No. 746,019. PATENTED DEC. 8, 1903.

T. N. CASE.

AIR PUMP.

APPLICATION FILED MAY 22, 1903.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 2.

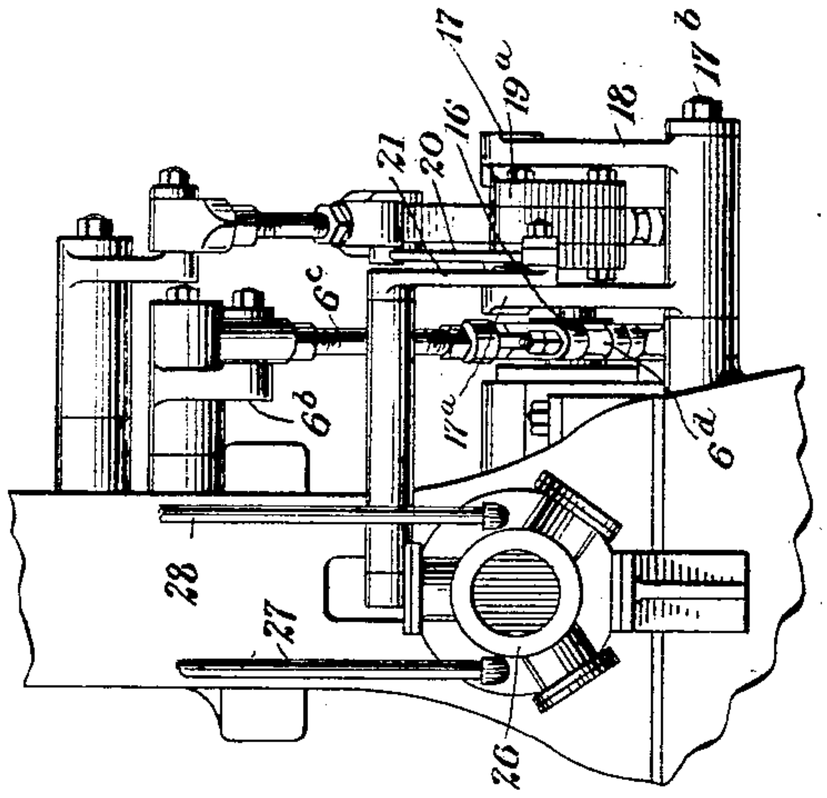

Fig. 1.

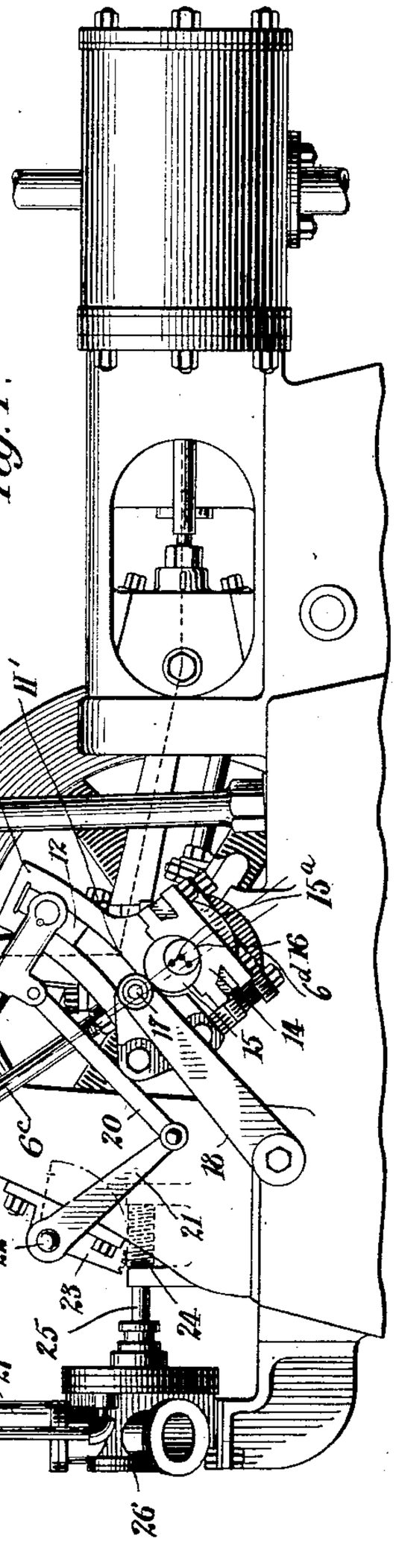

Fig. 7.

