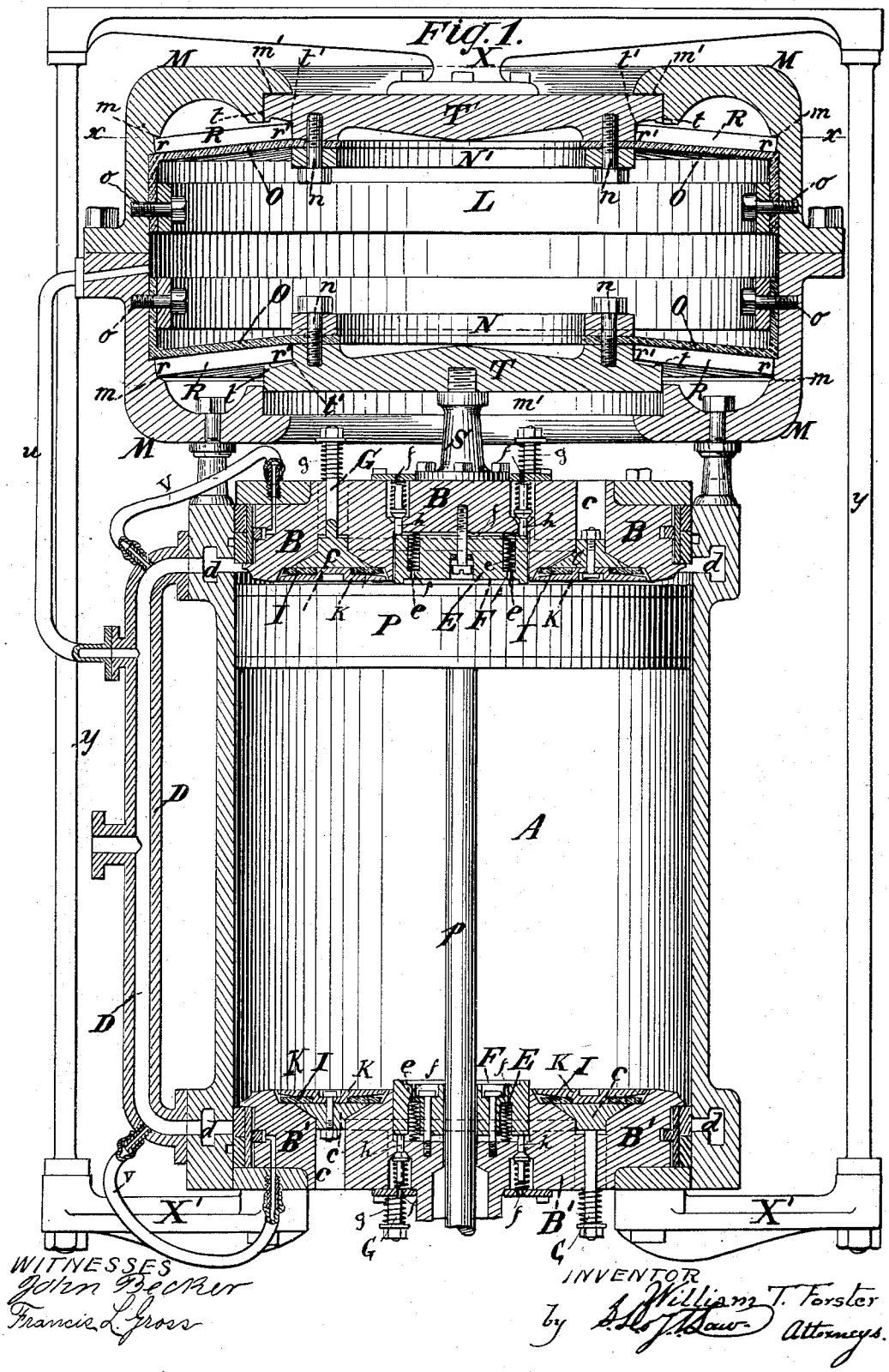
(No Model.) 2 Sheets—Sheet 1.

W. T. FORSTER.

AIR COMPRESSOR.

No. 375,929. Patented Jan. 3, 1888.

Fig. 1.



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(No Model.) 2 Sheets—Sheet 2.

