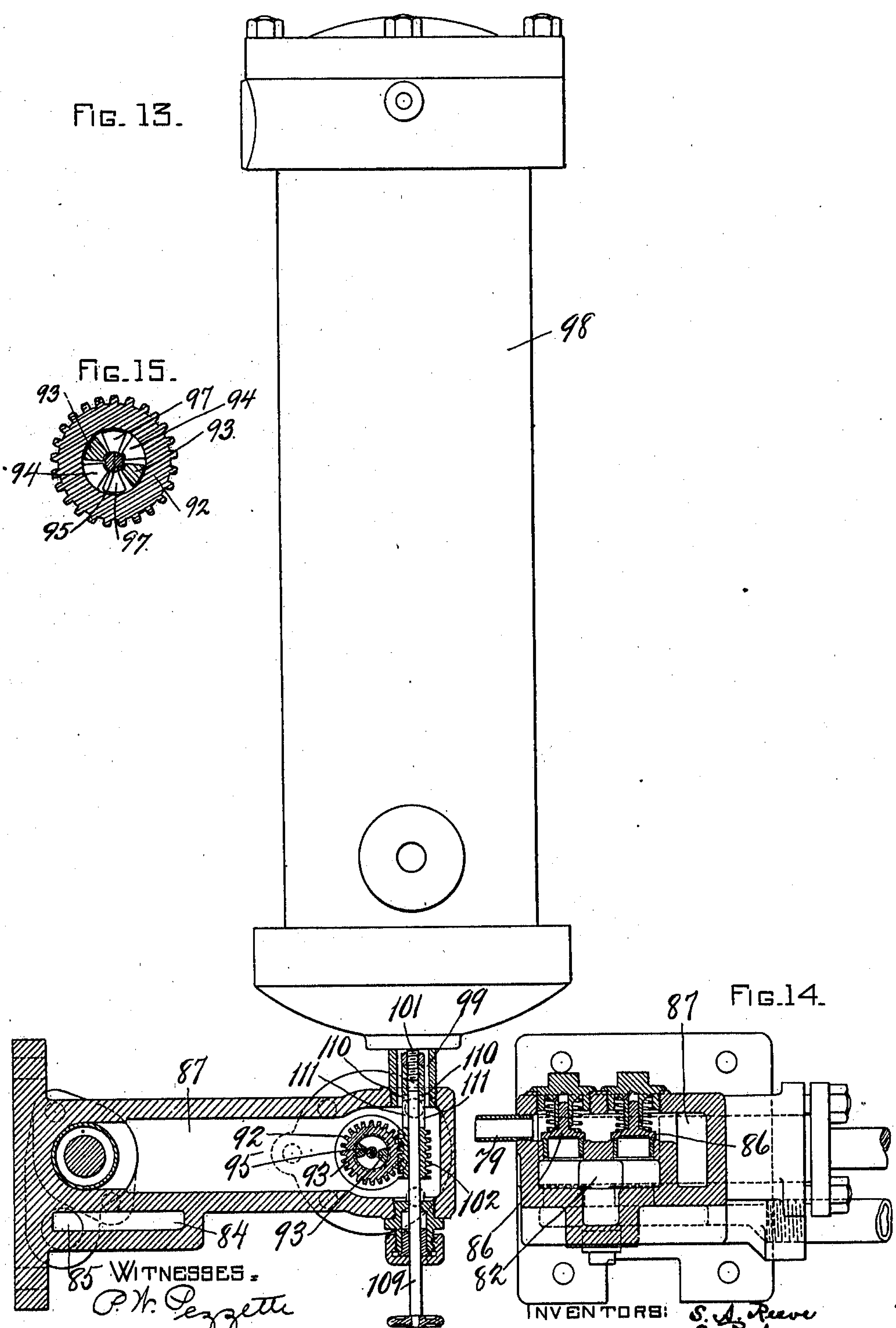
8 SHEETS—SHEET 6.



WITNESSES: P. W. Pezzetti, George Pezzetti

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GENERATING APPARATUS.

APPLICATION FILED MAY 1, 1902.

982,871. Patented Jan. 31, 1911.

8 SHEETS—SHEET 7.

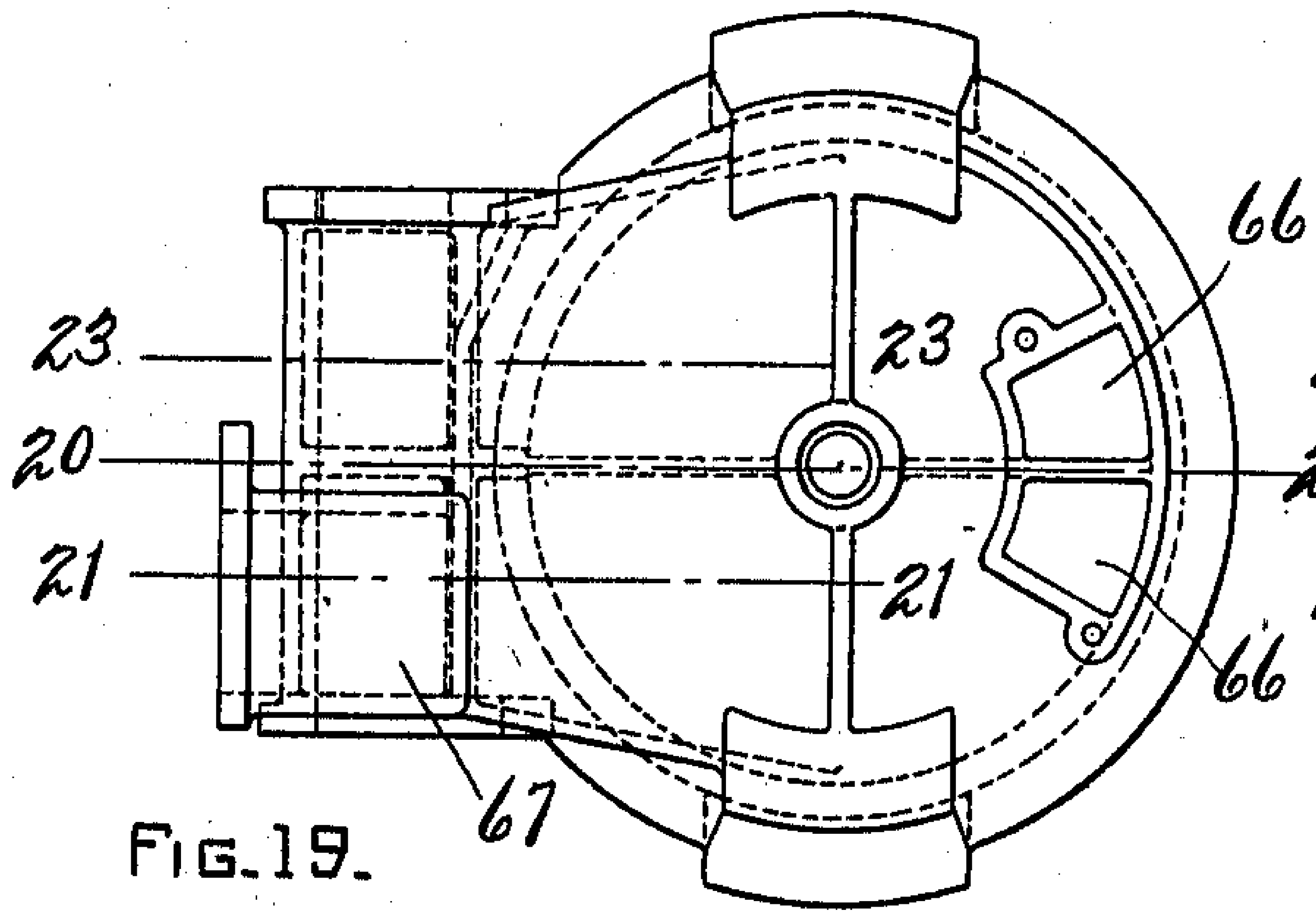


Fig. 19.