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NO MODEL. 3 SHEETS—SHEET 2.

Fig. 4.

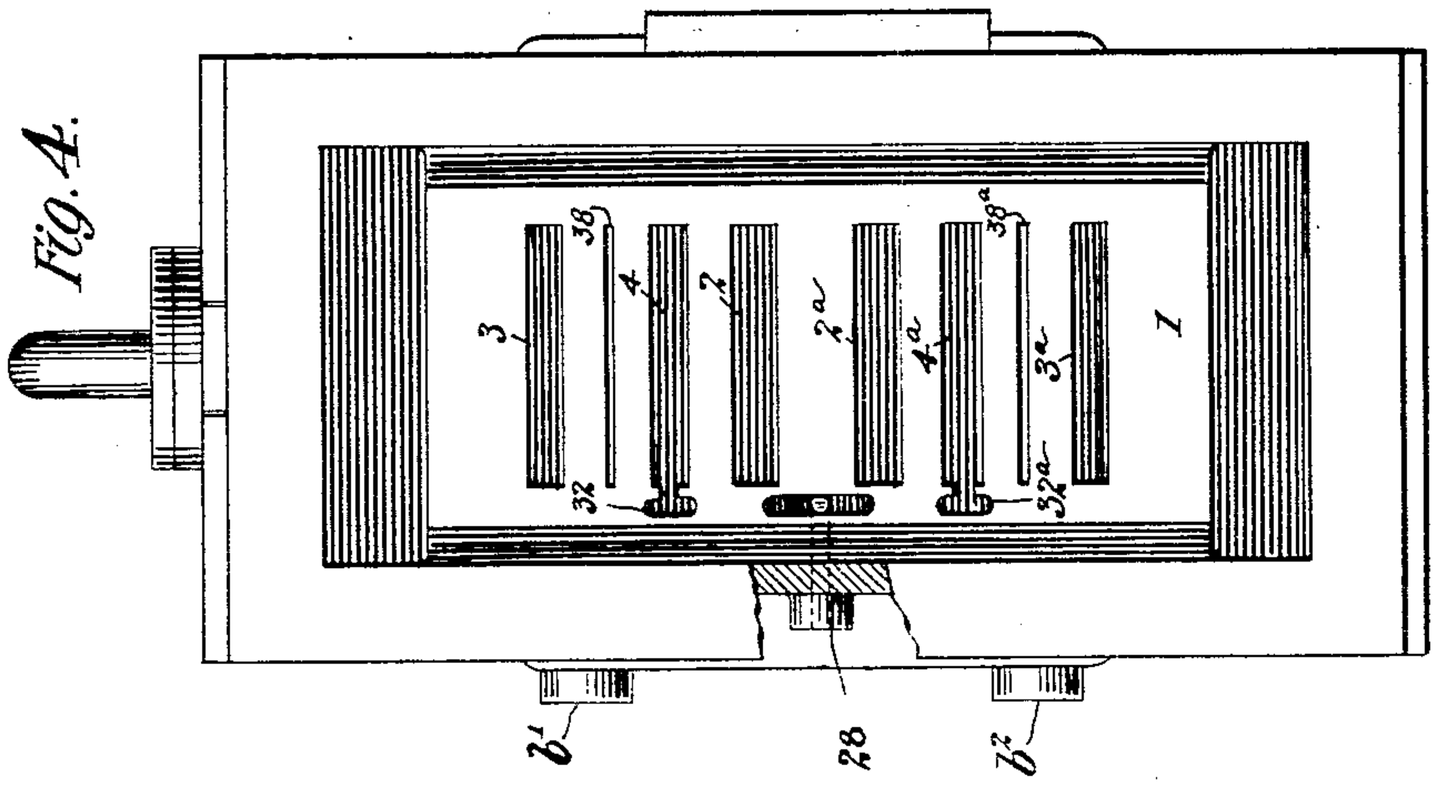
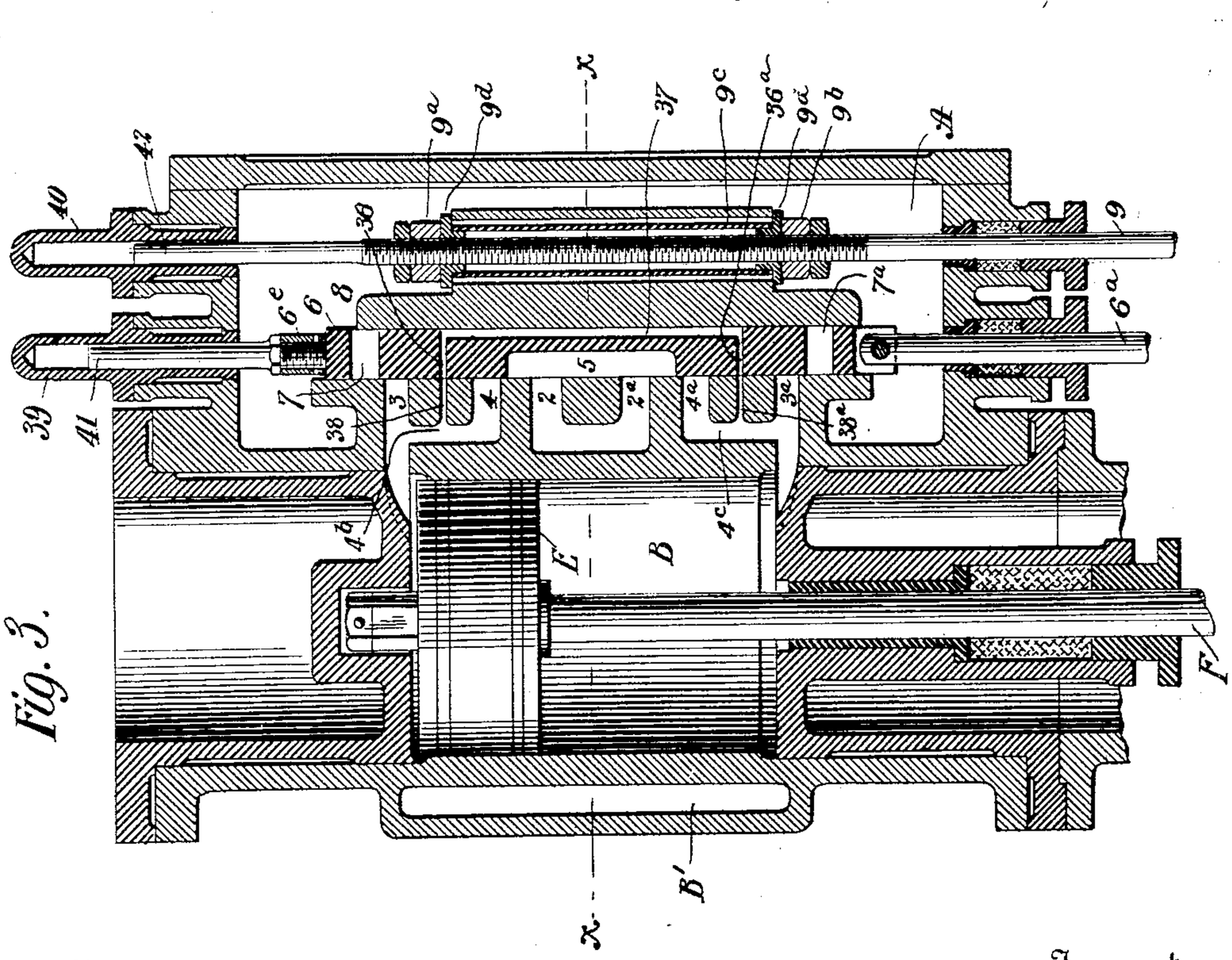


