No. 609,087.

Patented Aug. 16, 1898.

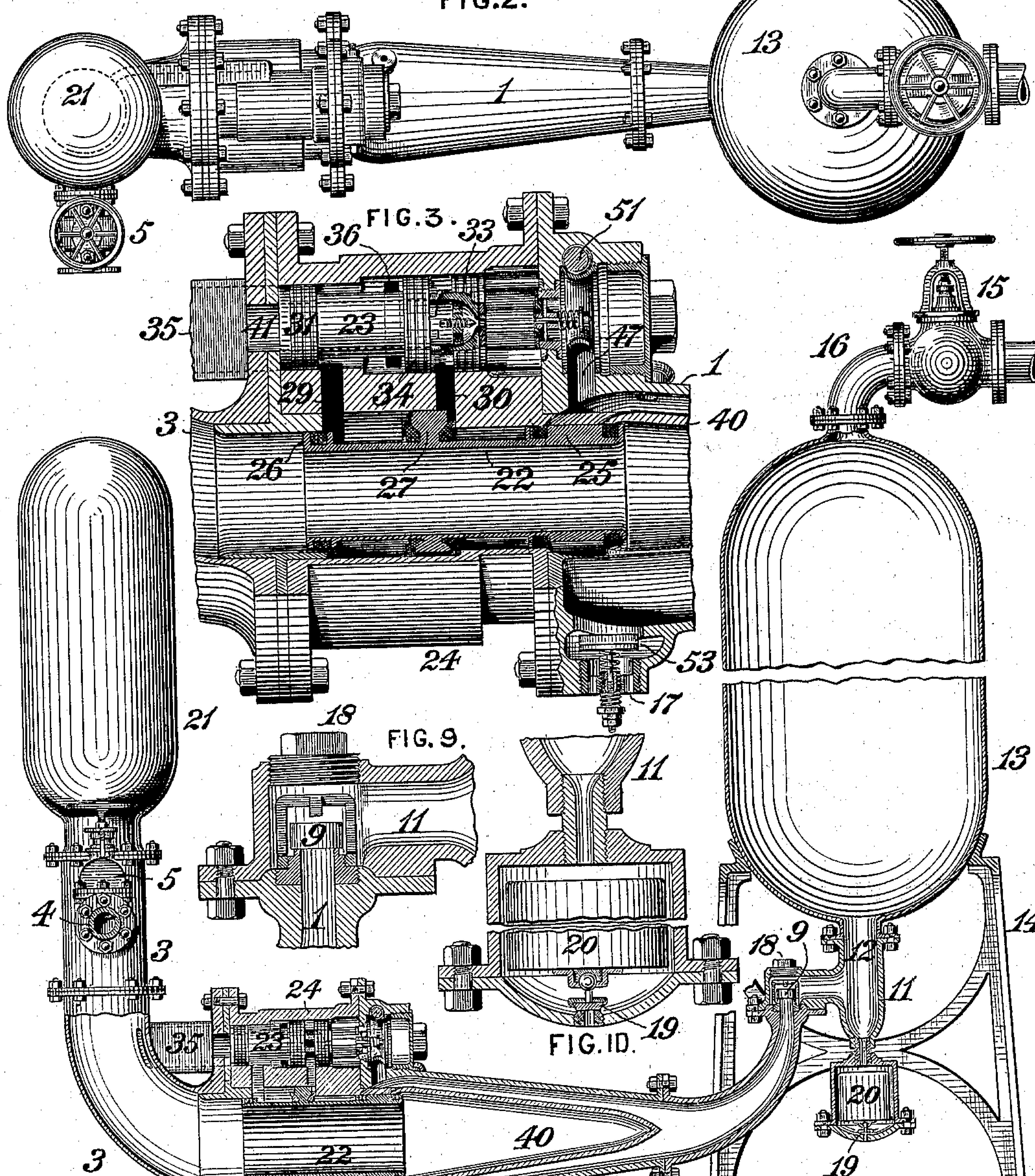
C. N. DUTTON.

AIR COMPRESSOR.

(Application filed July 27, 1896.)

(No Model.)

3 Sheets—Sheet 1.



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3 Sheets—Sheet 2.

FIG.4.