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Fig. 2.

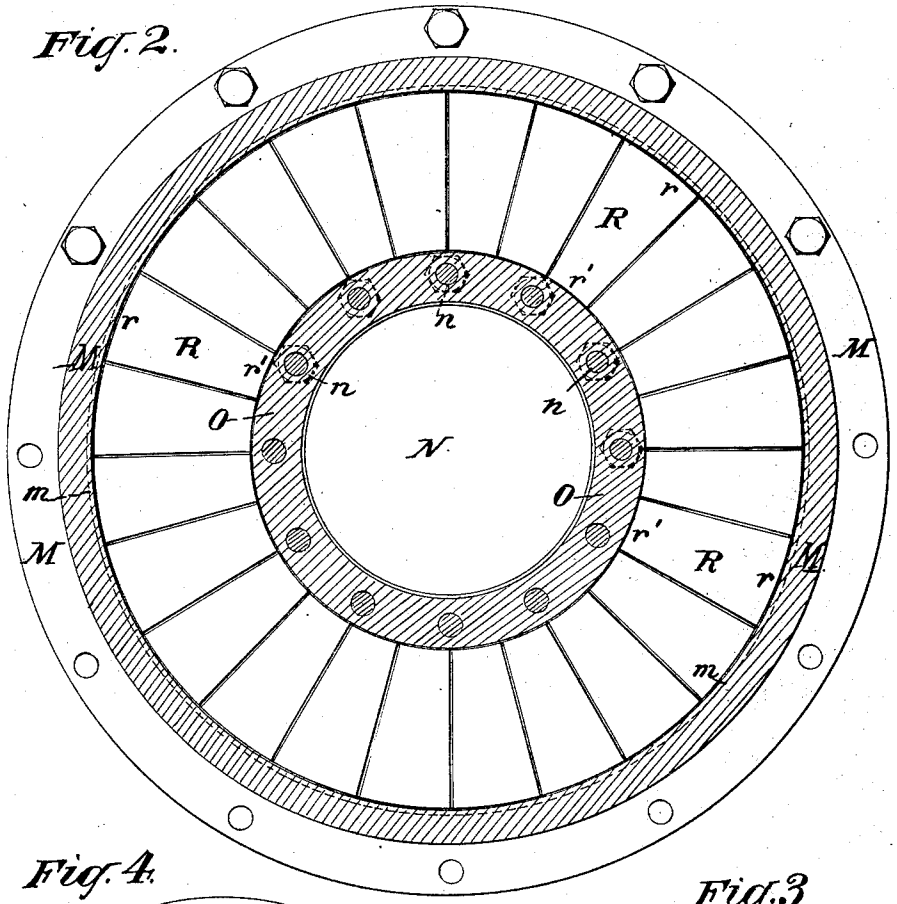


Fig. 4.

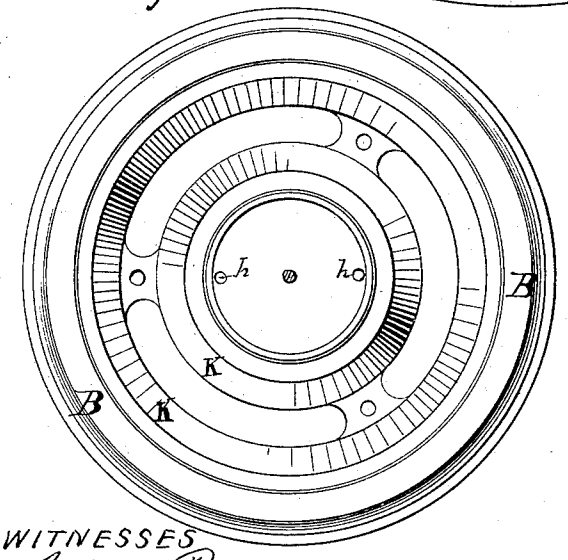
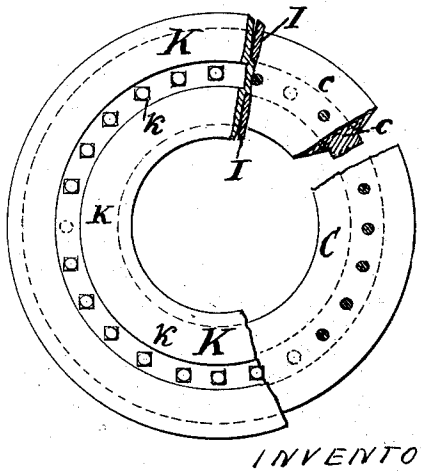


Fig. 3.



