(No Model.) 3 Sheets—Sheet 1.

F. W. GORDON.

FLUID COMPRESSOR.

No. 583,049. Patented May 25, 1897.

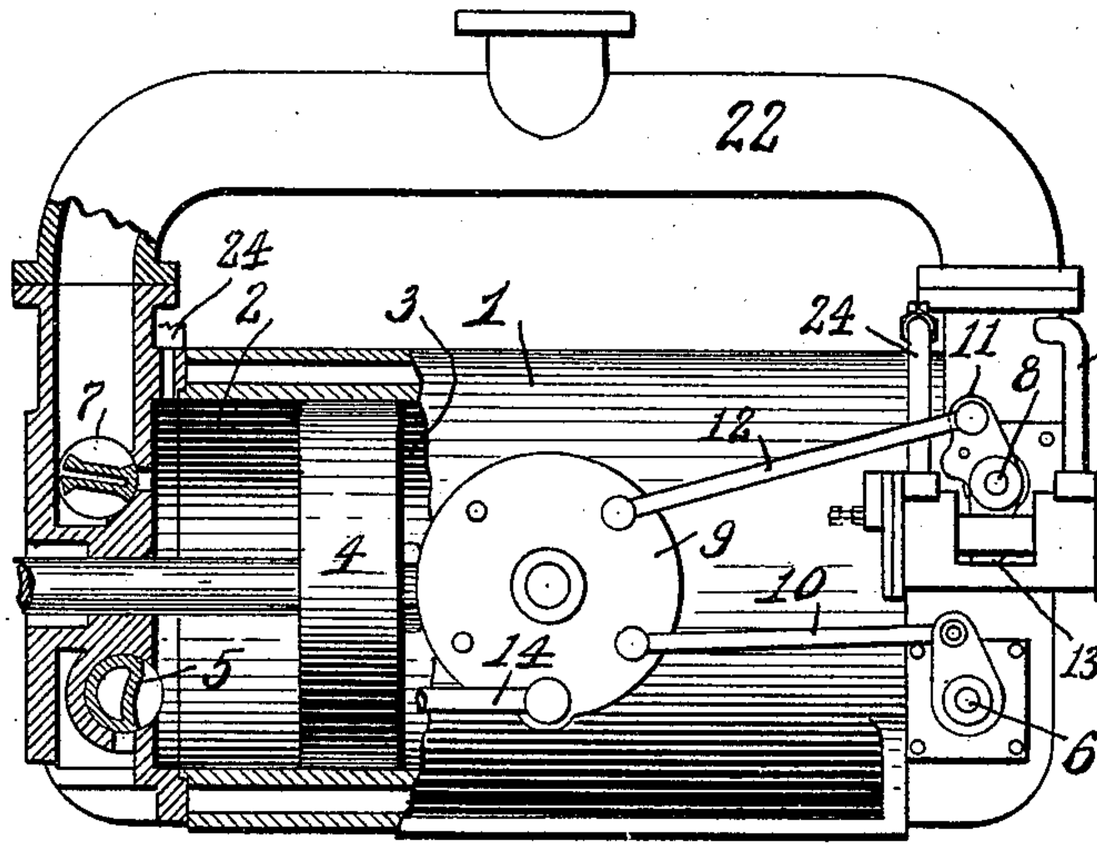

FIG. 1.

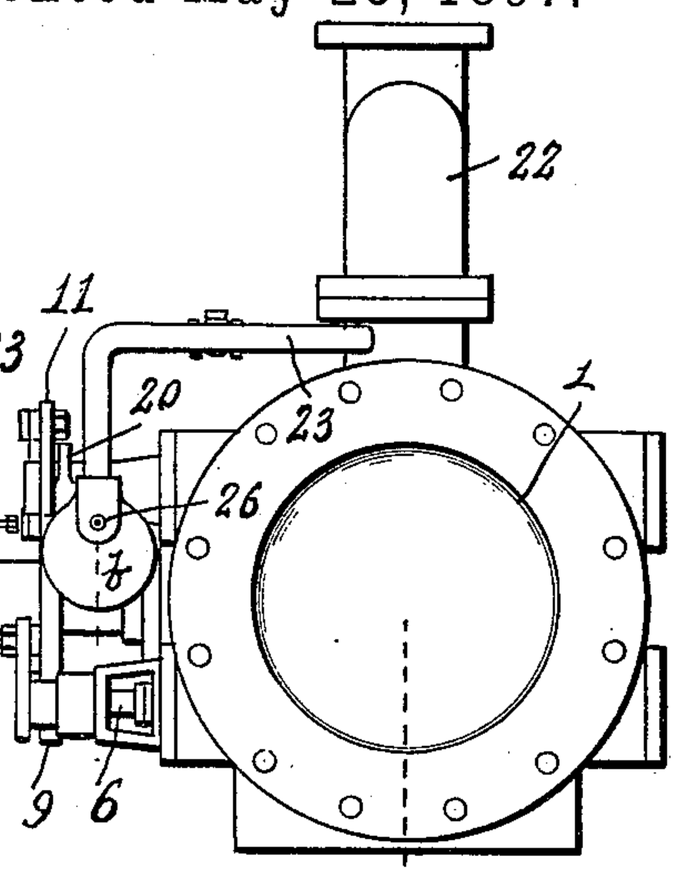

FIG. 2.