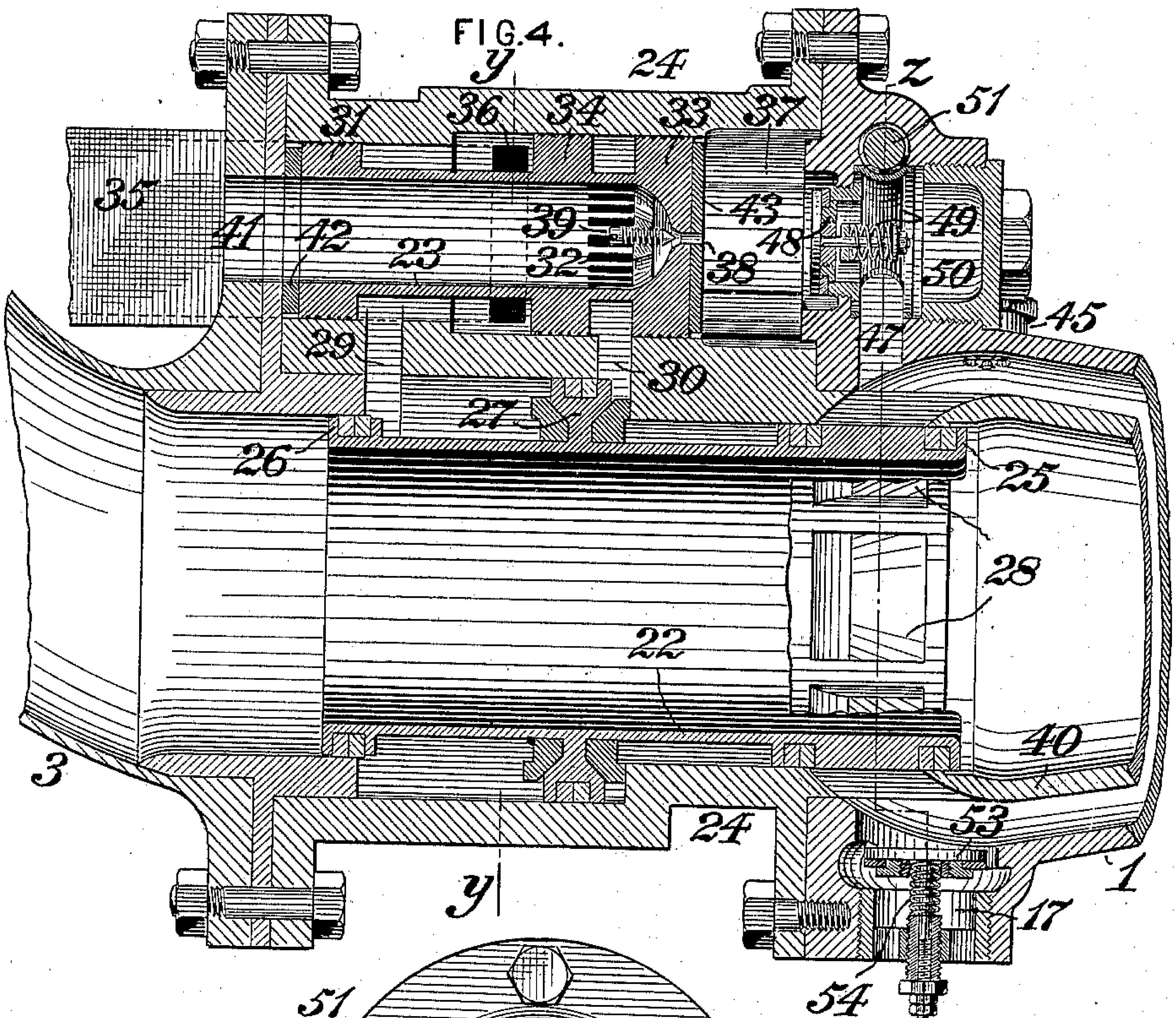
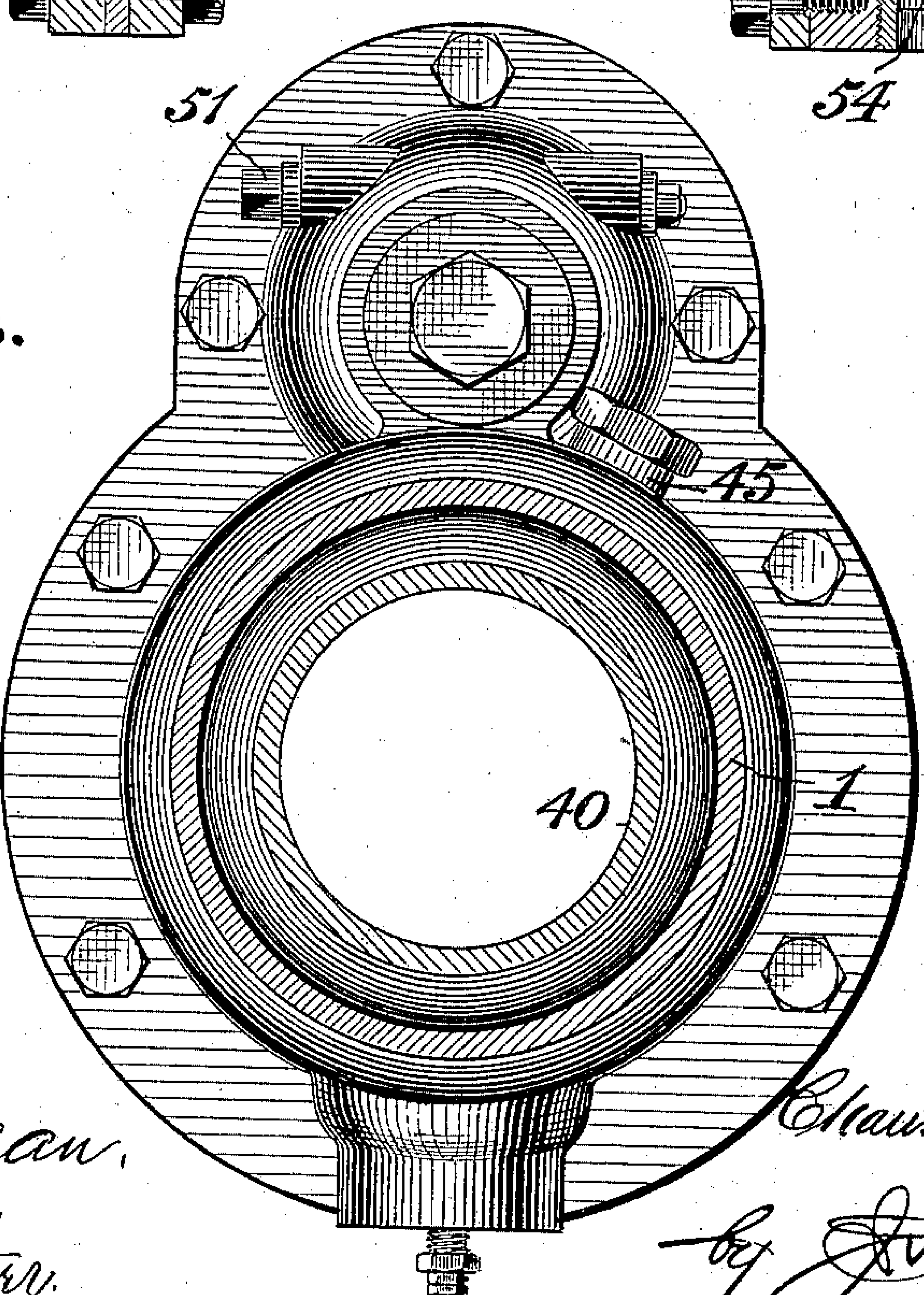