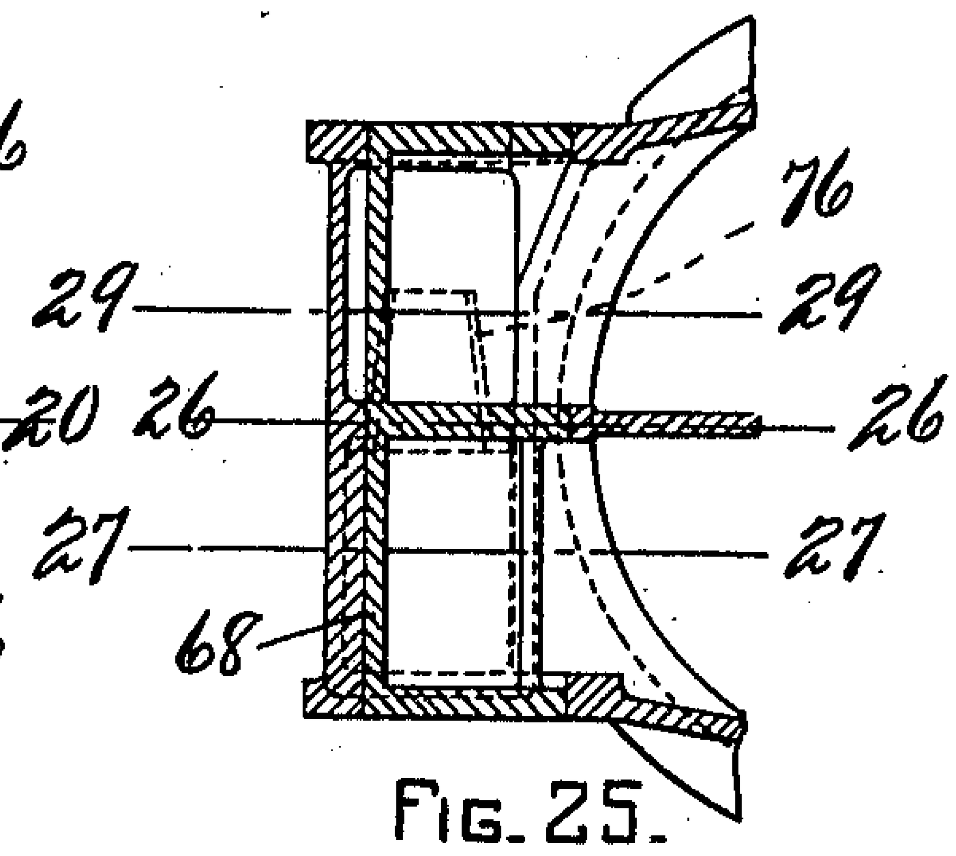


Fig. 25.

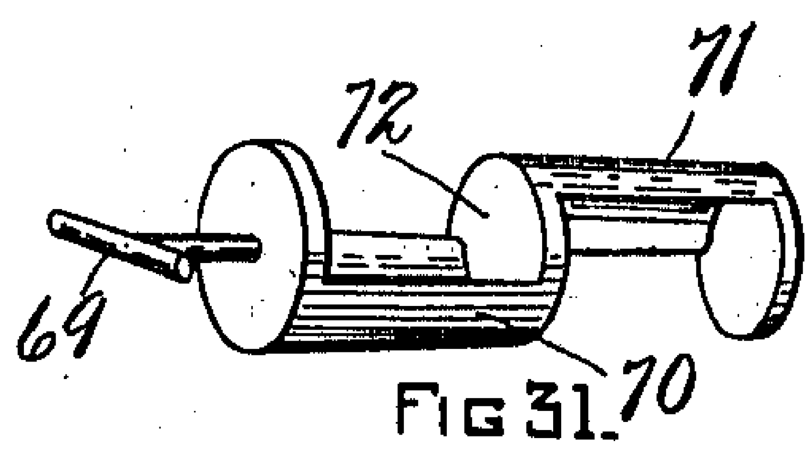


Fig 31.

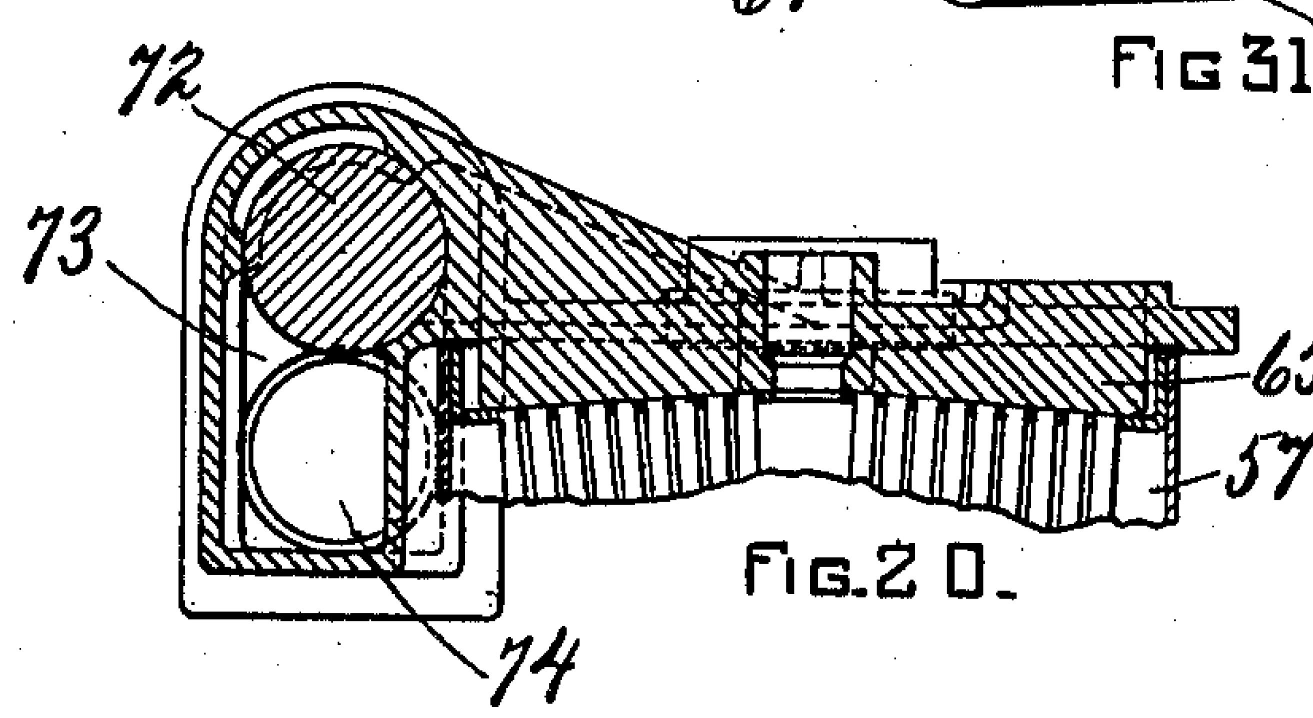


Fig. 20.

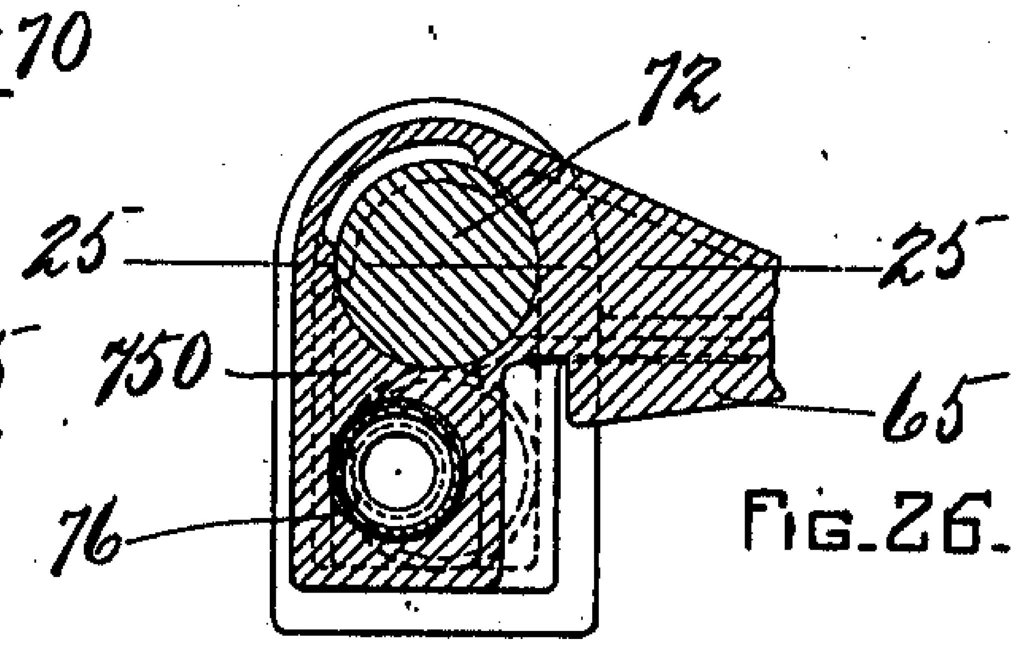


Fig. 26.

Fig. 21.