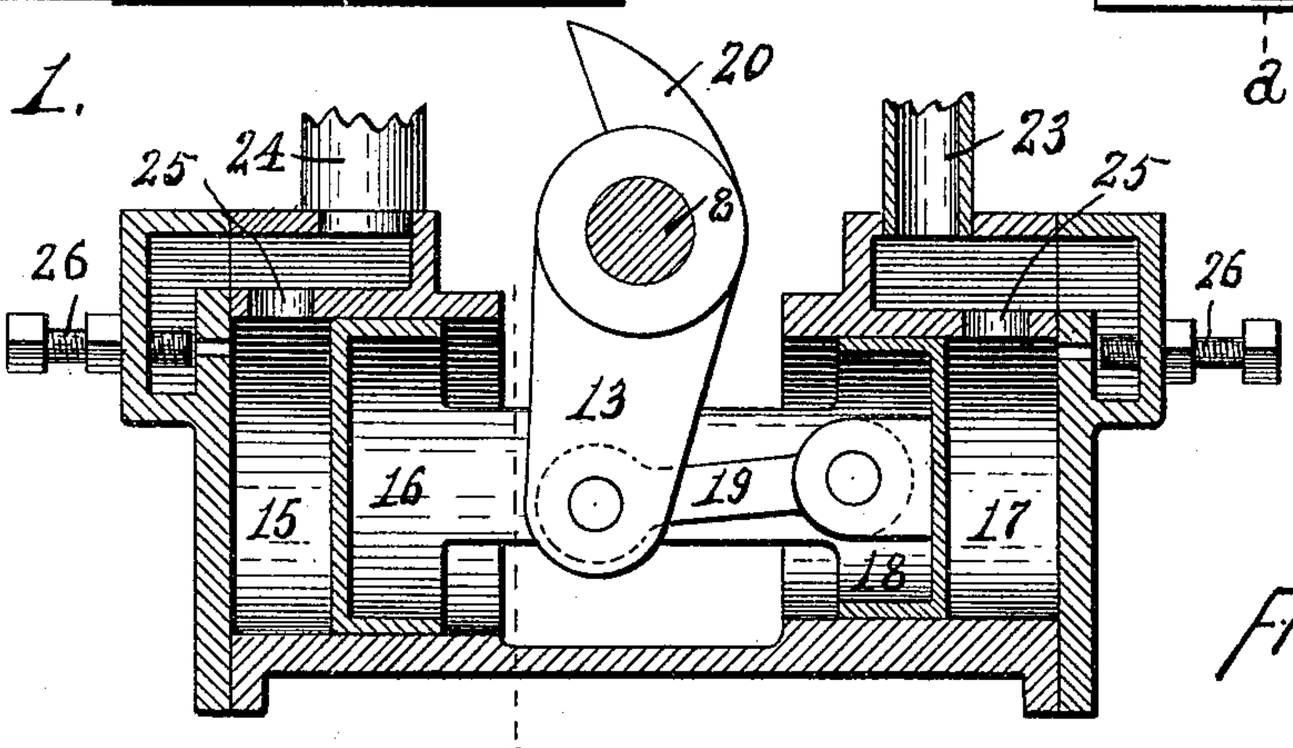

FIG. 3.

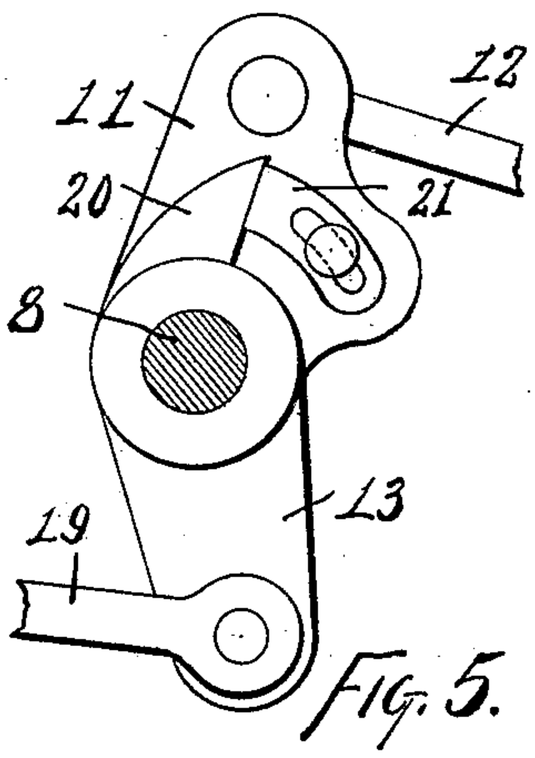

FIG. 5.