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UNITED STATES PATENT OFFICE.

WILLIAM T. FORSTER, OF KANSAS CITY, MISSOURI.

AIR-COMPRESSOR.

SPECIFICATION forming part of Letters Patent No. 375,929, dated January 3, 1888.

Application filed October 21, 1885. Renewed February 8, 1887. Serial No. 226,968. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM T. FORSTER, residing in Kansas City, in the county of Jackson and State of Missouri, have invented certain new and useful Improvements in Air-Compressors, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, making a part of this specification.

My invention relates to improvements in apparatus for compressing air or other gases; and it consists more particularly in a novel construction of the valves and mechanism governing the passage of the compressed air from the air-cylinder to the receiving vessel or reservoir.

In the accompanying drawings, consisting of two sheets, in which like letters of reference refer to like parts, Figure 1 is a sectional elevation of my improved compressor, showing one of the cylinder-heads or exhaust-valves pushed out to allow the compressed air to pass from the cylinder to the reservoir. Fig. 2 is a plan view of one of the ends of the diaphragm, partly in section, through the line *x x*, Fig. 1. Fig. 3 is a view of the circular inlet-valve, part of the same being removed to show the construction. Fig. 4 is a plan view of the inner surface of one of the cylinder-heads or exhaust-valves, the cup E, occupying the center, not being shown.

My improved compressor consists, essentially, of an air-cylinder containing a piston, in which the air is compressed and which is provided with movable heads or ends adapted to slide outward when the air within has reached the required degree of compression and uncover the ports by which the compressed air escapes into the reservoir, and which thus constitute the exhaust-valves of the compressor, and in connection therewith a diaphragm or equalizer consisting of a hollow closed vessel with flexible ends attached to the outside of the movable cylinder-heads and having its interior communicating with the reservoir, so as to be filled with compressed air, and thus exert an outward pressure on the flexible ends, and thereby on the cylinder-heads, equal to the inward pressure of the compressed air in the cylinder. The movable cylinder-heads are thus made to form balanced valves having an equal balancing-pressure on both their faces or sides just before they slide outward to uncover the ports, and thus but little extra power in the piston above that required to compress the air is required to move or slide the exhaust-valves.

As shown in the drawings, and as I propose to construct my improved compressor, A is the air or compression cylinder containing the piston P, which is moved back and forth by the piston-rod *p*, in the usual manner. At each end of the cylinder and fitting closely in the same, so as to inclose the chamber and render it air-tight, are the movable heads B and B′, provided with the circular inlet-valves C and adapted to slide back and forth in the ends of the cylinder. In the walls of the cylinder, near each end, are circular or other shaped ports *d*, which form the outlets or discharge-orifices, and which communicate with the side or discharge pipe, D, by which the compressed air passes from the cylinder A to the reservoir. The arrangement of the ports and movable heads is such that when the head is in place within the cylinder the sides of the head extend over and cover the port, as shown at B′, and thus prevent the air from passing into the discharge-pipe; but when the head is pushed out, as at B, by the compressed air the head slides past the port and uncovers the same, thus allowing the port to communicate with the interior of the cylinder and the compressed air to escape into the discharge-pipe. The movable heads B and B′ thus form the exhaust-valves of the compressor and control the passage of the compressed air from the cylinder A to the receiving-reservoir. As the ports *d* are placed near the ends of the air-cylinder A, and but a short distance from or beyond the inner face or edge of the cylinder heads or valves B and B′, when the latter are within the cylinder, the heads are required to be moved or slid but a short distance in order to open or uncover the ports. The motion of the valves to open and close the outlets or ports is thus very little, insuring prompt action of the valves and decreasing the friction and wear of the same.