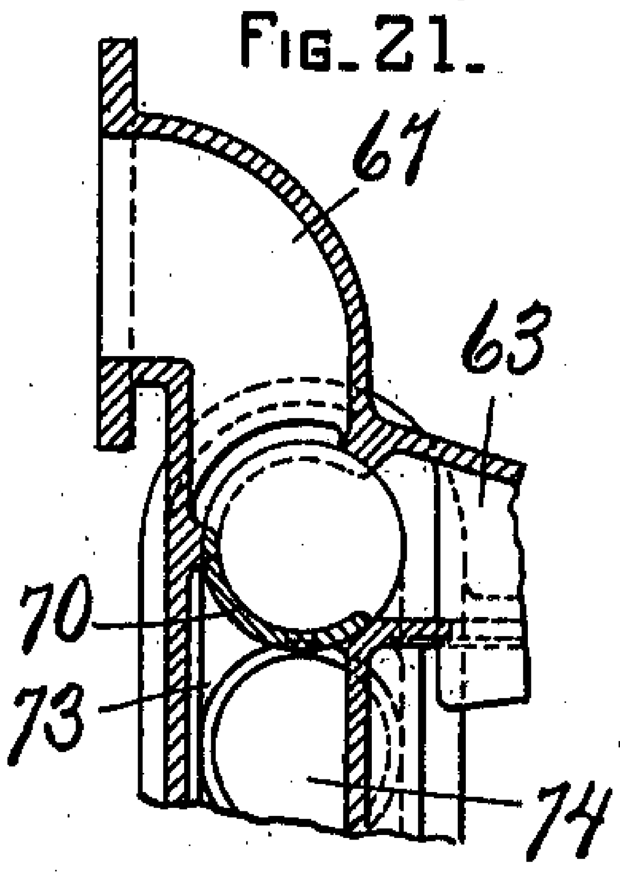


Fig. 22.

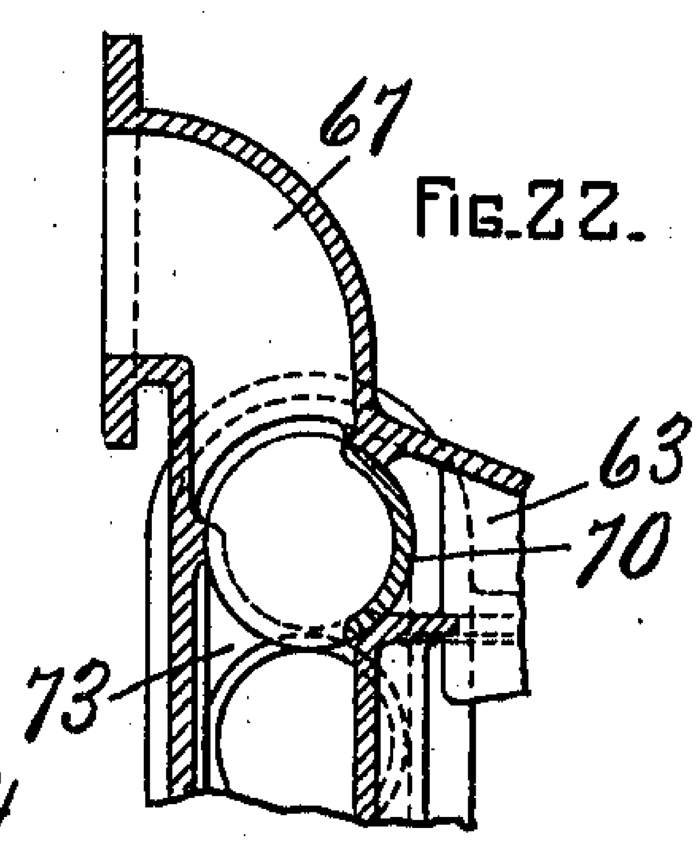


Fig. 27.

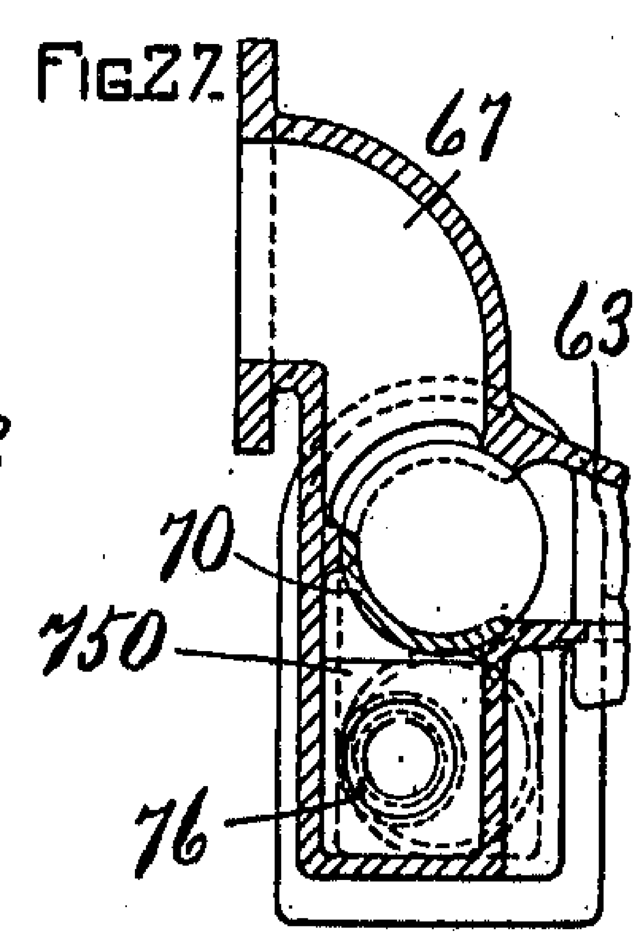


Fig. 28.

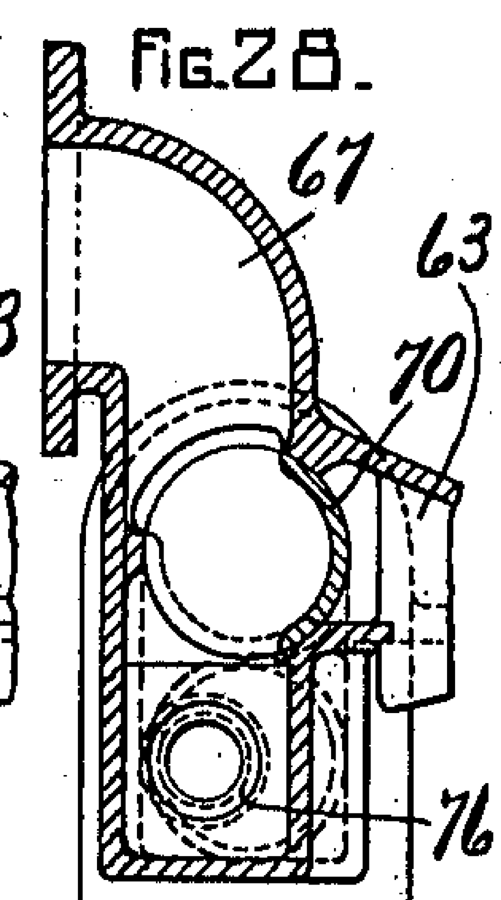


Fig. 23.

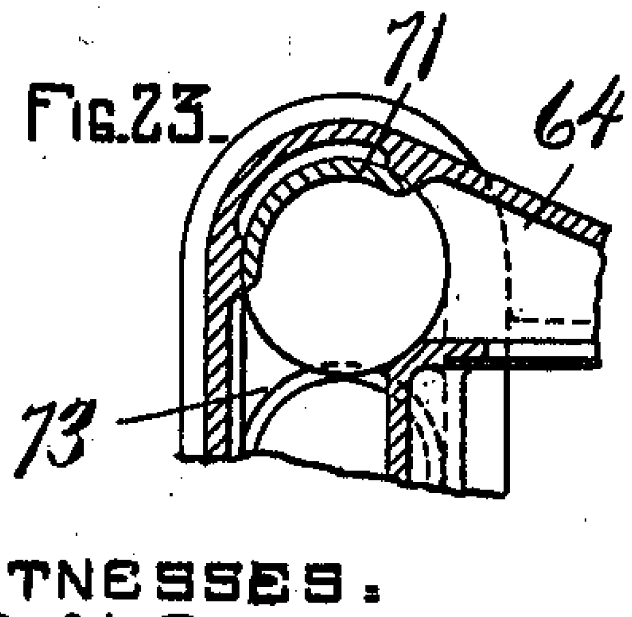
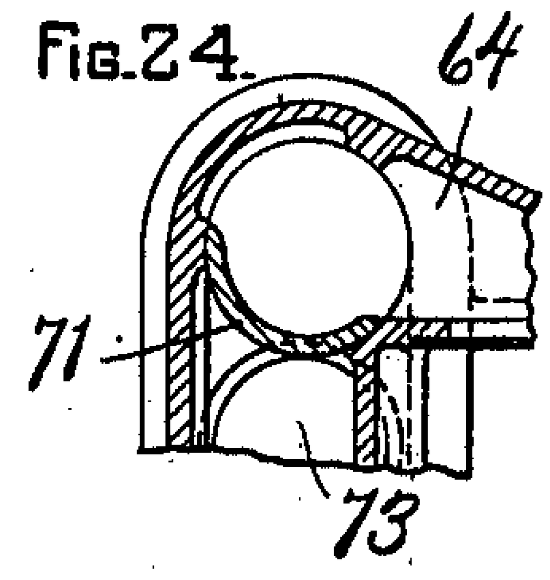


Fig. 24.