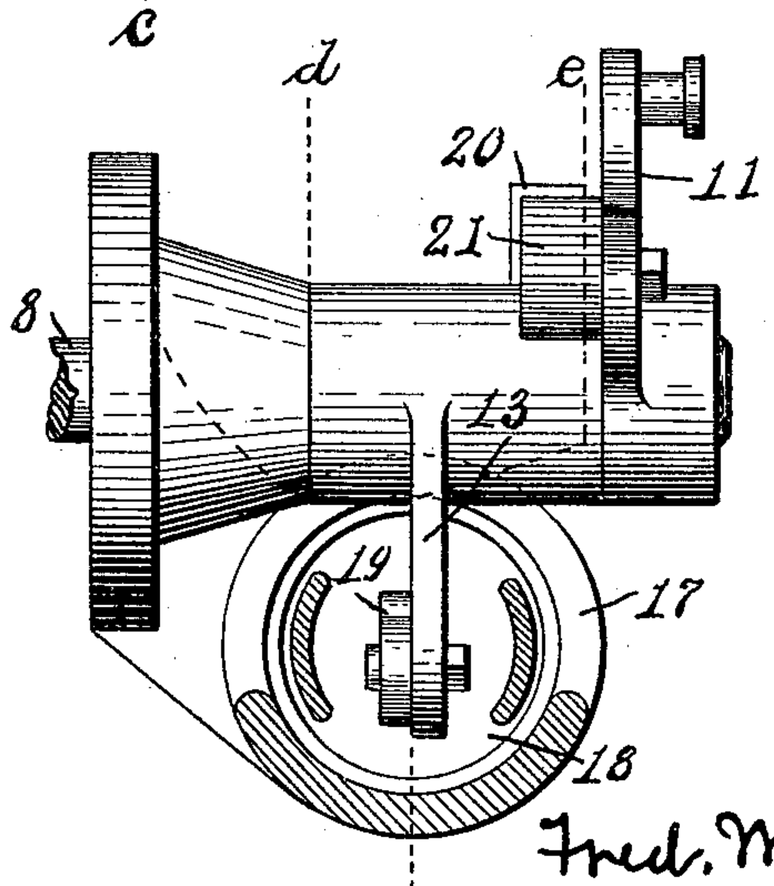

FIG. 4.

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(No Model.) 3 Sheets—Sheet 2.

F. W. GORDON.

FLUID COMPRESSOR.

No. 583,049. Patented May 25, 1897.

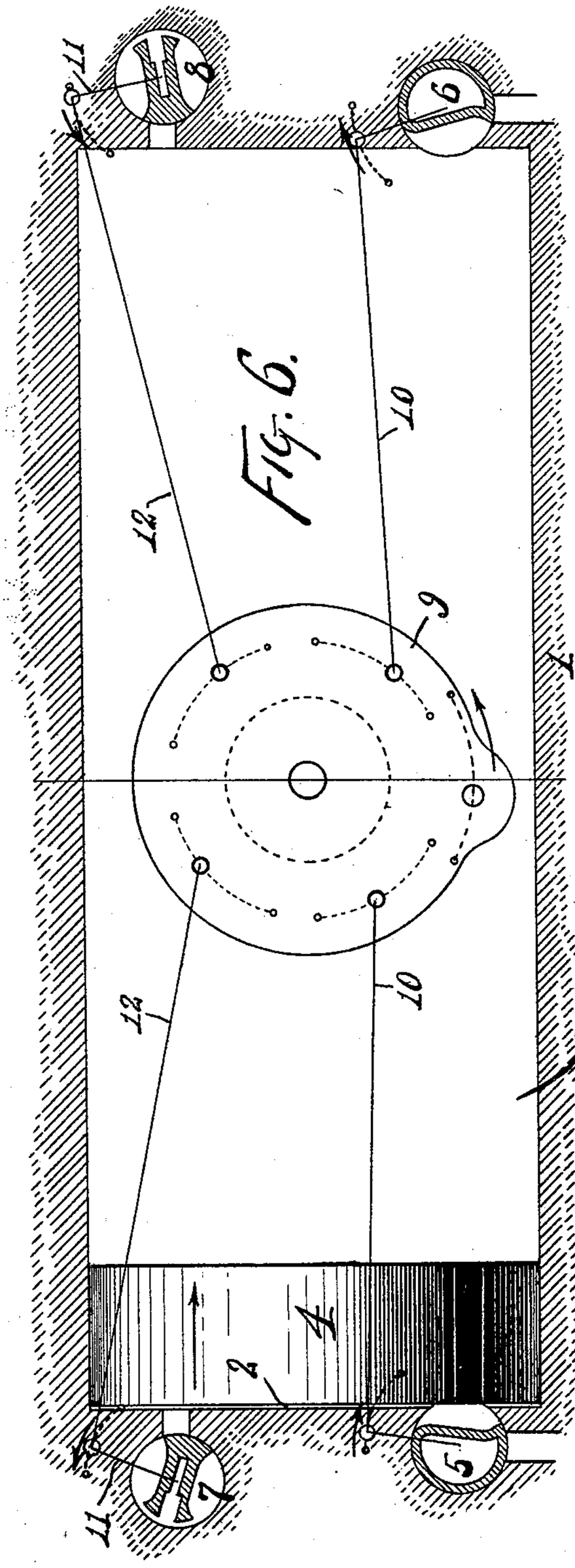

FIG. 6.