Fig. 3.



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No. 746,019. PATENTED DEC. 8, 1903.

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AIR PUMP.

APPLICATION FILED MAY 22, 1903.

NO MODEL. 3 SHEETS—SHEET 3.

Fig. 6.

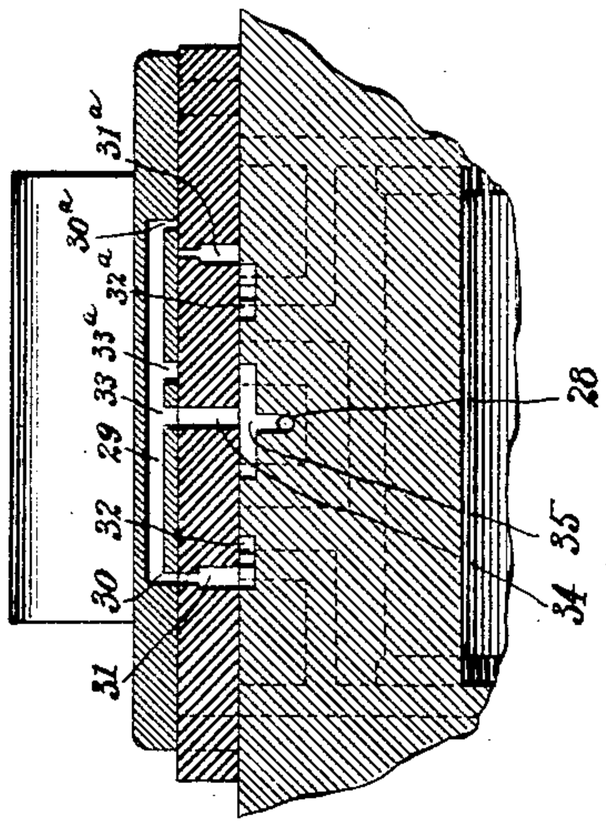

Fig. 5.

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No. 746,019. Patented December 8, 1903.

UNITED STATES PATENT OFFICE.

THEODORE N. CASE, OF MOUNT VERNON, NEW YORK.

AIR-PUMP.

SPECIFICATION forming part of Letters Patent No. 746,019, dated December 8, 1903.

Application filed May 22, 1903. Serial No. 158,224. (No model.)

To all whom it may concern:

Be it known that I, THEODORE N. CASE, a citizen of the United States, residing at Mount Vernon, Westchester county, State of New York, have invented certain new and useful Improvements in Air-Pumps, of which the following is a full, clear, and exact description.

My invention relates to improvements in air-pumps, said improvements being particularly adapted for pumps which are to be operated at a high speed and having for their object the production of a simple and efficient apparatus for compressing or exhausting air or other gases.

The following is a description of an application embodying my invention, reference being had to the accompanying drawings.

Figure 1 is a side elevation of a pump embodying my improvements. Fig. 2 is an end elevation of a portion of the same. Fig. 3 is a longitudinal section of the air-cylinder, valve-chamber, and valves. Fig. 4 is a plan view of the main-valve seat of the cylinder. Fig. 5 is a horizontal section of the cylinder on the line $x\ x$, Fig. 3. Fig. 6 is a section of parts on the line $y\ y$, Fig. 5. Fig. 7 is a perspective of a detail.

Referring more particularly to the drawings, A is the valve-chamber, behind which is the air-cylinder B, Fig. 3, surrounded by the water-jacket B′, having inlet and outlet openings $b'\ b^2$.

C is the suction-port; D, the discharge-port; E, the piston within the cylinder B, and F the piston-rod connected to the cross-head G, which is operated by the rod H, connected to the crank-shaft of the engine in the ordinary way.

H′ is the center of the crank-pin, and H^2 is the center of the pin connecting the rod H to the cross-head G.

Within the valve-chamber A is the main-valve seat 1, having passages 2 2^a, connecting with the suction-port C, and discharge-passages 3 3^a, adapted to be connected with the discharge-port D. The passages 3 3^a connect with the respective ends of the air-cylinder B and also are connected, respectively, by passages 4^b 4^c with suction-passages 4 4^a, which are adapted to be alternately connected to the passages 2 2^a by the chamber 5 in the main slide-valve 6 at times when the one of the passages 3 3^a on the side on which connection is made is closed. The main valve 6 has openings 7 7^a, which when they register with the ports 3 3^a connect said ports with the discharge-port D, subject to the action of the release-valve 8, which slides upon the main valve 6 and controls the time of opening of the passages 7 7^a. The purpose of the release-valve 8 is to open the passages 7 7^a when the pressure within the cylinder has reached as near as may be the pressure of the valve-chamber.

The main valve 6 is operated by an eccentric on the main shaft 16 through the rod 6^a, crank 6^b, and rod 6^c, connected to the eccentric-strap 6^d. The cycle of the main valve 6 relative to the piston E is unvarying, and its stroke does not change. By changing the length of stroke of the release-valve 8 and the cycle of its positions relative to the main valve 6 the edges of the release-valve will uncover the edges of the discharge-ports 7 7^a at varying points in the stroke of the piston E. The variations are necessary to meet the varying conditions of pressure in either the suction or discharge ports, or both, for a given position of the piston E, so that the air ahead of the piston may be discharged when its pressure is approximately equal to that of the valve-chamber or the atmosphere.