FIG.5.



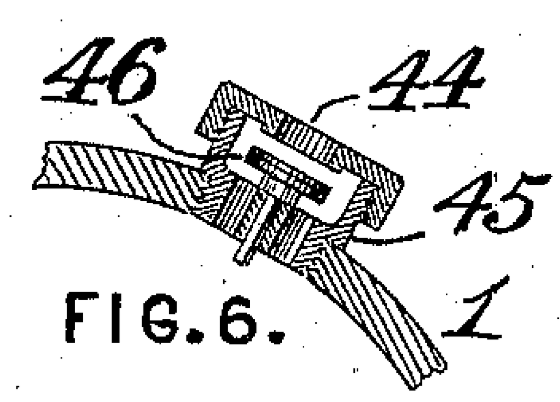


FIG.6.

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No Model.) 3 Sheets—Sheet 3.

FIG. 8.

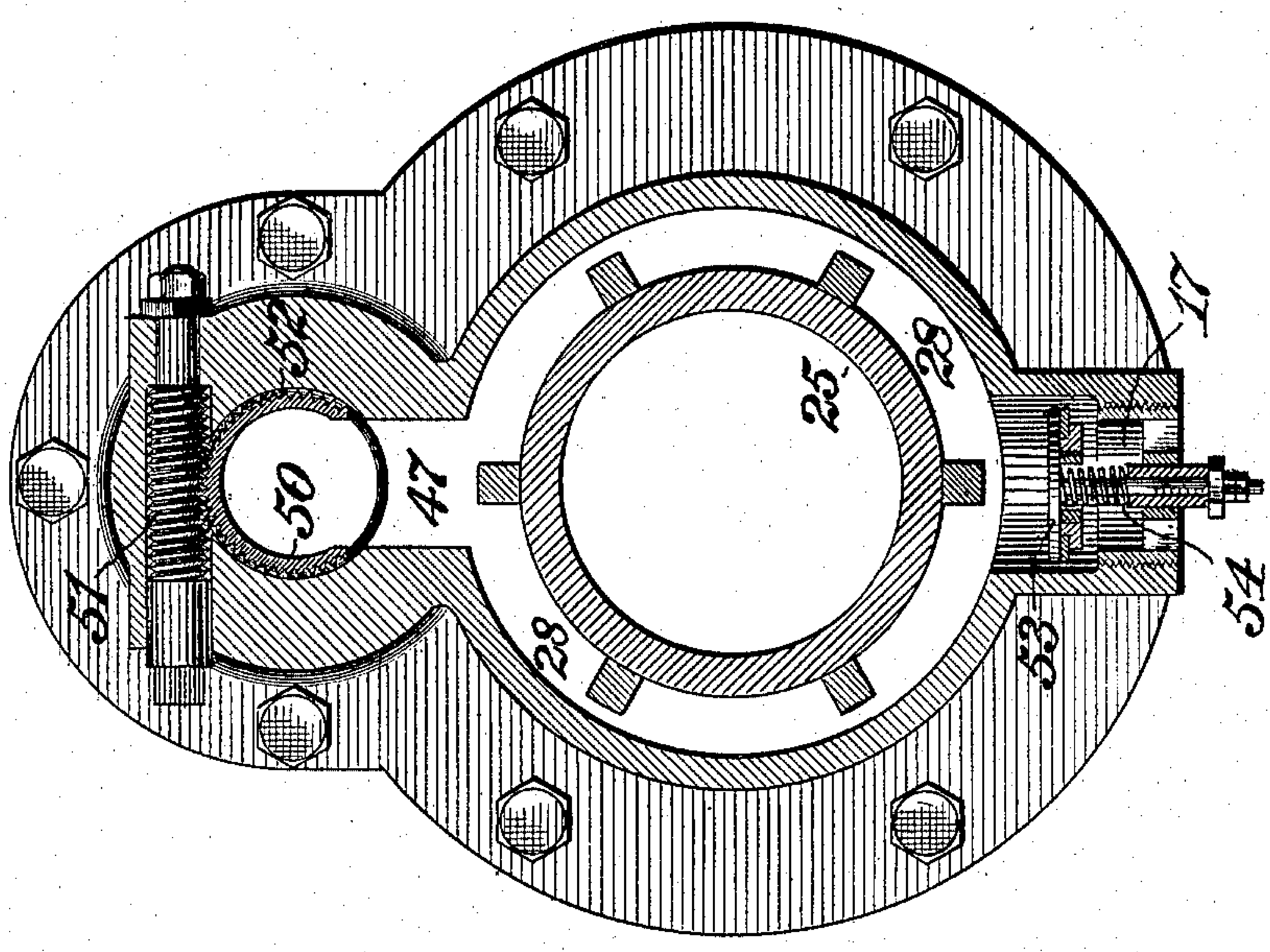
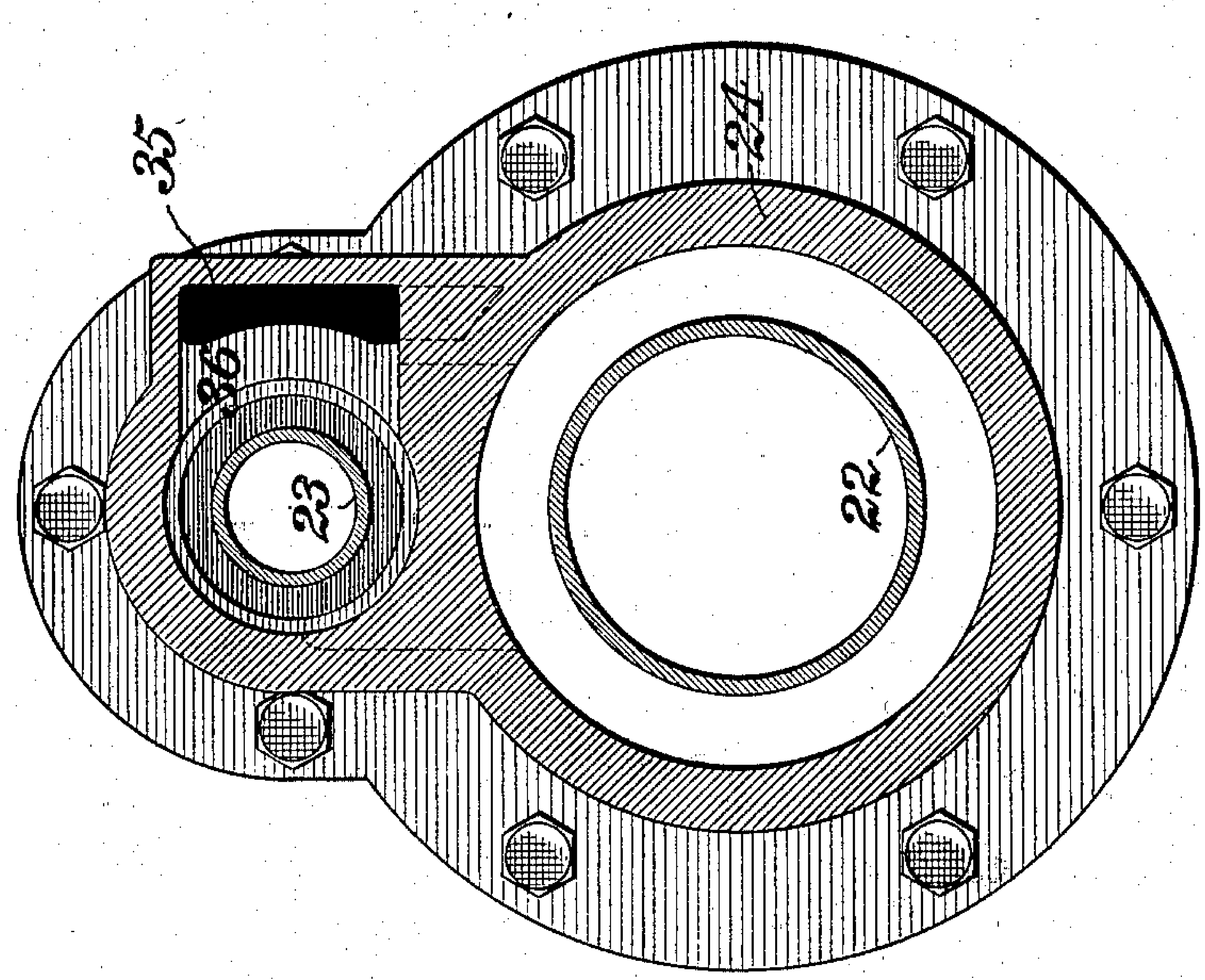


FIG. 7.



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UNITED STATES PATENT OFFICE.

CHAUNCEY N. DUTTON, OF NEW YORK, N. Y.

AIR-COMPRESSOR.

SPECIFICATION forming part of Letters Patent No. 609,087, dated August 16, 1898.

Application filed July 27, 1896. Serial No. 600,651. (No model.)

To all whom it may concern:

Be it known that I, CHAUNCEY N. DUTTON, of the city, county, and State of New York, have invented a certain new and useful Improvement in Air-Compressors, of which improvement the following is a specification.