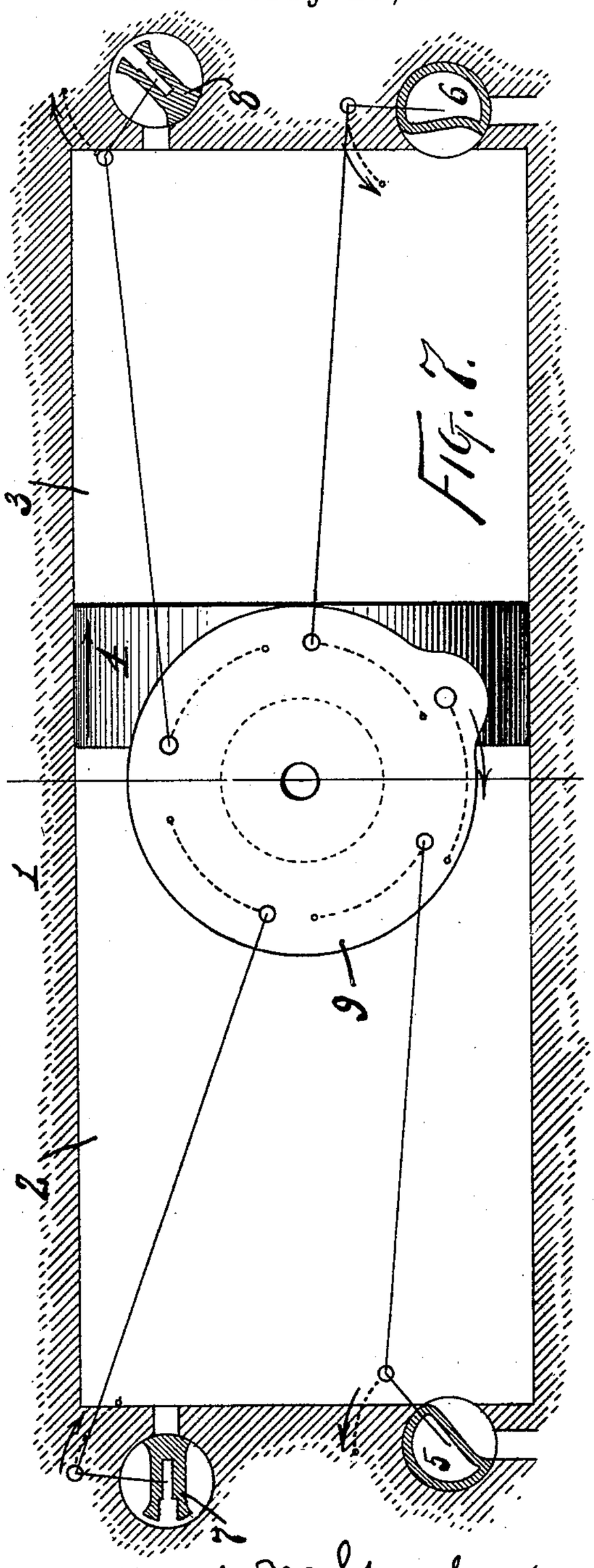

FIG. 7.

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3 Sheets—Sheet 3.

F. W. GORDON.

FLUID COMPRESSOR.

No. 583,049. Patented May 25, 1897.

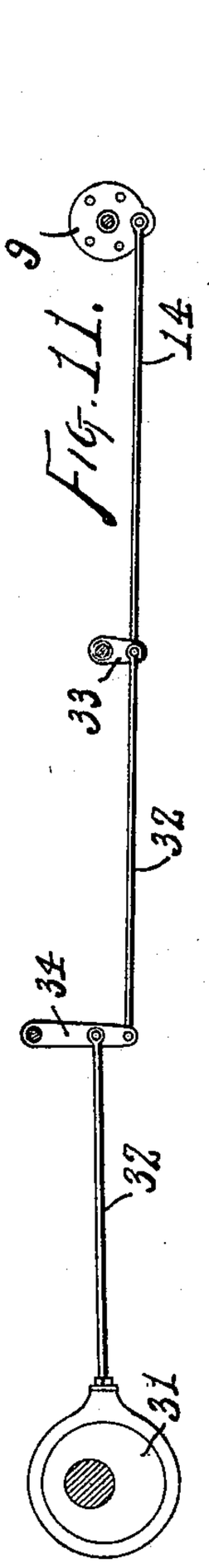

Fig. 11.