At one end of the air-cylinder A is placed a diaphragm or equalizer, L, consisting of an air-tight cylinder with flexible ends inclosed or held in a frame, M, which is connected to the outside of the walls of the air-cylinder by

bolts, as shown in the drawings. The ends or upper and lower slides of the diaphragm L are formed by a circular strip or ring, O, of flexible material—as rubber—secured, by bolts o', to the outside edge of the diaphragm or cylinder and by bolts n to a rigid center piece or disk, N. By reason of this outer circle, O, of flexible material, the entire extent of the ends or upper and lower sides of the diaphragm are capable of being depressed inward by a pressure from without or forced outward by a pressure from within. A circular frame or ring, T and T', is secured, by the bolts n, to the flexible ends on both sides of the diaphragm, so as to move with the same, and is arranged to slide in recesses m', formed in the frame M.

On the outside of the flexible rings O, and resting against them, is a series of steel plates or flat rods, R, (shown more clearly in Fig. 2,) which extend from the edge of the cylinder to the inner edge of the ring O and completely cover the latter, as is shown in Fig. 2. The outer end, r, of these plates or rods rests loosely in bearings or depressions m in the frame M, and the inner end, r', rests against the under side of the circular frames T and T'. The plates or rods R are thus held in place and against the flexible ring O by their extreme ends, and are so arranged that the inner end, r', can freely move back and forth or up and down as the ends of the cylinder are forced outward or inward.

On the under side of the frames T and T', and at the extreme ends of the latter, are points or projections t, which are so constructed and arranged that when the ends of the cylinder, and consequently the frames T and T', have been depressed or moved inward a certain distance these projections will strike or come in contact with the outer surface of the plates or rods R, as is shown in Fig. 1 in the case of the inner or lower frame, T. Whenever the points t come in contact with the plates or rods, they change the fulcrum or movable point of bearing on the latter from the inner end, r', to a point nearer the fixed end r, and thus decrease the length of the rod between the points of contact, and thereby increase the resisting power or force of the rods. These plates or rods are preferably made of steel, so as to be capable of resisting great pressure, and are constructed of such proportion and the projections t are so located and arranged that when the latter come in contact with the rods and press them inward the rods exert a resistance equal to or a little greater than the full pressure of the piston in the air-cylinder as the latter forces the head or valve outward, and thus the plates or rods, and consequently the ends of the diaphragm, control the movement of the head and prevent its being pushed out too far. The circular frame T, and therefore the flexible end of the diaphragm to which it is fastened, is connected by means of the post S with the outer face or side of the movable cylinder-head or exhaust-valve B in the end of the air-cylinder A, and the opposite frame, T', and flexible end on the other side of the diaphragm are connected, by means of the cross-head X, side rods, y y, and cross-heads X' X', with the movable cylinder-head or exhaust-valve B' in the other end of the air-cylinder. The movable cylinder-heads are thus connected with the flexible ends of the diaphragm and move together with the same. The interior of the diaphragm L communicates, by means of the tube u, with the discharge-pipe D, and thus with the reservoir containing the compressed air. The diaphragm is therefore filled or charged with compressed air at the same degree of compression as the air in the receiving-reservoir.

The diaphragm is constructed of such proportion with respect to the size and capacity of the air-cylinder that the pressure of the flexible ends of the diaphragm on the movable heads of the air-cylinder, or the exhaust-valves B and B', with which they are connected, is equal to the pressure of the compressed air in the reservoir, or equal to the degree of compression it is desired to obtain in the air-cylinder A. This outward pressure on the heads or valves B and B' holds them in place in the cylinder and prevents their moving until the air has been compressed to the required degree and the valves are required to move.

From the above description and the drawings the operation of the compressor will be readily understood. The interior of the cylinder A is filled with air entering through the inlet-valves C in the heads B and B'. When the piston commences its movement toward either head, the inlet-valve C in that head is closed by the pressure of the air in the cylinder and held closely on its seat, thus preventing the escape of the air from the cylinder. As the piston advances toward the head, the air inclosed between the surface of the piston and the inner surface of the head is compressed until the desired degree of compression is obtained, or until the air in the cylinder is compressed to the same degree as that in the reservoir and in the diaphragm communicating with the latter. At this moment, as the cylinder and diaphragm both contain air at the same pressure, and as they are constructed of the proper proportion with respect to each other, the pressure on the under surface of the head or valve, caused by the pressure of the air in front of the piston, is equal to the pressure on the outer surface of the head or valve caused by pressure of the air on the flexible end of the diaphragm. The pressure on both sides of the head or valve is therefore the same, or the valve is balanced between the two equal pressures, and it follows that a very slight additional pressure either way will move the valve. As the piston continues to advance, the extra or increased pressure on the under side of the head or valve forces it outward, and as the latter moves in the sides of the cylinder it uncovers or slides past the ports d, and the compressed air passes or escapes through the side pipe, D, into the