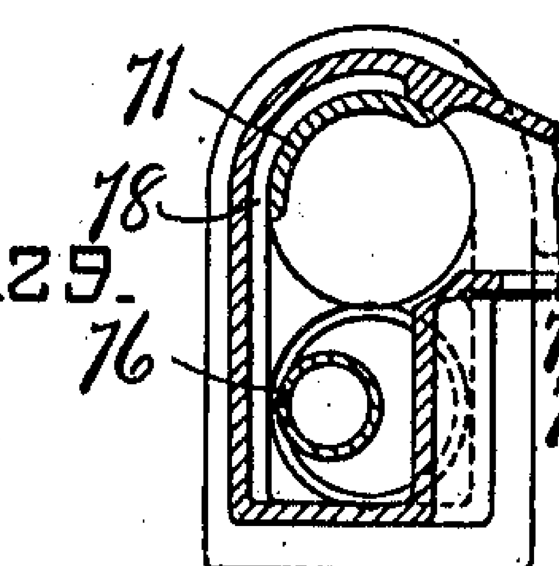


Fig. 29.

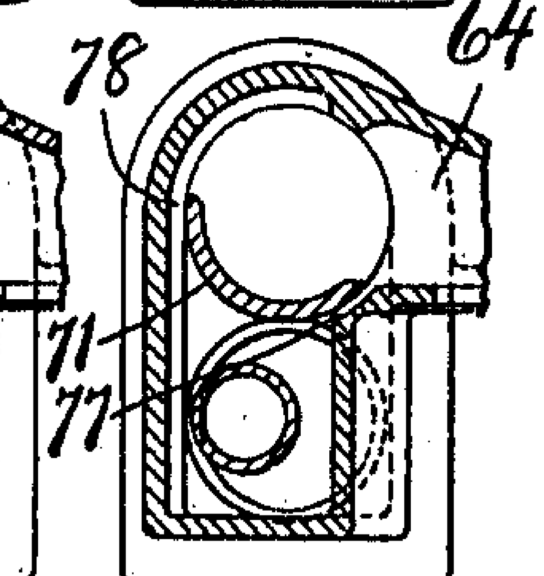


Fig. 30.

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GENERATING APPARATUS.

APPLICATION FILED MAY 1, 1902.

982,871. **Patented Jan. 31, 1911.**

8 SHEETS—SHEET 8.

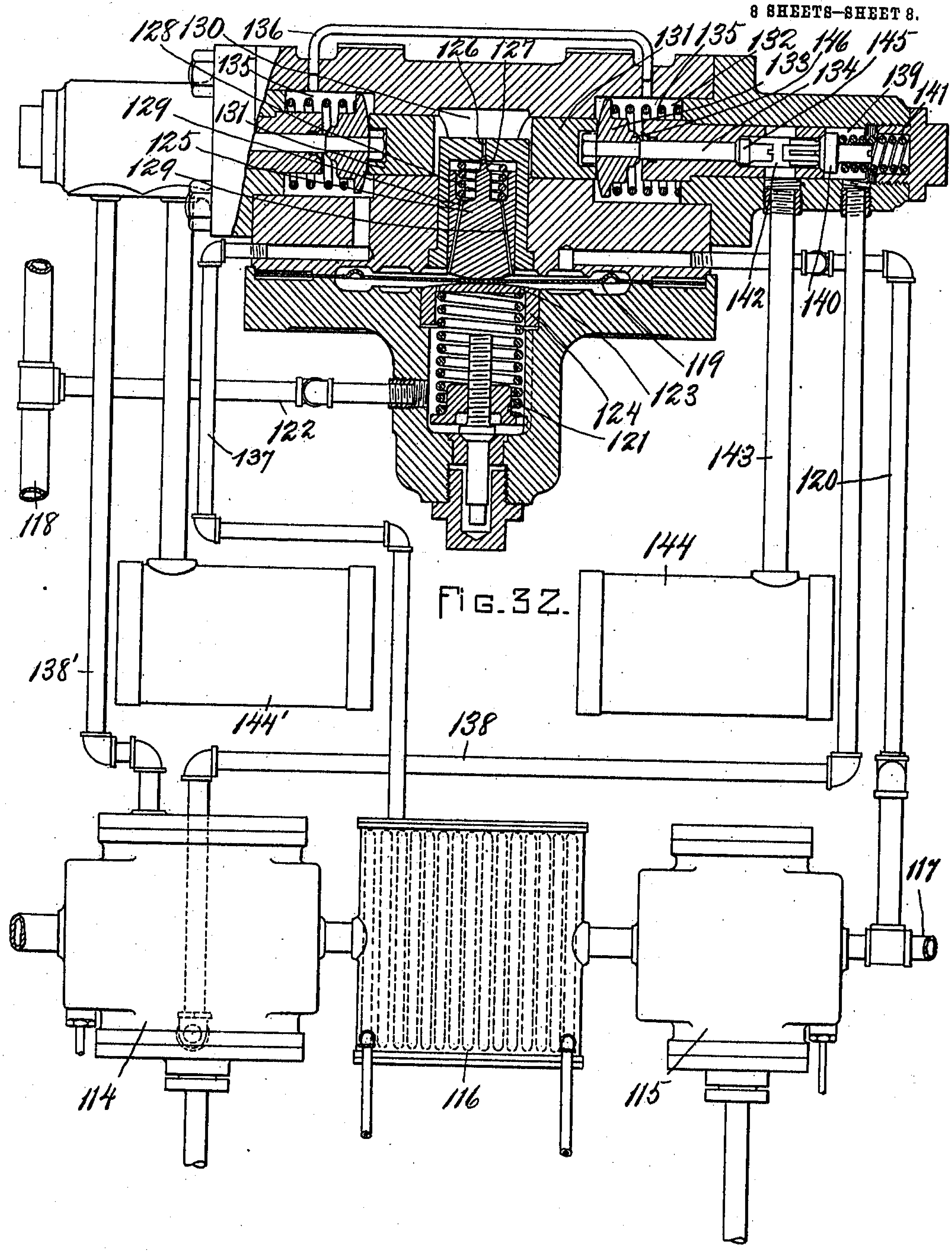

FIG. 32.

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UNITED STATES PATENT OFFICE.

SIDNEY A. REEVE, OF WORCESTER, AND EDWARD P. NOYES, OF WINCHESTER, MASSACHUSETTS, ASSIGNORS, BY MESNE ASSIGNMENTS, TO C. P. POWER COMPANY, OF NEWARK, NEW JERSEY, A CORPORATION OF NEW JERSEY.

GENERATING APPARATUS.

982,871. Specification of Letters Patent. Patented Jan. 31, 1911.

Application filed May 1, 1902. Serial No. 105,490.

To all whom it may concern:

Be it known that we, SIDNEY A. REEVE and EDWARD P. NOYES, respectively of Worcester, in the county of Worcester and State of Massachusetts, and of Winchester, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Generating Apparatus, of which the following is a specification.

This invention principally relates to internal-combustion motor apparatus in which air and fuel are burned continuously under constant pressure (as distinguished from constant-volume or explosive combustion) in a closed combustion-chamber and the products of combustion quenched with water to create a working mixture of steam and burned gases which may be employed to drive motors of the steam-engine type.

Our invention deals with the following matters in connection with such a system.

First, it provides improved means for regulating the relative quantities of air and fuel participating in the combustion, for which purpose we have devised a novel resistance and air by-pass mechanism whereby an axial by-pass movement is superimposed upon an axial resistance-varying movement of certain valve-mechanism, and a further improvement whereby the volume of one of the fluids, such as compressed fuel-gas, is caused to control the other combustion-fluid, for example, by by-passing a quantity of air around the burner proportionate to a quantity of gas released past a loaded valve to the suction of the fuel pump.

Secondly, our invention furnishes a novel means for regulating the relative performance of the air and fuel compressors by controlling the cylinder-clearance of one of them through the pressure of its fluid released by a pressure-balance mechanism.

Thirdly, it provides improved auxiliary steam-boiler devices for starting by steam pressure and then using the auxiliary boiler as a feed-heater for the water-chamber of the main generator.

Fourthly, our invention includes novel means for automatically preserving an adjustable constant level of water in the generator and auxiliary boiler and establishing the normal level in either one at will.

Fifthly, the invention has to do with the construction of the continuous-combustion generator.