The object of my invention is to provide simple, efficient, and desirable means for effecting the compression of air by the utilization of the impact of falling water, thereby dispensing with the compressing-pistons and actuating mechanism heretofore ordinarily employed.

The improvement claimed is hereinafter fully set forth.

Various devices have heretofore been proposed and put into practice for the hydraulic compression of air; but such devices, so far as my knowledge and information extend, do not have the capacity of compressing air fully up to the pressure corresponding with the head of water by which they are operated. My invention, on the other hand, provides a direct-acting hydraulic air-compressor in which the pressure of the air may be many times greater than that due to the hydrostatic head of the operating water.

The general principles of the apparatus are as follows: An automatic valve mechanism is provided by which water is allowed to be intermittently discharged with as nearly as may be the full velocity due to its head into an air-compression chamber in which it acts by impact to compress a charge of air. The force being delivered as a blow upon the elastic cushion of air to be compressed, the degree of compression may be made as high as desired by suitably proportioning the compression-chamber and its delivery end to the volume of water employed at each impulse and its velocity. The air is compressed into a suitable reservoir, confined therein by a check-valve, and means are provided for intermittently drawing the waste water out of the compression-chamber and allowing a new volume of air to enter to be compressed by the next succeeding discharge of water.

In the accompanying drawings, Figure 1 is a vertical central section through an air-compressor, illustrating an application of my invention; Fig. 2, a plan or top view of the same; Fig, 3, a view, partly in longitudinal central section and partly in elevation and on an enlarged scale, of the valve-casing of said compressor; Fig. 4, a longitudinal central section, on a further-enlarged scale, through the valve-casing; Fig. 5, a transverse section through the compressing-chamber, showing the valve-casing in end elevation; Fig. 6, a central section through the air-supply chamber; Figs. 7 and 8, transverse sections through the valve-casing at the lines *y y* and *z z*, respectively, of Fig. 4; Fig 9, a vertical central section, on an enlarged scale, through the chamber of the reservoir check-valve; and Fig. 10, a similar section through the chamber of the reservoir drain-valve.

In the practice of my invention I provide a conical compressing chamber or tube 1, which is reduced in diameter, preferably by being continuously inwardly inclined or curved in longitudinal section from its receiving to its delivery end and is secured to a suitable frame or bed plate 2 at as low a level as practicable in order to utilize the full effect of the head of water by which compression is effected. The receiving end of the compressing-chamber 1 is connected to a vertical supply-tube 3, which receives and delivers to the compressing-chamber a body of water, which passes through it and which is intermittently supplied from a higher level by an automatic valvular mechanism, as hereinafter described, so as to fall in successive portions or charges into the compressing-chamber and effect therein by its impact the compression of air, which enters at the larger receiving end of the compressing-chamber, by forcing the same into the contracted space therein at and adjoining its smaller delivery end.

Water is delivered from a high level to the supply-pipe 3 through a conduit 4, controlled by a valve 5, and in order to admit of the employment of a comparatively small pipe 4 for leading the water from the head-level to the supply-pipe an air-chamber 21 is connected to the supply-pipe. By reason of the intermittent action of the apparatus this air-chamber, when made of proper dimensions, admits of the reduction in diameter of the pipe 4.

The valvular mechanism for effecting the intermittent supply of water to the compressing-chamber 1 consists of a hollow piston main valve 22 and a differential piston controlling-valve 23, working in a casing or chamber 24, interposed between and connected at its ends to the supply-pipe 3 and compressing-chamber 1. The main valve 22 is a hollow open-ended cylinder having on one end a valve-piston 25, which controls ports 28, establishing communication through the central bore of the main valve 22 from the supply-pipe 3 to the compressing-chamber 1. The ports 28 are formed in the larger end of a conical deflector 40, formed on or fixed to the end of the casing 24 next the compressing-chamber 1 and projecting axially into the latter, so that water shall be delivered thereto in an annular body. A piston 26, formed on the opposite end of the main valve, cuts off communication between the supply-tube 3 and the space within the casing 24 around the body of the main valve. An operating-piston 27 of larger diameter than the end pistons 25 and 26 is formed on the body of the main valve, and all three pistons are provided with suitable packing.

The body of the controlling-valve 23 is hollow or tubular and open at one end, which is constantly in communication with a discharge-port 41 in the casing 24. A piston 31 is formed on the body of the controlling-valve at and adjoining its open end, and two pistons 33 and 34 of equal diameter, which is greater than that of the piston 31, are also formed upon the controlling-valve, the piston 33 being located at its inner end or that farthest from the piston 31 and the piston 34 being at a distance from the piston 33 about equal to or slightly greater than the width of a supply-port 30, leading from the controlling-valve compartment of the chamber 24 to the main-valve compartment of said chamber on the right-hand side of the operating-piston 27. Said compartments are also connected by a supply-port 29 on the left-hand side of the piston 27. Elastic buffers or cushion-plates 42 43 are fixed upon the ends of the controlling-valve to prevent shock at the limits of its traverse.