The release-valve 8 is operated by the rod 9, which is connected to one arm of the crank 10, the other arm being connected to a radius-bar 11, whose lower end is connected to a link-block 12, sliding in the slot of the link 13, which link forms a part of or is rigidly connected with the strap 14 of the eccentric 15 upon the shaft 16 of the driving-engine. The link 13 is connected at the points 17 17^a with the base of the pump by a rocker 18, whose ends are pivoted to the link and to a projection on the base at 17 17^a 17^b, respectively. The link 13 is formed with projecting ears 19 19^a, so that the link-block 12 and the radius-bar 11, attached thereto, can slide along said link until the center of the block 12 is in line with the point 17 at which the rocker 18 is connected thereto. The position of the bar 11 and the link-block 12 is controlled by a rod 20, connected by flexible joints to the bar 11 and to a lever 21, which lever is connected to a shaft 22, on whose other end is a toothed

segment 23, which engages with a worm-gear 24, mounted on the shaft 25 of an air-motor 26. This motor 26 is connected by pipes 27 28 with the valve-chamber and the air-cylinder, respectively. The connection of pipe 27 with the valve-chamber is an uninterrupted connection. The connection of the pipe 28 with the air-cylinder takes place only at intervals, the connection being made just prior to the uncovering of the passages 7 7ª. This connection is made by a passage 29 in the slide-valve 8, having branches 30 30ª, which periodically register with passages 31 31ª in the main valve 6, which passages register with openings 32 32ª, connected with passages 4 4ª in the main-valve seat. The passage 29 has also openings 33 33ª, which alternately register with the passage 34 in the main valve, which passage is connected with an opening 35 in the main-valve seat leading to the pipe 28. The connection between the passages 30 and 31 being made just before the valve 8 uncovers the passage 7 of the valve 6, the pressure just prior to the beginning of the discharge is transmitted through the passage 29 to the pipe 28 and thence to the motor 26 or an intermediate motor-controlling device. A similar connection is made between the passages 30ª 31ª just prior to the beginning of the discharge through the passage 7ª, and the pressure due to it is also impressed upon said motor. If the pressure in the pipe 28 exceeds atmospheric pressure or the pressure of the valve-chamber in the pipe 27, the motor 26 will operate in such a direction as to move the segment 23, with its lever 21 and rod 20, so as to move the link-block 12, connected to the bar 11, within the link 13 in such a direction as to cause the eccentric 15 to operate the valve-stem 9 through the link 13, bar 11, and crank 10, so as to cause the valve 8 to uncover the passages 7 7ª somewhat earlier. Every change of position of the link-block 12 relatively to the link 13 produces a change in the cycle and length of stroke of the release-valve 8. The nearer the block 12 is to the point 17 the later will the release-valve uncover the ports 7 7ª in the main valve 6. If the pressure transmitted from the opening 32 through the passages 31 30 29 and from the opening 32ª through the passages 31ª 30ª 29ª to the pipe 28 is less than atmospheric or valve-chamber pressure, the motor 26 is operated in a reverse direction, so that it operates through the link 13 to cause the valve 8 to keep the passages 7 7ª closed until a later instant. By means therefore of a single valve 8, operated by eccentric 15 and controlled by the link 13 and the motor 26, I am able to uncover the ports 7 7ª at substantially the instant when the pressure within the cylinder equals the atmospheric or discharge pressure and to maintain them closed at all other times and to automatically adjust the release-valve to the conditions of varying pressure. In this way I avoid premature release and also the compression of air within the pump-cylinder to an unnecessary extent through using only positively-actuated devices.

The openings 31, 31ª, and 34 are on the same side of the main valve 6. The passage 29, with which the branches 30, 30ª, 33, and 33ª connect, is a straight passage and confined to one side of the release-valve 8. This makes the process of manufacture as simple as possible and provides the shortest possible air connection to the motor 26. The shorter this connection and the smaller the volume of air therein the quicker will the motor 26 feel the effect of changes of discharge-pressure in the pumping-cylinder.