Of the accompanying drawings,—Figure 1 represents a rear elevation partly in section and with portions omitted, showing an engine and generating apparatus constructed in accordance with our invention. Fig. 2 represents a side elevation of the apparatus with the generator and feed-water regulator mainly in vertical section. Fig. 3 represents a rear elevation on an enlarged scale and partly broken away, showing the upper part of the generator. Fig. 4 represents a vertical sectional view of the upper part of the generator taken on the line 4—4 of Fig. 3. Fig. 5 represents a section on line 5—5 of Fig. 4. Fig. 5ª represents a side elevation partly in section, of the mechanism for stopping the flow of fuel upon extreme variations in the generator pressure. Fig. 6 represents a side elevation of the device for moving the fulcrums of the levers in the generator-head. Fig. 7 represents a vertical sectional view of this device. Fig. 8 represents a sectional view showing a modified form of device for this purpose. Fig. 8ª represents a horizontal section of the annular ribbed member surrounding the combustion chamber. Fig. 9 represents a vertical sectional view of the float-chamber. Fig. 10 represents a horizontal section of the pump and feed-water controller. Figs. 11, 12, 13, 14, and 15 represent sections on the correspondingly-numbered lines of Fig. 10. Fig. 16 represents a detail side elevation of the sleeve for the piston-valve in the controller. Figs. 17 and 18 represent end and side views of the actuating stem in the controller. Fig. 19 represents a top plan view of the boiler and exhaust controlling mechanism. Fig. 20 represents a section on line 20—20 of Fig. 19. Figs. 21 and 22 represent sections on line 21—21 of Fig. 19, showing the exhaust-controlling valve member in two different positions. Figs. 23 and 24 represent sections on line 23—23 of Fig. 19 with said valve member in its two positions. Fig. 25 represents a horizontal section showing a modification of the exhaust controlling mechanism. Fig. 26 represents a section on line 26—26 of Fig. 25. Figs. 27 to 30 inclusive, represent sections corresponding to Figs. 21 to 24 inclusive, showing two different positions of the valve member in this modification. Fig. 31 represents a detail perspective view of the valve member. Fig. 32 represents a sectional and diagrammatic view, showing the mechanism for maintaining the air and gas pressures in a predetermined relationship.

The same reference characters indicate the same parts in all the figures.

In the drawings,—50 represents a motor which may be an ordinary steam-engine or any motor adapted to be operated by an expansible fluid used after the manner of steam. 51 is a combustion chamber having an enlarged lower part and a contracted upper part, as seen in Fig. 2.

52 is a cooling chamber adapted to contain a body of water which immerses the lower ends of a series of tubes 53 53 projecting downwardly from the combustion chamber and formed with slots 54 54 whose upper ends terminate at different heights so that the products of combustion passing through different tubes may pass through a greater or less depth of water or over the surface of the water. These tubes give a maximum amount of conductive and evaporative surface. The annular space 55 surrounding the upper part of the enlarged portion of combustion chamber 51 constitutes a superheating chamber into which the quenched products of combustion and steam rise from the cooling chamber 52, thereby becoming reheated and jacketing and keeping down the temperature of the walls of the combustion chamber. From the superheating chamber 55 the steam and products of combustion pass out through the engine pipe 56 to the engine. This pipe leads from an annular space 162 which connects with the superheating chamber 55 over the upper edge of an annular dike 164. The latter surrounds the upper part of the combustion chamber 51 and extends substantially as high as the enlarged lower part thereof, its object being to maintain the outflow from the cooling chamber in contact with this part of the combustion chamber throughout the upper part of its length, thus utilizing all this part of the surface of said portion above the water-level as reheating surface for the steam and gases and protecting said part from overheating.

Gas and air are supplied in definite proportions to the upper part of the combustion chamber 51 through pipes 117 118 from suitable compressors driven from the engine. The air-compressing means being a well-known feature of apparatus of this kind, is not shown. The gas-compressing apparatus is indicated at 114 115 in Fig. 32 and will be hereinafter more fully referred to. The gas and air are ignited and their products of combustion pass downwardly through the tubes 53 and up through or over the water in cooling chamber 52, thereby reducing the temperature of the gases to a stable point and creating a quantity of steam. Ignition is initially effected by an igniter indicated at 240 in Fig. 1, and if interrupted for any brief period during the operation of the apparatus, is again effected upon renewal of the flow of combustion fluids, by the hot walls of the combustion chamber, which may be of fire clay, or by a ball 241 of fire clay (Fig. 2) placed just below the point of introduction of the combustion fluids.

Below the cooling chamber 52 is arranged a boiler or steam generator 57 adapted both for use in starting the apparatus, at which time the boiler supplies the steam engine temporarily after the manner of an ordinary boiler, and for use as a feed-water heater during the normal running of the apparatus. This boiler is connected with the cooling chamber 52 through a contracted conduit 58. 59 is an outside downtake conduit connecting the cooling chamber 52 with the boiler 57 and having a stop-valve 60. A burner 61 is provided for heating the boiler 57, and the products of combustion from this burner pass upwardly through two sets of flues 62 62 to two chambers 63 64 at the upper end of the boiler, separated by a partition 65, and from thence they pass to the atmosphere through outlets 66 66 (Fig. 19).

In effecting a start steam is raised in the boiler 57 by means of the burner 61 and is utilized to run the engine until the air and gas compressors connected with the engine have raised the air and gas pressure above the falling steam pressure, after which air and gas are admitted to the combustion chamber and ignited and the apparatus then operated in a normal manner. After a start has been effected the action of the burner 61 may be discontinued and the boiler 57 used as a feed-water heater heated by the exhaust from the engine, or the boiler may be continued in action. Apparatus to direct the engine exhaust through the heating passages of the boiler 57 or divert it away from the boiler is shown in Figs. 19 to 31 inclusive.

Referring at first to Figs. 19 to 24 and Fig. 31, and also to Fig. 1, 67 represents the exhaust pipe of the engine connecting with one half of a cylindrical chamber or bearing containing a rotary valve member 68. This member has a handle 69 to rotate it by hand and is formed with two valve portions 70 71 connected by a transverse web or partition 72 which coincides with the partition 65. Below the valve member 68 is an open space 73 of the full length of the valve, from which there is an exhaust outlet 74 connecting with an exhaust pipe 75 (Fig. 2). The valve member 68 has one position, shown in Figs. 21 and 23, in which its valve portion 70 shuts off the exhaust pipe 67 from the chamber 73 and connects it with the chamber 63, while its valve portion 71 opens the chamber 73 to the chamber 64. Thus it will be seen that the exhaust is compelled to pass downwardly through one group of flues 62, across through the boiler combustion chamber above the burner 61, up through the other group of flues 62 and out through the outlet 74. In the other position of the valve member 68, its valve portion 70 shuts off the exhaust pipe 67 from the chamber 63 and connects said exhaust pipe with the chamber 73, while its valve portion 71 shuts off the chamber 64 from the chamber 73. Thus in this position of the valve member the exhaust passes directly to the outlet 74.

Figs. 25 to 30 represent a modification in which the valve member 68 is constructed and operated as in the foregoing description. The chamber below the valve member, however, is divided in halves by a partition 750 in which is placed an ejector nozzle 76. The seat of the valve member 68 is cut away at 77 and 78 so as to afford a communication between the chamber 64 and the chamber in which the nose of the nozzle 76 is located. When the valve member 68 is turned as shown in Figs. 28 and 30, to afford a direct outlet for the exhaust, the exhaust is admitted to the rear of the nozzle 76 and passing therethrough as a jet it sucks the products of combustion of the burner 61 through the chamber 64 and discharges them through the outlet 74. The natural draft outlets 66 may then if desired be closed. Feed-water is pumped into the boiler 57 through a delivery pipe 79 by a pump whose piston 80 is operated from the engine. Said piston 80 works in a cylinder 81 having open communication with an intermediate chamber 82. Suction valves 83 allow water to enter this chamber on the suction stroke from a suction chamber 84 having a suction inlet 85. On the forcing stroke of the pump the water is forced from the chamber 82 past discharge valves 86 into a discharge chamber 87 connecting with the delivery pipe 79 (Fig. 14). 88 is a stationary sleeve having middle ports 89 communicating with the intermediate chamber 82 and end ports 90 communicating with the discharge chamber 87. 91 is a balanced by-pass valve fitted to slide in the sleeve 88 and having one position shown in Fig. 10, in which it shuts off communication between the ports 89 90, and another or outward position in which it opens communication between said ports. This valve has a rotatable gear member 92 provided with two sets of abutments 93 94 located in different angular positions on the gear member and also in different positions along its axis. 95 is an actuating stem continuously reciprocated through a rock-lever 96 from the piston-rod of the pump and having abutments 97 adapted to engage either set of abutments 93 94 on the gear member. When the abutments 94 are engaged the valve 91 is brought into closed position by the reciprocation of the stem 95, and when the abutments 93 are engaged the valve is brought into open position. 98 is a float chamber connected with the discharge chamber 87 through a pipe 99 and containing a float 100 mounted on a rod 101 which connects at its lower end with a cylindrical rack 102 meshing with the teeth of the gear member 92. As the float rises and falls the gear member 92 is rotated. The rod 101 and connected parts are counter-balanced by a connection through a bell-crank lever 103 and a horizontally-movable link 104 with a bell-crank lever 105 carrying a weight 106. The rod 101 is screw-threaded throughout its length and engaged with a threaded sleeve or nut 107 on the float 100, which latter is held from rotating by a vertical guide-rod 108. For rotating the rod 101 and thereby adjusting the float 100 vertically, there is provided a rotatable stem 109 accessible from the outside of the apparatus and provided with projections 110 110 (Fig. 13) engaging the sides of slots 111 at the lower end of rod 101, whereby the vertical regulating movement of said rod is permitted. The upper part of the float chamber 98 connects through a pipe 112 with the superheating chamber 55 of the generator and its lower part by the pipe 79 with the boiler 57, so that the water-level is maintained the same in the float chamber 98 and the cooling chamber 52 or boiler 57. Should the water-level fall below the point predetermined by the position of the float 100 on its rod 101 the gear member 92 would be so rotated as to bring its abutments 94 into the path of the abutments 97 on the reciprocating stem 95 so as to close valve 91, thereby causing the feed-water which passes through the discharge valves 86 to enter the boiler 57. As the pump is capable of delivering an excess of feed-water the level rises and the float 100 rotates the gear member 92 until the abutments 97 lie in angular position between the abutments 93 94 or else engage the abutments 93 and open the by-pass valve 91. Should said valve be open the discharge chamber 87 is put into comunication with the intermediate chamber 82 lying between the suction and discharge valves, and the water which is forced out of the intermediate chamber 82 on the forcing stroke of the pump piston is allowed to return to said chamber on the return stroke.