The controlling-valve 23 is moved in one direction—that is to say, to the right—by water admitted from the supply-pipe 3 through a branch pipe 35, which opens by a port 36 to the controlling-valve chamber between the pistons 31 and 34. The pressure of the water upon said pistons acts to move the valve in the direction of the larger piston 34, or to the right, and the motion is slow because of the small difference in areas of the pistons 31 and 34 and also because of the restricted discharge of back water from behind the piston 33. The movement of the controlling-valve in the opposite direction is effected by a portion of the water from the compressing-chamber, which enters the controlling-valve compartment through a port 47, controlled by a check-valve 48, which is normally closed by a spring 49. In order to regulate the speed at which water is admitted to the right-hand side of the controlling-valve, and thereby to control the period during which the ports 28 shall be open by being uncovered by the main valve, so that water shall not be wasted by being admitted to the compressing-chamber after the compressing operation has been effected, the area of opening of the port 47 is made variable by means of a regulating device, consisting in this instance of a ring 50, having an opening on its side adjacent to the port 47 and which is angularly adjustable to increase or decrease the delivery area of the port 47 by a worm 51, rotatable in a bearing in the chamber 24 above the ring 50 and engaging a worm-gear 52, cut on the periphery of said ring, to rotate it and regulate the opening of the port 47.

Air is admitted to the compressing-chamber through an independent air-supply port or passage 44, formed in the cap of an air-supply chamber 45, fixed on the upper side of the compressing-chamber and communicating by open ports therewith. The air-supply port is controlled by an outwardly-opening check-valve 46, working in the chamber 45. The valve 46 is closed by the pressure within the compressing-chamber during each compressing operation and opens by its own gravity thereafter for the admission of air for the next succeeding compressing operation.

The smaller or delivery end of the compressing-chamber 1 is controlled by an outwardly-opening reservoir check-valve 9, which is seated after each compressing operation by the pressure on the outer side of the valve. The reservoir check-valve 9 governs communication between the compressing-chamber and a chamber or casing 11, which is connected by a passage 12 with a reservoir 13, which is made of proper strength to safely resist the maximum pressure to which air is to be compressed by the apparatus, and is provided with a suitable stop-valve 15, controlling a delivery-pipe 16, through which compressed air is led from the reservoir to the desired point of use. The reservoir is supported on a frame or stand 14, which may be formed on or fixed to the bed-plate 2 or be separately secured to a suitable foundation.

The bodies of water by which the compression of air in the compressing-chamber 1 is effected escape successively therefrom after delivering their energy to the air therein through a discharge-passage 17, formed at the lowest point of the compressing-chamber and controlled by an inwardly-opening discharge-valve 53, which is normally held off its seat by a spring 54 and is closed by the pressure within the compressing-chamber during each compressing operation and opened for the discharge of water thereafter by the spring 54, which is adjustable, so as to hold the valve 53 off its seat against a less or greater pressure for a longer or shorter time until such pressures obtain or are generated in the compressing-chamber as consistent with the water, acquiring as nearly as possible the velocity due to the available head, so as to realize commercially in compressed air as much as possible of its work. Were both the valves 53 and 46 to close before the full velocity is acquired the machine would give a low efficiency. The efficiency and also the degree of compression, which can be economically obtained, depend largely upon correct porportioning of the compressing-chamber 1 and check-valved passage leading therefrom to the reservoir 13. The best form is that shown, in which the compressing-chamber tapers nearly uniformly from its receiving end to its outlet or connection with the reservoir, the shape being such that the work is done as uniformly as may be and the capacity such that the last of the work or living force of the mass of moving water is absorbed by the compressed air just as it is completely forced out of the compressing-chamber and the water touches the check-valve. In any other form of compressing-chamber there would be a large percentage of slip, equivalent to clearance in a mechanical compressor, and a reduced efficiency, due to the fact that the water would recoil before all the air was forced into the reservoir. It will be observed that the air-compressing chamber is horizontal, or nearly so. In all other hydraulic or hydrostatic air-compressing devices with which I am familiar the compressing-chambers have been made vertical, with the object of functioning by the flat upper surface of the water while compressing air. It is obvious that in vertical air-compressors the work done in lifting the water through the height of the compressing-chambers represents a loss of power. Practical experience in the use of water and air in confined spaces at high velocities demonstrates that the water will do its work quite as well from one direction as from another under such conditions.

An opening is formed in the wall of the chamber 11 opposite the reservoir check-valve 9 and is closed by a screw-plug 18, by the removal of which the valve 9 may be readily removed and replaced for repair or renewal. Any water which may be entrained with the air into the reservoir-supply-valve chamber 11 is released therefrom by a drain-valve 19, closing an opening in the bottom of the chamber and connected to a float 20, adapted to rise and fall with the level of the water therein.

In all compressors heretofore constructed it has been extremely difficult to approximate isothermal compression. Nearly all compressors are adiabatic, or nearly so. The deflector 40, which, as before described, is concentric in the compressing-chamber, has an important function, in addition to that above described, in abstracting from the air the heat set free in the act of compressing, which it effects by reason of being always filled with water, and, moreover, because the outer surface of the deflector and the inner surface of the compressing-chamber are both in contact with water at every stroke of the machine their temperature is maintained permanently very nearly equal to the temperature of the water. The thin bodies in which the air is disposed during compression greatly facilitate frequent contact between each individual particle of air and the cold walls of the deflector and compressing-chamber, and the absorption of heat by them from the compressed air thus approximating more nearly to isothermal compression than any compressor heretofore designed. This function will be further elucidated in an improved form in a separate application, which will be shortly filed.