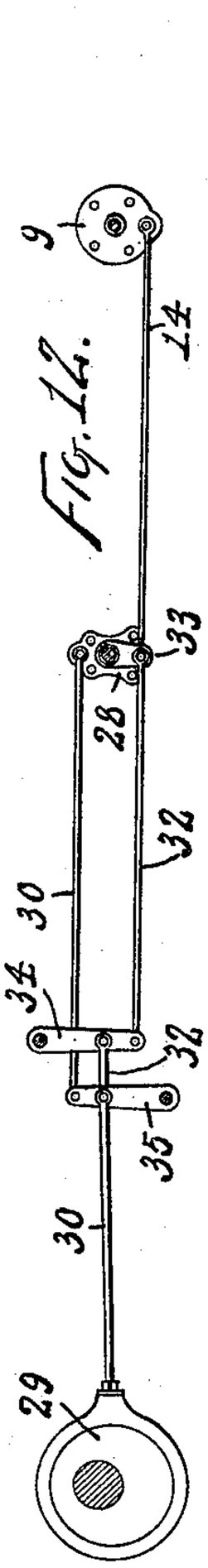

Fig. 12.

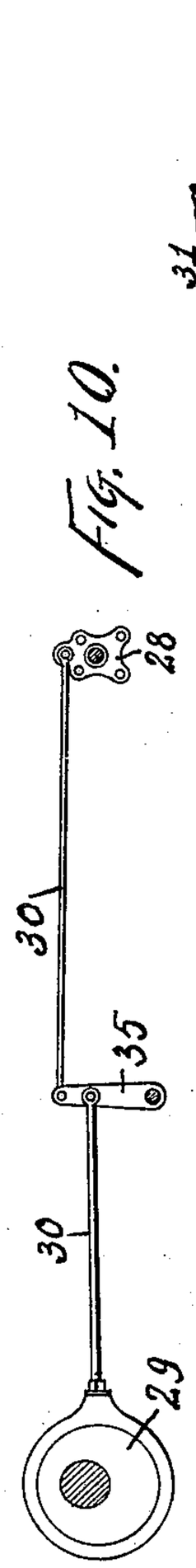

Fig. 10.

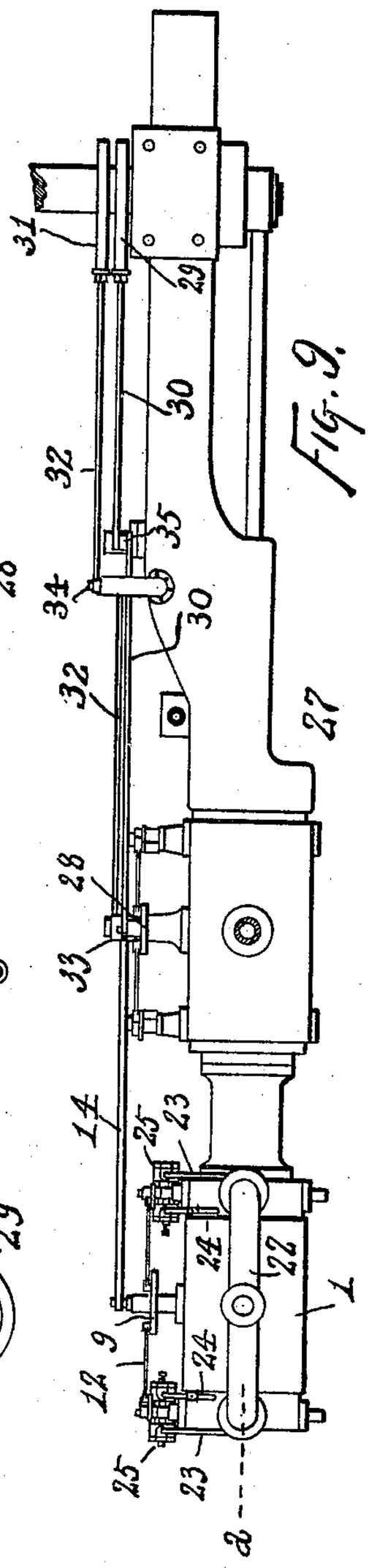

Fig. 9.

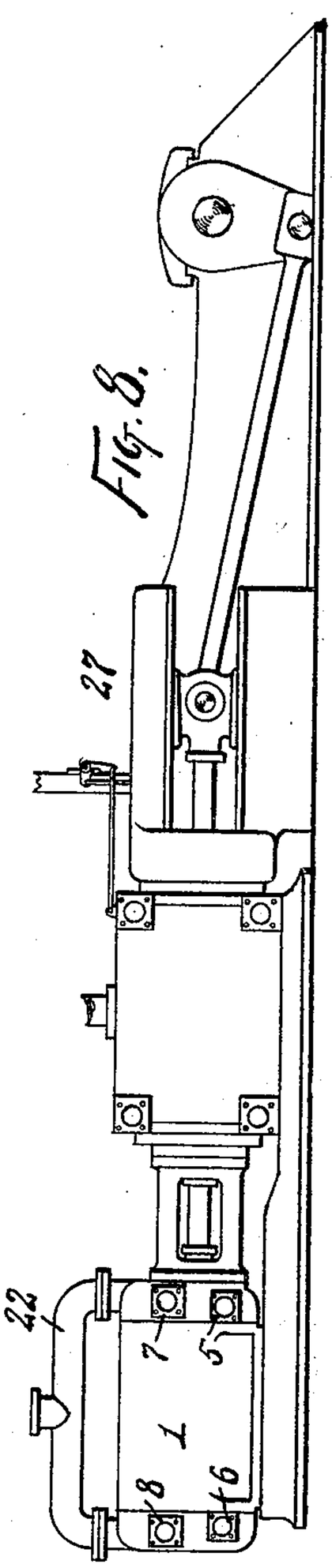

Fig. 8.