The delivery of the pump, therefore, ceases until the water has again fallen to or below its normal level.

It will be noted in Fig. 2 that the float chamber 98 is horizontally opposite both the cooling chamber 52 and the boiler 57. The float 100 may therefore be adjusted by rotation of its rod 101 so as to establish the normal water-level either in the boiler or cooling chamber. In raising steam in the boiler 57 for a start, the level is kept at about the line *x*—*x* (Fig. 2) and a circulation is maintained, if desired, between the boiler and float chamber through the pipe 79 and a pipe 113, connecting the two. When combustion has been established in the combustion chamber, the water-level is raised by rotation of the rod 101 until it reaches about the normal running line *y*—*y*, and during the raising of the level and while the boiler 57 is maintained in action as a boiler, a return circulation is preferably maintained between the boiler and cooling chamber through the downtake pipe 59.

Mechanism for keeping the combustion fluids for supplying the combustion chamber in a predetermined pressure-relationship is illustrated sectionally and diagrammatically in Fig. 32. 114 115 represent two gas compressors operated by the engine (the driving connection not being shown) and adapted to impart successive degrees of compression to the gas. 114 is the low-pressure compressor, 115 the high-pressure compressor, and 116 is an inter-cooler interposed between the two compressors. 117 represents the gas-delivery conduit leading to the generator, and 118 represents the air conduit leading from a suitable air compression apparatus to the generator. 119 is a diaphragm receiving on its upper side the pressure of the compressed gas through a branch conduit 120 connected with the gas-delivery pipe 117, and on its under side receiving the pressure of a lightly-compressed spring 121 and of the compressed air received through a branch conduit 122 connected with the air conduit 118. The air pressure reaches the under side of the diaphragm through ports 123 formed in a sliding block 124 interposed between the spring 121 and diaphragm 119. Above the diaphragm is a sliding block 125 having a release valve 127 controlling a passage 126, said valve being normally pressed away from its seat by spring 128 acting on the sliding block. The gas pressure reaches the upper side of the block through ports 129 therein. Beyond the passage 126 is a chamber 130 in the sides of which are two movable pistons 131 normally pressed inwardly by springs 132 acting on heads 133 which are attached to sliding stems 134. Beyond the pistons 131 are leakage chambers 135 connected across on the two sides of the device by a conduit 136, the left-hand leakage chamber being connected with the inter-cooler 116 by a conduit 137. The movement of the stems 134 is designed to control the clearance of the low-pressure compressor 114, one of the stems controlling one end of the compressor cylinder and the other stem controlling the other end. As the mechanisms controlled by the two stems are alike, only one of said mechanisms is shown in full and described. The lower end of the cylinder of compressor 114 is shown as connected by a pipe 138 with a chamber 139 in which is a valve 140 normally seated by a spring 141. This valve controls the communication between chamber 139 and a chamber 142 entered by the outer end of the stem 134 and connected by pipe 143 with a clearance chamber 144. It will be noted that the stem 134 carries oppositely-acting valves 145 146 adapted to seat against suitable valve seats formed on opposite sides of the partition in which the stem slides. As the stem moves from one extreme position to the other without dwelling in an intermediate position these seating valves avoid the use of a stuffing box for the stem.

So long as the air and gas pressures are equal the tension of spring 121 holds the release valve 127 closed. When gas pressure rises above air pressure sufficiently to overcome the tension of this spring the diaphragm 119 is depressed and the valve 127 is opened so as to release a portion of the gas to chamber 130. This presses the piston 131 outwardly and through the medium of the stem 134 unseats the valve 140 and opens the cylinder space of the compressor 114 to the clearance chamber 144. This immediately reduces the output of the gas compressor apparatus and when the gas pressure has fallen to its normal relationship with the air pressure, the valve 127 closes. The released gas leaking past piston 131 is returned through pipe 137 to the inter-cooler 116 and pumped again through the high-pressure compressor 115. The leakage gas might of course be piped to the suction side of the low-pressure compressor, but by returning it between the high and low-pressure compressors we save the work of compressing this gas in the low-pressure compressor. This leakage might be returned to any other part of the compressing system having a mean pressure lower than the pressure of the leakage gas. The clearance of the opposite end of the cylinder of compressor 114 is controlled through a pipe 138′ and a clearance chamber 144′. Obviously a controlling apparatus similar to the foregoing may be employed for controlling the output of the air compressor and thus the pressures of air and gas may be maintained at a substantially exact relationship. This need not be a relationship of equality as the set imparted to the spring 121 determines the pressure difference if any.

The compressed air passing through conduit 118 reaches a chamber 147 in the generator-head and its pressure acts upwardly on a diaphragm 148 which receives on its upper side the pressure of a spring 149, and also through a pipe 150 the terminal pressure of the apparatus. From the chamber 147 the air passes through a resistance-valve mechanism to be presently described, which is automatically regulated by the diaphragm 148 so that the initial air pressure is always greater than the terminal pressure beyond the resistance-valve mechanism by an amount determined by the tension of spring 149. As the gas pressure is maintained in a predetermined relationship to the air pressure by the mechanism hereinbefore described, a flow is insured for both air and gas at all degrees of opening of the resistance-valve mechanism. The resistance-valve mechanism is constructed as follows: The diaphragm 148 acts through a cross-bar 151 and links 152 153 on two levers 154 154 fulcrumed on fulcrum-pins 155 156 and connected at their inner ends by links 157 158 with two resistance-valve members 159 160 sliding in axial alinement in a fixed sleeve 161. The lower valve member 160 controls the burner air and gas and the upper valve 159 controls air which is by-passed around the combustion chamber through a pipe 163, entering the annular space 162 shown in Fig. 2, and passing thence out through the engine-pipe 56. The by-pass valve member 159 has ports 165 movable into and out of register with ports 166 in the fixed sleeve 161 which open into an annular chamber 167 connecting with the by-pass pipe 163. Gas enters the generator-head through the pipe 117 into an annular space 168 connecting with ports 169 in the sleeve 161 with which ports 170 in the valve member 160 are adapted to move into and out of register. The link 158 connects with the upper end of a central hollow stem 171 attached to the shell of the valve member 160 by hollow arms or branches 172, the latter containing ports 173 movable into and out of register with ports 174 in the sleeve 161 connecting with an annular space 175, said space connecting through a conduit 190 with the chamber 147. The valve member 160 also has ports 176 controlling ports 177 in the sleeve 161 which connect with an annular space 178. The latter is continued downwardly as indicated at 179 to an annular space 180 from which air may flow through a series of holes 181 located in alinement with the spaces between an outer series of webs or fins 182 formed on an annular partition 183. Passing around the lower end of the latter the air then passes upwardly between an inner annular series of fins 184 and through a space 185 and holes 186 into the upper end of the combustion chamber 51. The stem 171 carries at its lower end a seating cone-valve 187 above which is slidingly mounted an upwardly-seating check-valve 188. Below the axial stem-passage is another upwardly-seating check-valve 189. The object of these check-valves is to shut off connection between the combustion chamber and the resistance-valve mechanism in case of any sudden rise in pressure in the combustion chamber. At the downward limit of movement of diaphragm 148 the cone-valve 187 closes and shuts off all possibility of flow in either direction past it.