In the operation of the apparatus a portion of the water which passes into the supply-tube 3 under the pressure due to its head is admitted through the passage 35 and port 36 to the chamber of the controlling-valve 23, between the pistons 31 and 34 of said valve, and the excess of its pressure on the piston 34 above that on the smaller left-hand-end piston 31 moves the controlling-valve to the right-hand limit of its traverse, thereby admitting water from the port 36 through the controlling-valve chamber and the port 30 to the right-hand side of the operating-piston 27 of the main valve 22 and moving said main valve to the left-hand limit of its traverse, in which it uncovers the ports 28 and admits a body of water through its tubular body and the ports 28 to the compressing-chamber 1, in which said body of water effects by its impact a compression of air admitted through the supply-passage 44, and a portion thereof unseats the valve 48 and passes through the opening controlled by said valve into the right-hand end of the controlling-valve chamber, in which it exerts its pressure upon the full area of the right-hand piston 33 of the controlling-valve 23. The controlling-valve is thereby rapidly moved to the left-hand limit of its traverse, being the position in which it is shown in Fig. 5, and water is admitted through the ports 36 and 29 to the left-hand side of the operating-piston 27 of the main valve 22, moving said piston to the right-hand limit of its traverse and cutting off the supply of water to the compressing-chamber by closing the ports 28. The discharge-valve 53 then opens and drains the compressing-chamber, and thecheck-valve 46 opens to admit a new charge of air. The water which has effected the previous stroke of the main valve to the left is exhausted through the ports 30, the ports 32, which are formed in the body of the controlling-valve between the pistons 33 and 34, the tubular body of said valve, and the discharge-port 41.

The body of water admitted to the compressing-chamber enters it at nearly the velocity due to its hydrostatic head, and its velocity being checked by the air in the compressing-chamber it strikes a blow upon said air, delivering its energy by impact, the measure of the compression being fixed by the taper of the compressing-chamber and the area of the discharge-opening relatively to the volume of water supplied, and its velocity, and the volume of air compressed in the air-chamber. When the supply-water enters the compressing-chamber, it acts upon the drain-valve 53, controlling the discharge-passage 17, and the air-valve 46, closing them, so as not to waste water, and after compression is effected these valves open and permit the water to drain from and a new supply of air to enter the compressing-chamber.

The preliminary movement of the controlling-valve 23 to the right is made comparatively slowly, as the waste or back water which has effected its previous stroke to the left can escape only through a restricted port 38 in the right-hand piston 33 of the valve, the transverse area of which port may be varied by an adjusting-screw 39, having a conical end. The speed at which the controlling-valve travels to the right may thus be properly regulated, so that the main valve will remain in position to keep the ports 28 closed sufficiently long to allow all water to escape from the compressing-chamber after having effected a compressing operation therein. When, however, the controlling-valve has been moved sufficiently far to the right to close both the main-valve supply-ports 29 and 30, its right-hand piston 33 passes into an enlarged bore 37 in its chamber, and the waste or back water on its right-hand side then escapes freely around the piston 33 and through the ports 32 and the body of the valve to the discharge-port 41. The controlling-valve then rapidly completes its right-hand stroke and by opening the port 30 to the port 36 effects the left-hand traverse of the main valve 22, by which the ports 28 are opened, as before described.

It will be obvious that while the only function of the main valve and controlling-valve in the application herein described and shown is that of automatically effecting the alternate opening and closure of the ports through which water is admitted to the compressing-chamber the reciprocation of the operating-piston of the main valve may be utilized for any other desired purpose in a water-pressure engine or motor. I do not, therefore, herein claim said automatic valvular mechanism in and of itself, and the same forms the subject-matter of a separate application filed by me November 13, 1897, Serial No. 658,439.

I do not, further, desire to limit my present invention to combinations embodying the specific automatic valvular mechanism herein described and shown for effecting the intermittent supply of water to the compressing-chamber, as various other automatic mechanisms for performing the same function may be substituted by a mechanic skilled in the art without departure from the governing and essential features of my invention and without involving any substantial difference of operation from that of the combination of essential members which is exemplified in the apparatus herein described and shown.

I claim as my invention and desire to secure by Letters Patent—

1. The combination, substantially as set forth, of a compressing-chamber, a conduit adapted to supply water under pressure thereto, a main valve governing a supply-port between the conduit and the compressing-chamber, and an automatic controlling-valve, actuated by water supplied from a conduit and controlling the fluid transmission of operating power to the main valve.

2. The combination, substantially as set forth, of a compressing-chamber, a valve-controlled air-supply port or passage opening thereinto, a reservoir, a check-valve controlling communication between the compressing-chamber and reservoir, a conduit adapted to supply water under pressure to the compressing-chamber, a main valve governing a supply-port between the conduit and the compressing-chamber, and an automatic controlling-valve, actuated by water supplied from a conduit and controlling the fluid transmission of operating power to the main valve.

3. The combination, substantially as set forth, of a compressing-chamber, a discharge-passage therefrom, an air-supply port or passage thereto, a conduit adapted to supply water under pressure to the compressing-chamber, a main valve governing a supply-port between the conduit and the compressing-chamber, and an automatic controlling-valve, actuated by water supplied from a conduit and controlling the fluid transmission of operating power to the main valve.