The main valve 6, driven by its own eccentric, and the release-valve 8, driven by a link, such as I have shown, have never to my knowledge been used for controlling the discharge of air from an air-cylinder. In this combination, as shown, the center 15ª of the release-eccentric 15 lies on the same side of the center of the shaft as the center H′ of the piston-crank by which the connecting-rod of the pump-piston is actuated, so that 15ª reaches the limit of its stroke at the same time as does H′. In the construction shown

$$\frac{\text{length } 15^a - 17}{\text{radius of release eccentric}} = \frac{\text{distance } H' - H^2}{\text{radius of crank}}$$

and the point 17 will assume the same positions in its stroke relative to 15ª as the point H^2 (and with it the piston E) assumes relatively to the crank-pin H′. The effect of this feature is that the release-valve 8, driven by this point 17, whose movement is transmitted to the release-valve 8 in a reversed direction by the crank 10, partakes of exactly the same inequality of motion as does the pump-piston E when the center of the link-block 12 coincides with the point 17, the center about which the link turns. When the center of the block 12 is moved away from the center 17, the effect is to change the length of the stroke of the release-valve 8 and at the same time alter its cycle relative to the piston E, although the irregularities of its stroke following those of the piston E are still maintained. By reason of the relatively long eccentric rod or bar 6ᶜ valve 6 moves with practical symmetry on its seat with respect to the crank-center H′—that is, for the same angular position of the crank-center H′ on up and down strokes the edges of the main valve 6 will be found successively at the same distance from the center of the main-valve seat 1. The motion of the release-valve 8 relative to its seat on top of the main valve 6 will show irregularities of the same nature as if the main valve 6 were stationary. Thus if release takes place at three-quarter stroke of piston E on upstroke it will also take place at the same point on the downstroke of the piston. This evens up the amount of work done in each end of the pump-cylinder and meets the theoretical requirements of valve-gear very closely.

It is to be noted that I provide passages 4 4^a, connected with the passages 3 3^a by passages 4^b 4^c. These passages 4 4^a are auxiliary passages for connecting the ends of the cylinder with the suction-port C through the passages 2 2^a and chamber 5. There is an instant when all of these passages 3 4 3^a 4^a are closed by the valve 6, this instant being at the very ends of the up and down strokes of the piston E. I construct the main valve with a passage 36 37 36^a and the main-valve seat with passages 38 38^a, connected with passages 4^b 4^c and leading to the ends of the air-cylinder. At the time when the ports 3 4 3^a 4^a are all closed the passage 36 37 36^a registers with the passages 38 38^a, and thereby connects the two ends of the air-cylinder and causes the pressure at the two ends to be equalized, part of the compressed air on one side of the piston rushing through the connection 38 36 37 36^a 38^a to the other side of the piston. This enables the suction to be so much the greater upon the next succeeding stroke. The main valve is therefore a combined main valve and equalizing-valve. The equalizing-passage 36 37 36^a, with its ports 38 38^a, being independent of the discharge-ports 3 and 3^a can be constructed so as to make the equalizing period of any duration desired. Since the ports 36 36^a never cross ports 3 4 3^a 4^a, the passage 36 37 36^a is always filled with air at equalizing-pressure, so when equalizing occurs the volume of this passage is virtually neither added to nor subtracted from the clearance volume of the pump-cylinder.

The passage 37, which always contains air at equalizing-pressure, (which is when the pump is in operation always less than atmospheric or discharge pressure,) while it may be cored through the valve 6, in my present embodiment is on the rear surface of the valve 6 and is closed on one side by the valve 8. The valve 8 being subjected on its rear surface to the atmospheric or discharge pressure, the opening of the passage 37 results in an unbalanced area, so that the valve 8 is held to its seat by the atmospheric or discharge pressure.

The main valve 6 is surrounded by a frame 6^e, to which the rod 6^a is pivoted. The valve is free to move in the frame 6^e, so as to rise from its seat in case the pressure beneath from some abnormal cause is too great. The release-valve 8 is held from longitudinal movement on the rod 9 by nuts 9^a and 9^b, bearing against the tube 9^c, which the valve 8 surrounds, so as to leave the space for movement. The washers 9^d are spaced by the tube 9^c, so as not to clamp the valve 8, but rather to leave it free to lift from its seat on the main valve 6 in case the pressure beneath it becomes too great, thus again providing against injury from unusual and abnormal pressure.