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UNITED STATES PATENT OFFICE.

FREDERICK W. GORDON, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO THE PHILADELPHIA ENGINEERING WORKS, LIMITED, OF SAME PLACE.

FLUID-COMPRESSOR.

SPECIFICATION forming part of Letters Patent No. 583,049, dated May 25, 1897.

Application filed February 29, 1896. Serial No. 581,262. (No model.)

To all whom it may concern:

Be it known that I, FREDERICK W. GORDON, of Philadelphia, Philadelphia county, Pennsylvania, have invented certain new and useful Improvements in Fluid-Compressors, of which the following is a specification.

This invention pertains to improvements in fluid-compressors, such as air-compressors, gas-compressors, blowing-engines, and the like, and relates to improvements in the system of control for the discharge-valves.

My improvements will be readily understood from the following description, taken in connection with the accompanying drawings, in which—

Figure 1 is a side elevation, part vertical longitudinal section, of a fluid-compressor exemplifying my invention; Fig. 2, an end elevation thereof; Fig. 3, a vertical longitudinal section (plane of line *e* of Fig. 4) of one of the valve-controlling devices; Fig. 4, a vertical transverse section of the same in the plane of line *c* of Fig. 3; Fig. 5, a rear elevation of one of the valve-arms 11 and its immediate accessories, the valve-stem 8 appearing in section in the plane of line *d* of Fig. 4; Fig. 6, a diagram of the compressor cylinder and valves in one position of stroke; Fig. 7, a similar diagram at another position of stroke; Fig. 8, a side elevation of the compressor of Fig. 1, shown in conjunction with an actuating steam-engine; Fig. 9, a plan of the same; Fig. 10, a diagram of the connections between eccentric and wrist-plate of the steam-engine valve-gear; Fig. 11, a similar diagram pertaining to the valve-gear of the compressor, and Fig. 12 a similar diagram embodying the valve-gears of steam-engine and the compressor.

In the following specification the term "cylinder," when used without qualification, is to be understood as referring to the compressor-cylinder. Under some practical conditions a compressor will receive air directly from the atmosphere, while in other cases the air or other fluid to be compressed may be received from a preliminary compressor or under conditions of preliminary compression. For exemplification I have chosen a compressor receiving air from the atmosphere, and when in this specification I use the term "air" it is to be understood as meaning the fluid which the compressor is to receive, regardless of whether it be air or other fluid, air at atmospheric pressure or at other pressure. For exemplification I have chosen to show my compressor as actuated directly by the piston-rod of a steam-engine of the well-known Corliss type.

In the drawings, confining attention for the present exclusively to Figs. 1 to 5, inclusive, 1 indicates the compressor-cylinder, hereinafter referred to simply as the "cylinder;" 2, cylinder-space to the left of the compressor-piston; 3, cylinder-space to the right of the compressor-piston; 4, compressor-piston; 5, left-hand inlet-valve of rotary type and disposed in the cylinder-head; 6, right-hand inlet-valve; 7, left-hand discharge-valve; 8, right-hand discharge-valve, all the valves being in the cylinder-heads and the discharge-valves acting on ports leading from the cylinder into the valve-seats and the valves being slotted to permit them to retreat from their seatings under excessive pressure when covering their ports; 9, wrist-plate of compressor; 10, inlet-valve rods connecting arms on the inlet-valves with the wrist-plate, the arrangement being similar to the valve-gear of the Corliss steam-engine; 11, arms loose on the stems of the discharge-valves; 12, rods connecting these arms with the wrist-plate; 13, arms fast on the stems of the discharge-valves, and as the arrangement is the same for both discharge-valves the description will hereinafter be confined to the singular; 14, actuating-rod for the wrist-plate; 15, a cylinder mounted near the discharge-valve with which it is to coöperate, this cylinder being hereinafter termed the "major" cylinder; 16, piston for that cylinder; 17, a cylinder in line with cylinder 15, but of less diameter and hereinafter termed the "minor" cylinder; 18, piston of the minor cylinder, connected with the piston of the major cylinder so that both move together; 19, link connecting arm 13 with the united pistons 16 and 18; 20, a tappet projecting from the hub of arm 13, which arm, as before stated, is fast on the stem of the discharge-valve; 21, a tappet fast on arm 11, which is operated from the wrist-plate by rod 12, tappet 21 being adapted, as rod 12 pushes upon arm 11, to engage tappet 20 and force the discharge-valve to closed position,

tappet 21 being preferably adjustable with reference to arm 11; 22, discharge connection from the compressor, having connection with both discharge-valves and of course containing fluid at the pressure of discharge; 23, a pipe placing the discharge connection in communication with a minor cylinder; 24, a pipe placing the major cylinder in communication with its appropriate end of the compressor-cylinder, the major and minor cylinders with their accessories forming, when taken as a whole, the controlling device for the discharge-valve, it being understood, of course, that each of the two discharge-valves is similarly provided; 25, the admission-ports to the major and minor cylinders, so disposed as to be overrun by their pistons to secure a cushioning effect as the pistons complete their strokes, and 26 valves adjustably controlling secondary admission-ports to the major and minor cylinders to permit the admission of fluid when their main ports 25 are covered after cushioning.