Some of the air from chamber 147 passes directly down through the shell of valve member 160 and forms a first mixture with the gas entering through ports 170. Another quantity of air passes inwardly through ports 174 from chamber 175 and downwardly through the middle of stem 171 so as to join the first mixture of air and gas below the cone-valve 187. A supply of secondary or final air to support combustion is added by way of the ports 176 and chamber 178 and its connected passages, joining the first mixture at the point of ignition, such secondary air being caused to jacket the combustion chamber by passing between the fins 182 184 surrounding the upper part of the combustion chamber, and thereby become heated so as to increase the vigor of combustion, said air also serving to return back to the combustion chamber the heat which would otherwise be dissipated by conduction and radiation from said chamber.

The primary air and gas flowing through the port or opening around the cone-valve 187 are throttled thereby in proportion to the rise and fall of the diaphragm and the effect of said valve is to cause the pressure drop of the air and gas occurring under the control of the diaphragm, to take place substantially at the point of ignition. The passage of the two fluids in company past this resistance-valve or dam secures their intimate mixture with each other, and the jet-like issuance of these fluids from the higher pressure ante-chamber above the valve into the lower-pressure combustion chamber 51 tends to insure the maintenance of the flame and prevent back-burning, and when the fluids thus issuing are mingled with secondary air such as that issuing through the opening 185 and that coming through the hollow stem 171 the velocity of the jet insures that the final mixture shall be immediately complete. The heat at the point of ignition makes a seating valve desirable, since it hinders the use of sliding surfaces. The axial air-flow through stem 171 and the secondary air-flow through space 185 impinge respectively on the inside and outside of the hollow stream of air-and-gas mixture flowing past cone-valve 187 and insure an adequate and immediate supply of air thereto for effecting complete combustion. Supposing the fulcrums 155 156 to be fixed, the movements of the diaphragm 148 cause the by-pass and burner valve members 159 160 to move up and down substantially as though they were rigidly connected. All ports or passages are thus opened or cut off proportionately so that a predetermined difference is maintained between the initial pressure of the air and gas and the terminal pressure of the combustion chamber. Arrangement is, however, made for varying the relative positions of the valve members 159 160 in an axial direction without interfering with the longitudinal movements imparted by the diaphragm 148, thus changing the relation of burner and by-pass ports so as to increase or decrease the proportionate amount of air by-passed. This it will be readily seen can be effected by changing the positions of the fulcrum pins 155 156. Said pins are carried by the two arms 191 192 of a rock-lever 193 (Fig. 5) carried by a rock-shaft 194. As this shaft is rocked the pins 155 156 are moved by equal amounts respectively in opposite directions. The relative axial movement thus imparted to the valve members 159 160 changes the relative opening of the burner and by-pass air ports without changing the aggregate areas of said ports, one set of ports opening by as much as the other closes and vice versa.

The means for controlling the rock-lever 193, partly omitted in Figs. 1 and 2, is illustrated in full in Figs. 3, 6 and 7. The outer end of the rock-shaft 194 carries a depending arm 195 having a pin 196 at its lower end adapted to slide in a radial slot 197 on an arm 198 carried by a shaft 199. To said shaft is secured an arm 200 connected by a link 201 with a piston 202 in a cylinder 203. The lower side of the piston receives through a pipe 204 the released gas from a safety-valve 205 connected by a branch 250 with the gas conduit 117. Below a certain gas pressure no gas is released and the weight of the piston and attached parts holds the piston in its lowermost position and depresses the fulcrum pin 156, correspondingly elevating the fulcrum-pin 155. This fully closes the by-pass air ports 166. Should the gas pressure rise sufficiently to open safety-valve 205 the released gas will raise the piston 202 and rock the shaft 194 so as to raise the fulcrum-pin 156 and depress the pin 155. This allows the by-pass ports 166 to open and by-pass a portion of the air around the combustion chamber directly into the engine, and by a suitable adjustment and proportioning of parts the quantity of air by-passed may be made to bear a proportionate relation to the quantity of gas escaping through the safety-valve 205 so that the relative quantities of the two fluids partaking in the combustion are not varied. The gas received below the piston 202 escapes to the upper side of said piston through a groove 206 of graduated depth, and preferably passes back to the suction side of the compressor through a pipe 207. The latter has a stop-valve 208 which is kept nearly closed so that during release a pressure is maintained above the piston 202 and the movements of said piston are caused to occur gradually. Said piston thus floats on the gas released past the loaded valve 205, moving to different positions to afford an increased or decreased opening for the varying volumes of gas which escape past it, serving to meter the burner gas by measuring that part which fails to reach the burner, and variably opening the air by-pass in proportion to the quantity of gas released back to the gas-compressor suction.

The tendency of the elevation of piston 202 is to depress the valve member 160 and the conevalve 187. It is evident that if the cone-valve is seated and an escape of gas takes place through the valve 205 a strain on the parts will result from the obstructed effort of the piston 202 to rise. To allow for such a condition, we provide the mechanism shown particularly in Fig. 6. Fast to the rock-shaft 194 is a bracket 243 and loose on said shaft is a sleeve 244. The arm 195 is held from movement on said shaft longitudinally of itself by two oppositely-acting adjusting screws 245 245 mounted in the arm and engaging the collar 244 and is held from angular movement on the shaft by two oppositely-acting adjusting-screws 246 246 mounted in bracket 243 secured to the shaft, and embracing the arm between them. Between the right-hand screw 246 and the arm 195 is interposed a spring 247 which is stiff enough to transmit the angular movements of the arm 195 to the shaft 194 when the latter is free to move, but yields to permit the piston 202 to rise when the cone-valve 187 is seated.

The effect of adjusting the arm 195 longitudinally by means of the screws 245 is to increase or decrease the effective length of the arm 198 in a greater proportion than the increase or decrease of the length of the arm 195, thereby securing a different proportion between the movement of the piston 202 and that of the rock-shaft 194. Such angular re-adjustment of the arm 195 as may be necessary by reason of its longitudinal adjustment, may be effected by using the screws 246.

A modified device for controlling the rock-shaft 194 is shown in Fig. 8. In this instance the pin 196 at the lower end of arm 195 is connected with the lower arm of a lever 209 below its pivot 210, said lever being connected above its pivot by a link

211 with a sliding stem 212 attached to a diaphragm 213. The latter receives on its left-hand side the pressure of the gas conduit 117 through a pipe 214, and on its right-hand side the pressure of a spring 215 and the pressure of the air conduit 118 received through a branch pipe 216. The gas conduit 117 contains an adjustable stop-valve 217 which acts as a fixed resistance. A safety-valve 205 in branch connection with said conduit is adapted to release gas at a predetermined pressure. Since the air and gas empty into a common chamber, their pressures to the left of the resistance-valve 217 will be equal, and said valve will cause the gas pressure to the right of it to predominate over the air pressure. At normal pressures the excess of gas pressure is sufficient to overcome the pressure of the air and of the spring 215 and to hold the diaphragm 213 to the right, thus keeping the arm 195 swung to the left and the fulcrum-pin 156 depressed. As air and gas pressures rise a point is reached at which the safety-valve 205 releases. If all of the gas be released the flow past 217 becomes *nil*, the difference of pressures upon either side of it becomes zero, the diaphragm 213 is in fluid-pressure equilibrium and the spring 215, now unbalanced, will move 212 to the left to the limit of motion, thus by-passing all of the air. The release by 205 of any fraction of the gas will result in a proportionate fractional action on the part of the above mechanism.

Figs. 1, 2 and 5ª show the device employed for stopping the fuel supply when for any reason the pressure in the system rises or falls abnormally. 260 is a valve in the fuel conduit 117 closing with the flow and having a spring 261 tending to close it and a stem 262 connected pivotally to a lever 263 having a fixed fulcrum at 264. A spring 265 attached to said lever overcomes the spring 261 and normally holds the valve open. 266 is a diaphragm whose normal motion to the left is opposed by a spring 267 and its extreme motion further opposed by a spring 268. On the right said diaphragm receives the terminal pressure of the system through a pipe 269 connected with the reheating chamber 55. The stem 270 of diaphragm 266 is pivotally connected with the lower arm of a lever 271 having a fixed fulcrum at 272, and is adapted to encounter in its leftward movement a screw 273 on lever 263. The upper arm of lever 271 carries a screw 274 adapted to encounter the end of valve stem 262. Between certain limits of pressure determined by the set of the screws 273 274, the diaphragm 266 is adapted to move under the differential action of the terminal pressure and spring 267 without effect on the valve 260. In case of an abnormal rise of pressure in the generator, movement of stem 270 to the left causes it to encounter screw 273 and close valve 260, thereby shutting off the fuel supply to the combustion chamber. In case of abnormal fall of pressure, movement of stem 270 to the right causes screw 274 to encounter the valve stem 262 and close the valve 260. In either case the valve remains closed by reason of the pressure of the fuel upon it, until restored manually, the pull of spring 265 being insufficient to open said valve when the latter is closed with normal gas pressure behind it. Obviously also, the position of valve 260 and the power of its spring 265 or other constant force tending to hold the valve open, may be such that any abnormal rush of fluid in pipe 117 such as might be caused by the rupture of said pipe at a point posterior to the valve, will close the valve independently of diaphragm 266.