It will be seen that in my new pump but a single release-valve is used, which is controlled, preferably, by automatic means, as shown, so as to uncover the ports in the main valve as soon as the pressure ahead of the piston equals the atmospheric or discharge pressure. This single valve is held to its seat by an unbalanced area, due to the difference between equalizing-pressure and atmospheric or discharge pressure, and the equalizing is effected by the main valve itself through independent ports in such a way that the period during which equalizing takes place can be definitely limited and is in no way dependent upon the size of the discharge-ports of the pump.

In case it is desired to operate two cylinders in tandem the stuffing-box caps 39 and 40 admit of removal. The tail-rods 41 and 42 can then be removed and valve-rods of the added cylinder put in their places, permitting of the addition without expensive reconstruction.

My invention admits of various modifications, and I therefore do not wish to be limited to precisely the embodiment shown and described, nor do I wish to be limited to the automatic adjustment of the release-valve, since it is obvious that the time of release can be modified by the manual movement of the slide within the link in place of the automatic arrangement.

What I claim is—

1. In a pump, the combination of an air-cylinder having a valve-seat, a piston in said cylinder, a main valve on said seat, a release-valve thereon, an eccentric, a strap thereon, a link for operating said release-valve, the link being rigidly connected to said strap and having a sliding connection for adjusting said release-valve, and a rocker connected to said link.

2. In a pump, the combination of an air-cylinder having a valve-seat, a piston in said cylinder, a main valve on said seat, a release-valve thereon, an eccentric, and a strap thereon, a link for operating said release-valve, the link being rigidly connected to said strap and having a sliding connection for adjusting said release-valve, a rocker connected to said link, and means for automatically adjusting said sliding connection.

3. In a pump, the combination of an air-cylinder having a valve-seat, a piston in said cylinder, a main valve on said seat, a release-valve thereon, an eccentric, and a strap thereon, a link for operating said release-valve, the link being rigidly connected to said strap and having a sliding connection for adjusting said release-valve, a rocker connected to said link, and an air-controlled means for automatically adjusting said sliding connection.

4. In a pump, the combination of an air-cylinder having a valve-seat, a piston in said air-cylinder, a main valve on said seat, a release-valve thereon, an eccentric, and a strap thereon, a link for operating said release-valve, said link being rigidly connected to said strap and having a sliding connection for adjusting said release-valve, a rocker connected to said

link, and means controlled by the cylinder and valve-chamber pressures for automatically adjusting said sliding connection.

5. In a pump, the combination of an air-cylinder having a valve-seat, a piston in said cylinder, a main valve on said seat, a release-valve thereon, an eccentric, and a strap thereon, a link for operating said release-valve, said link being rigidly connected to said strap and having a sliding connection for adjusting said release-valve, a rocker connected to said link, a worm and gear for controlling said sliding connection and air-controlled means for operating said worm.

6. In combination an air-cylinder, a piston working therein, suction and discharge ports therefor, a main valve controlling said ports and having an equalizing-passage connecting the two ends of the cylinder when said discharge and suction ports are closed and independent of said discharge and suction ports.

7. In combination an air-cylinder, a piston therein, suction and discharge ports therefor, a main valve, a release-valve thereon, said main valve having an equalizing-passage closed on one side by said release-valve and producing an unbalanced area on said release-valve.

8. In combination an air-cylinder, a piston therein, suction and discharge ports therefor, a main valve, a release-valve thereon, said main valve having an equalizing-passage closed on one side by said release-valve and producing an unbalanced area thereon, said equalizing-passage being connected to the ends of the cylinder when the suction and discharge ports are closed and independent of said ports.

9. In combination an air-cylinder having a valve-seat, a piston in said cylinder, a main valve having suction and discharge passages, and an equalizing-passage, said main-valve seat having independent equalizing-ports.

10. In an air-pump, the combination of a cylinder, a piston therein, suction and discharge ports therefor, a main valve, a release-valve, an automatic motor device for adjusting said release-valve, said main and release valves having openings communicating with said cylinder and also with said motor device just prior to the beginning of the discharge on both strokes of the piston, the openings communicating with the cylinder and motor devices on one stroke being on the same side of the main and release valves as the openings communicating with the cylinder and motor device on the other stroke.

Signed at New York city, New York, this 21st day of May, 1903.

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