Where the compressor-piston receives its motion from or in correspondence with the movement of a crank, the wrist-plate of the compressor may best be operated from an eccentric on the crank-shaft. I have shown for mere purposes of illustration the compressor as being actuated from the piston-rod of a steam-engine of the Corliss type, the valve-gear of the compressor being actuated by an eccentric on the crank-shaft. This exemplification may now be considered in connection with Figs. 8 to 12, inclusive, in which—

27 indicates a steam-engine of the Corliss type arranged tandem to the compressor, the piston-rod of the engine being prolonged to form the piston-rod of the compressor; 28, wrist-plate of the engine; 29, eccentric of the engine valve-gear; 30, rods connecting end of eccentric 29 to engine wrist-plate 28; 31, eccentric on the engine-shaft for operating the compressor valve-gear; 32, rods connecting this eccentric with the compressor wrist-plate 9, through the medium of actuating-rod 14, heretofore referred to; 33, idle-rocker in this rod system of the compressor valve-gear, this rocker being mounted at the axis of the engine wrist-plate, but having no connection with it; 34, a second idle-rocker in this rod system of the compressor valve-gear, and 35 an idle-rocker in the eccentric-rod system of the engine valve-gear.

The compressor-eccentric should be set eighty-seven degrees in advance of the crank, so that the inlet-valves of the compressor will open after the crank has passed the center three degrees, though these valves will be controlled somewhat by the amount of compression and the extent of clearance in the compressor.

Referring back to Figs. 1 to 5, inclusive, the action of the wrist-plate on arm 11 is to push the discharge-valve to closed position through the medium of the tappets, and arm 11 is at liberty to make its retreating motion without influencing the valve. As the valve is thus forced to position of closure the major and minor pistons move toward the major cylinder. The major cylinder 15 always contains fluid at pressure corresponding with its appropriate end of the compressor-cylinder, while the minor cylinder 17 always contains fluid at pressure corresponding with that of discharge from the compressor. Movement of the major piston as effected by pressure upon it tends to move arm 13 and open the discharge-valve. The movement of the major piston is opposed by the pressure acting on the minor piston. A valve-opening movement due to the pistons must therefore result from excess of energy on the major piston due to the excess of pressure upon it or due to its superior area. When the valve is pushed to closed position by the action of the wrist-plates through the tappets, the movement of the valve is resisted by the pressure on the major piston and aided by the pressure on the minor piston, and the preponderance of resistance, if any, must be overcome by the action of the wrist-plate.

The general valve behavior may be understood from Figs. 6 and 7. Fig. 6 shows the pressure-piston just beginning its stroke to the right. All valves are closed, having been put in that position by the wrist-plate. Cylinder-space 2, representing the clearance, will have a pressure the same as discharge connection 22. Cylinder-space 3 will have the pressure of the atmosphere or other fluid received by the compressor, the cylinder having just completely filled and the inlet-valve 6 been closed. Under these conditions the major piston pertaining to discharge-valve 8 will be under atmospheric pressure and the minor piston will be under the pressure of the discharge-main. Consequently the pressures have no tendency to open discharge-valve 8, but on the contrary the major piston will be against its cylinder-head and the discharge-valve 8 held to closed position. At the left end of the cylinder the minor and major cylinders are under equal pressures, and the opening of the valve would tend to result from the preponderating area of the major piston; but opening movement of this valve is prevented at this time by the action of the wrist-plate acting on the valve through its tappets. The piston now starts to the right from the position shown in Fig. 6, and all the valves remain closed. At valve 8 the wrist-plate is moving arm 11 idly back, leaving the valve closed. Inlet-valve 6 is increasing its lap. Inlet-valve 5 has not exhausted its lap. The pressure in clearance-space 2 quickly drops by expansion, thus causing the minor piston pertaining to valve 7 to become effective in increasing the lap of that valve and holding it closed, valve 7 going to full lap either by the positive action of the wrist-plate or by the anticipating effect of the minor piston. When the piston shall have so far advanced that pressure in space 2 equals that of the

air to be dealt with, then the wrist-plate will open inlet-valve 5, and that valve will stay open till the stroke is completed, whereupon it will close. As the piston advances to the right the fluid to the right of the piston will rise in pressure, thus increasing the pressure of the major-piston-controlling valve 8. When that pressure is sufficient, with reference to the greater diameter of the major piston, the friction of valve movement can be overcome and valve 8 will be quickly opened, valve positions being then as indicated in Fig. 7. The compressed fluid now goes to the discharge-main, and at the end of the stroke the wrist-plate will have closed all valves ready for the beginning of a new stroke.