We claim:—

1. In internal-combustion motor apparatus, the combination of a combustion chamber, two independently-movable resistance valves controlling a supply of combustion fluid therefor, a movable member for imparting a common resistance-varying movement to said valves, two levers interposed between said member and the respective valves, and connections for imparting simultaneous opposite movements to the fulcrums of the respective levers indepenc.ent of the movements of said member.

2. In internal-combustion motor apparatus, the combination of a combustion chamber, means to supply air and gas thereto, valve mechanism adapted to divert air from the combustion chamber, means controlled by the gas pressure for automatically releasing gas, and means actuated by the released gas for controlling said air-diverting valve mechanism.

3. In internal-combustion motor apparatus, the combination of a combustion chamber, means to supply combustion fluid thereto under pressure, means to release a portion of said fluid, a piston arranged to float on the released fluid, and means whereby said piston controls the combustion in said chamber.

4. In combination, a continuous-combustion chamber, means to supply compressed air and gas thereto, means to divert one of said fluids upon the attainment of a predetermined pressure thereof, and a meter permitting escape of fluid past it for measuring the quantity of the fluid released and diverting a corresponding quantity of the other fluid.

5. In combination, a continuous-combustion chamber, means to supply compressed air and gas thereto, a floating meter-piston measuring the gas and effecting a variable escape-opening therefor, and a compressed-air by-pass controlled by saia piston.

6. In combination, a combustion-chamber having a continuous-combustion burner, means to supply compressed air and gas to said burner, means to mix the air and gas before reaching the burner, a valve forming part of the burner and controlling the mixture at its entrance into the combustion-chamber, and means for automatically effecting a variable opening of said valve corresponding with different pressures of the mixture.

7. In continuous-combustion generating apparatus, the combination of a combustion chamber, means for supplying combustion fluids thereto, provisions for mixing said fluids before they reach said chamber, and a resistance-valve mechanism controlling the mixed fluids and differentially controlled by the fluid pressures initial and terminal to said mechanism.

8. In combination, a pressure combustion-chamber having a continuous burner, means for supplying compressed air and gas thereto, means for effecting a partial mixture of the air and gas anterior to the burner, means for forming an annular entrance for said mixture into the combustion-chamber, means for adding further combustion-fluid to complete the mixture beyond said entrance, and means for automatically varying the size of said entrance in accordance with the pressure of the system.

9. In combination, a pressure combustion-chamber having a continuous burner, means for supplying compressed air and gas thereto, a conical resistance-valve forming part of the burner and having an annular opening around it to form a hollow stream of combustion fluid entering the combustion-chamber, said valve being adjustable to vary the size of said entrance, and means for adding further combustion fluid beyond said valve to burn with the fluid passing the same.

10. In continuous-combustion generating apparatus, the combination of a combustion chamber, means to supply a combustion fluid continuously thereto, a positively-seating valve controlling the fluid flow to said chamber, a device controlling the seating movement of said valve and adjustable by the absolute pressure of the system, and a yielding connection between said device and the valve, permitting movement of said device after the valve meets its seat.

11. In continuous-combustion generating apparatus, the combination of a combustion chamber, a fuel conduit leading thereto, a normally open valve in said conduit, means controlled by the pressure in said combustion chamber for closing the valve, and provisions for holding the valve closed.

12. In continuous-combustion generating apparatus, the combination of a combustion chamber, a fuel conduit leading thereto, a normally open valve in said conduit closing with the flow and arranged to be held closed by the fuel pressure back of it, and means controlled by the pressure in said combustion chamber for closing the valve.

13. In continuous-combustion generating apparatus, the combination of a combustion chamber, a fuel conduit leading thereto, valve mechanism controlling said conduit, a reciprocating device controlled by the pressure in said combustion chamber, and operating connections between said device and valve mechanism arranged to close said valve mechanism upon movement of said device in either direction, said connections having provisions for permitting a normal movement of the device without operating said mechanism.

14. In continuous-combustion generating apparatus, the combination of a combustion chamber, a resistance-valve mechanism anterior thereto, and a backwardly-closing check-valve interposed between said combustion chamber and the resistance-valve mechanism, and adapted to shut off the communication therebetween.

15. In continuous-combustion generating apparatus, the combination of a combustion chamber, a cooling-chamber below the same, and a plurality of tubes connecting said combustion chamber with the cooling-chamber.

16. In continuous-combustion generating apparatus, the combination of a combustion chamber, and a cooling-chamber below the same, said combustion chamber being provided with a series of outlets into said cooling-chamber having upper terminations at different heights.

17. In continuous-combustion generating apparatus, the combination of a combustion chamber, a cooling-chamber below the same, and a plurality of tubes connecting said combustion chamber with the cooling-chamber and formed respectively with outlets having upper terminations at different heights.

18. In continuous-combustion generating apparatus, the combination of a combustion chamber, a cooling-chamber associated therewith, a reheating chamber leading from said cooling-chamber, a dike surrounding said reheating chamber, an eduction chamber surrounding the dike and connecting thereover with the reheating chamber, and an eduction conduit connected with said eduction chamber.

19. In internal-combustion motor apparatus, the combination of a combustion chamber, a cooling-chamber connected therewith, a steam-generator located below said cooling-chamber and having a contracted connection therewith, and an outside downtake conduit connecting said cooling-chamber and steam-generator.

20. In internal-combustion motor appara-

tus, the combination of a combustion chamber, a cooling-chamber associated therewith, a steam-generator connected with said cooling-chamber, an engine connected to receive the output of the combustion and cooling chambers, and means to direct the exhaust from said engine into or away from heating relation with said steam-generator.

21. In internal-combustion motor apparatus, the combination of a combustion chamber, a cooling-chamber associated therewith, a steam-generator connected with said cooling-chamber and having two sets of gas passages, a combustion chamber connecting said sets of passages at one end, an engine connected to receive the output of the combustion and cooling chambers, and valve mechanism controlling the engine exhaust and having provisions either to afford a direct outlet therefor or an inlet therefor to one of said sets of gas passages and an outlet from the other set.

22. In internal-combustion motor apparatus, the combination of a combustion chamber, a cooling-chamber associated therewith, a steam-generator connected with said cooling-chamber, an engine connected to receive the output of the combustion and cooling chambers, and an ejector operated by the engine exhaust and having suction connection with the heating passages of the steam-generator.

23. In internal-combustion motor apparatus, the combination of a combustion chamber, a cooling-chamber associated therewith, a steam-generator associated with said cooling-chamber and having a natural-draft gas outlet, an engine connected to receive the output of the combustion and cooling chambers, an ejector, and valve mechanism having provisions in one position to connect the engine exhaust to the jet portion of said ejector and the heating passages of the generator to the suction portion of the ejector, and in another position to divert the engine exhaust through said heating passages.

24. In internal-combustion motor apparatus, the combination of a combustion chamber, a compressing system for supplying a combustion fluid thereto including successive compressors, means to automatically release the compressed fluid, and a conduit for the return of the released fluid connected with the compressing system at a point beyond the first compressor having a lower mean pressure than that of the released fluid.

25. In internal-combustion motor apparatus, the combination of a combustion chamber, means for supplying compressed combustion fluid thereto, a mechanism controlled by the fluid for automatically controlling its pressure and having two chambers at different pressures, a partition separating said chambers, and a sliding stem included in the controlling mechanism and traversing said partition, said stem having oppositely-seating valves co-acting with seats on the opposite sides of the partition.

26. In internal-combustion motor apparatus, the combination of a combustion chamber, a cooling-chamber connected therewith, a steam-generator below the cooling-chamber and connected with the latter, and mechanism for automatically maintaining a normal water-level in the system, said mechanism having provisions for establishing the said water-level either in the generator or in the cooling-chamber.

27. In continuous-combustion generating apparatus, the combination of a combustion chamber, a cooling-chamber connected therewith, a steam generator below said cooling-chamber and connected with the latter, a float chamber having vapor and water connections with the cooling-chamber and generator respectively and located horizontally opposite the two, a float in said chamber, mechanism controlled by said float for automatically maintaining a normal water-level in the system, and provisions for adjusting said float to a normal position horizontally opposite either the cooling-chamber or the steam-generator.

28. The combination of a liquid chamber, a device controlling the liquid-level in said chamber, a constantly-operated actuator, and a level-responsive means controlled by the liquid-level in said chamber and adapted to effect connection and disconnection between said device and said actuator.

29. The combination of a liquid chamber, a pump for supplying liquid thereto and having suction and discharge valves, an intermediate chamber between said valves open to the pump cylinder, a discharge chamber, and means controlled by the liquid-level in the chamber for automatically opening and closing the connection between said intermediate chamber and the discharge chamber.

In testimony whereof we have affixed our signatures, in presence of two witnesses.

SIDNEY A. REEVE.
EDWD. P. NOYES.

Witnesses:
R. M. Pierson,
P. W. Pezzetti.