4. The combination, substantially as set forth, of a compressing-chamber, an air-supply port or passage opening thereinto, a reservoir, a check-valve controlling communication between the compressing-chamber and reservoir, a discharge-passage for the release of water from the compressing-chamber, a drain-valve for the release of water from the reservoir, a conduit adapted to supply water under pressure to the compressing-chamber, a main valve governing a supply-port between the conduit and the compressing-chamber, and an automatic controlling-valve, actuated by water supplied from a conduit and controlling the fluid transmission of operating power to the main valve.

5. The combination, substantially as set forth, of a compressing-chamber which is reduced in transverse area at and toward its delivery end, an air-supply port or passage opening thereinto, a reservoir, a check-valve controlling communication between the delivery end of the compressing-chamber and the reservoir, a discharge-passage for the release of water from the compressing-cham-

ber, a conduit adapted to supply water under pressure to the compressing-chamber, a main valve governing a supply-port between the conduit and the compressing-chamber, and an automatic controlling-valve, actuated by water supplied from a conduit and controlling the fluid transmission of operating power to the main valve.

6. The combination, substantially as set forth, of a compressing-chamber, an air-supply port or passage opening thereinto, a conduit adapted to supply water under pressure thereto, an air-chamber connected with said conduit, a reservoir, a check-valve controlling communication between the compressing-chamber and reservoir, a discharge-passage for the release of water from the compressing-chamber, a main valve governing a supply-port between the conduit and the compressing-chamber, and an automatic controlling-valve, actuated by water supplied from a conduit and controlling the fluid transmission of operating power to the main valve.

7. The combination, substantially as set forth, of a compressing-chamber, an air-supply port or passage opening thereinto, a conduit through which water may be supplied, under the impact of a fall from a height, to the compressing-chamber, a main valve governing ports for the admission of water from the supply-conduit to the compressing-chamber, an actuating-piston on said main valve, a controlling-valve governing ports for admitting water from the supply-conduit alternately to opposite sides of the actuating-piston, a passage for the admission of water from the supply-conduit to the controlling-valve chamber, a passage for the admission of water from the compressing-chamber to the controlling-valve chamber, a check-valve governing said last-named passage, a reservoir, a check-valve controlling communication between the compressing-chamber and reservoir, and a discharge-passage for the release of water from the compressing-chamber.

8. The combination, substantially as set forth, of a compressing-chamber, an air-supply port or passage opening thereinto, a conduit through which water may be supplied, under the impact of a fall from a height, to the compressing-chamber, a valve-casing interposed between and connected with the supply-conduit and compressing-chamber, ports opening into the compressing-chamber from said casing, a tubular main valve fitted to reciprocate in a chamber of the casing and having end pistons, one governing the compressing-chamber ports and the other preventing direct communication between the supply-conduit and the chamber of the main valve, an operating-piston on said main valve, a controlling-valve having pistons of unequal area, between which water is admitted from the supply-conduit and to the larger of which water is admitted from the compressing-chamber, ports governed by said valve for admitting water from the supply-conduit to opposite sides of the operating-piston of the main valve, a check-valve governing communication between the compressing-chamber and the larger piston of the controlling-valve, a reservoir, a check-valve controlling communication between the compressing-chamber and reservoir, and a discharge-passage for the release of water from the compressing-chamber.

9. The combination, substantially as set forth, of a water-supply tube, a compressing-chamber, a main valve governing ports for the admission of water from the supply-tube to the compressing-chamber, an actuating-piston on said main valve, a controlling-valve governing ports for the admission of water to opposite sides of the actuating-piston, a piston on said controlling-valve, and means for effecting a limited exhaust of water through said piston in the preliminary portion of the traverse of the controlling-valve in one direction, and a free exhaust around said piston in the succeeding portion of the same.

10. The combination, substantially as set forth, of a water-supply tube, a compressing-chamber, a main valve governing ports for the admission of water from the supply-tube to the compressing-chamber, an actuating-piston on said main valve, a tubular controlling-valve governing ports for the admission of water to opposite sides of the actuating-piston, a restricted port for the exhaust of water through an end piston on the controlling-valve, and through the body thereof during its preliminary traverse in one direction, a regulating device for varying the discharge area of said restricted port, ports in the body of the controlling-valve, of sufficient area for the full exhaust of water, and a valve-chamber for the controlling-valve having a space of larger diameter than the end piston in which the restricted exhaust-port is formed, through which space said end piston traverses during the latter portion of its stroke in one direction.

11. The combination, substantially as set forth, of a water-supply tube, a compressing-chamber, a main valve governing ports for the admission of water from the supply-tube to the compressing-chamber, an actuating-piston on said main valve, a controlling-valve governing ports for the admission of water to opposite sides of the actuating-piston, differential pistons on said controlling-valve, a passage for admitting water from the supply-tube to a smaller piston area of the controlling-valve, a check-valved passage for admitting water from the compressing-chamber to a larger piston area of the controlling-valve, and an adjusting device for varying the delivery area of said check-valved passage.

12. The combination, substantially as set

forth, of a water-supply conduit, a conical compressing-chamber communicating at its larger end therewith, a conical deflector, fixed in the compressing-chamber concentrically therewith, a reservoir, a check-valved passage connecting the smaller end of the compressing-chamber with the reservoir, and an automatic valvular mechanism for intermittently supplying water, under the impact of a fall from a height, to the compressing-chamber.

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