Compressors have heretofore been devised in which the positive valve-gear closed the discharge-valve, a latch then going into operation and holding the valve closed while the positive gear retreated, the latch being later disengaged by the action of a piston under the influence of the pressure beyond the discharge-valve, this disengagement of the latch permitting the valve to be opened by the action of a special valve-opening motor in the form of a suspended weight or a strained spring or a vacuum-engine. The general results attained by such construction are substantially the same as under my system, but the device is open to the objection that it involves the presence of a spring-latch and a valve-opening motor independent of the motor which disengages the latch. In my system I dispense with the spring and need no independent valve-opening motor, a single moving piece—namely, the differential piston—constituting the sole agent for determining the time at which the valve shall open and for opening it and for holding it open till the time arrives for it to be closed by the positive valve-gear. I disclaim a system in which a latch and a latch-disengaging motor and an independent valve-opening motor are involved.

Compressors have also been devised in which the discharge-valve was closed and held closed by the action of a steam or other fluid compressor motor, such motor tending at all times to close the valve irrespective of its position, the valve being opened against the constant tendency of the valve-closing motor by the action of a piston under the influence of the differential pressures of the compressor. In such device the valve-opening piston could not perform its duty till pressure was sufficient in preponderance to overcome not only the friction of the valve, but also the entire resistance offered by the constantly-strained valve-closing motor. Furthermore, when the main piston reached the end of its compressing-stroke the discharge-valve should be promptly closed, but in the device in question this could not take place, for a condition precedent to the closing of the discharge-valve was a reduction of the pressure which opened the valve, the consequence being that the valve would only close when the main piston, after completing its stroke, retreated far enough to effect an adequate reduction in the clearance-space, and it will be obvious that the retreating main piston, retreating while the discharge-valve is open, will be followed up by fluid regurgitating from the receiver, under which conditions the discharge-valve could not close unless the area opened by it was so contracted as to throttle the regurgitating fluid and permit of some expansion of the fluid in the clearance-space. The nature of the device was also such that special cushioning devices were required to arrest the movement of the valve at each terminal of its motion.

In my device I employ no fluid-pressure motor or other elastic means for closing the valve. I provide for closing the valve sharply at proper time by means of positive gear having positive connection with and moving in correspondence with the main piston of the compressor. It is thus practicable to close the discharge-valve when the main piston reaches the end of its compressing-stroke and to hold the valve closed while the piston retreats, thus avoiding regurgitation of compressed fluid into the clearance-space. I employ no constantly-strained valve-closing motor, but close the valve by positive means, and I employ no special cushioning devices, a single moving piece—namely, the differential piston—serving as the means for determining when the discharge-valve shall be opened, and serving as the sole agent for opening the valve and for holding it open, and serving as the cushioning agent at the extremities of the valve motion, and the valve-opening piston is loaded with no duty of overcoming the energy of the valve-closing means. I disclaim a device in which the discharge-valve is closed by the action of a constantly-acting special motor constantly exerting itself against the influence of the valve-opening motor.

I claim as my invention—

1. In a fluid-compressor, the combination, substantially as set forth, with the compressor-cylinder and discharge-valve, of a device under the direct influence of the piston of the compressor and arranged to give said valve its closing motion only, a differential piston having its major area in fluid communication with the receiving side of said valve and having its minor area in communication with the discharge side of said valve, and a positive connection between said differential piston and valve to cause the valve to open and be held open by the preponderating effect of pressure on the major area of said differential piston.

2. In a fluid-compressor, the combination, substantially as set forth, with the compressor-cylinder and discharge-valve, of valve-gear positively connected with and moving in correspondence with the main piston of the compressor and connected with said discharge-valve and acting to give it its closing

motion only, a differential piston having its major area in fluid communication with the receiving side of said valve and having its minor area in communication with the discharge side of said valve, and a positive connection between said differential piston and valve to cause the valve to open and be held open by the preponderating effect of pressure on the major area of said differential piston.

3. In a fluid-compressor, the combination, substantially as set forth, with the compressor-cylinder, discharge-valve, and inlet-valve, of a crank-shaft connected with the compressor-piston, an eccentric on the crank-shaft, connections between the eccentric and said valves to open and close the inlet-valve and close the discharge-valve and then leave the discharge-valve free of said connections till a second closure of the discharge-valve is in order, a differential piston positively connected with the discharge-valve, a fluid communication from the minor area of the differential piston to the discharge side of the discharge-valve, and a fluid communication from the major area of the differential piston to the receiving side of the discharge-valve.

4. In a fluid-compressor having a crank-shaft, the combination, substantially as set forth, of an inlet-valve, a discharge-valve, an eccentric on the crank-shaft, a wrist-plate rocked by the eccentric, a link connecting the wrist-plate positively with the inlet-valve, a link connecting the wrist-plate with a tappet on the discharge-valve to cause the wrist-plate to produce the closing motion only of the discharge-valve, and a differential piston positively connected with the discharge-valve and having its minor area exposed to the pressure at the discharge side of the discharge-valve and its major area exposed to the pressure at the receiving side of the discharge-valve.

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