reservoir. As the head or valve slides or moves outward, it depresses the flexible end of the diaphragm connected with its outer face or surface, as shown in Fig. 1, until the points *t* on the frame or ring T come in contact with the plates or rods R, when, as the rods are so constructed and arranged as to exert a resistance greater than the pressure of the piston or outward force of the head, the depression of the end of the diaphragm, and consequently the outward movement of the head or valve, is checked, and thus the cylinder-head is prevented from sliding entirely out of the cylinder. As will thus be seen, at the moment immediately preceding that at which the head or valve moves, and when the air in the cylinder has been compressed to the required degree, the pressure on both surfaces of the head or valve is equal, the pressure in the cylinder or on the under surface of the valve balancing that in the diaphragm or on the outer surface of the valve. The force necessary, therefore, to move the valve is only that required to overcome the weight of the valve and the friction of the latter on the sides of the cylinder. As the valve is held in place in the cylinder by the pressure of the air in the diaphragm on its outer surface, and not by its own weight, it need not be very heavy, and as it slides but a little distance in order to uncover the ports the force required to move the head or valve is very slight. In my improved compressor, therefore, the pressure of the piston necessary to move the exhaust-valve above that required to compress the air is very slight, and nearly all the power of the piston is applied in compressing the air. After the compressed air has passed from the cylinder into the reservoir and the piston has commenced its return-stroke to the opposite head the spring or resistance of the plates R, caused by the depression of the flexible end of the diaphragm by the movement of the cylinder-head and the force of the compressed air in the diaphragm, forces this head back in the cylinder to its former position, thus closing the ports and preventing the compressed air passing back into the cylinder.

In order to insure a more perfect movement of the head back into the cylinder and closing of the ports, I employ the device shown at E in the drawings. This consists of a movable cup, E, fitting in a recess in the inner face or surface of the cylinder heads or valves and adapted to slide out and in in the same. This cup in its normal position projects just beyond the face of the head, as shown in the lower part of Fig. 1, being held there by springs *e*. On the outer surface of the cup is formed a depression or cavity, F, from which extend small channels *f* through the head, terminating in the outer face or surface of the latter. In these channels and connected with the cup are valves *h*, so arranged that when the cup is in its normal position, projecting beyond the surface of the head, these valves are closed. After the piston has forced the head or exhaust-valve outward and opened the ports, it continues to advance as the air passes from the cylinder until all the air has escaped from the cylinder and the piston has come in contact with the head. As the cup E projects beyond the surface of the head, the piston first strikes it and incloses or shuts in the air contained in the depression or cavity F. The piston, continuing to advance, forces the cup back, and at the same time opens the valves *h*, connected with it, as shown at E, and the air contained in the depression escapes through the channels *f* out of the cylinder. It follows, therefore, that when the piston has reached the head and is ready to return, the pressure of the air on the lower or inner surface of the head is reduced by the amount of air which has escaped from the depression in the cup E. The pressure on the inner surface of the head is thus less than that on the outer surface, caused by the air in the diaphragm. The cylinder-head is therefore pressed down and held closely against the surface of the piston by the greater pressure in the diaphragm, and as the piston returns the head slides back with it; hence the movement of the head back into the cylinder is a very quick one, and the ports are immediately closed, and, moreover, as the head is held down close against the piston, there is no opportunity for the compressed air to pass back into the cylinder. The cup or device E, furthermore, acts as a cushion for the piston to strike against, and prevents the piston and cylinder-head from being injured when they come in contact with each other.

Any variety of inlet-valves may be used to admit the air into the cylinder; but I prefer to employ the valves shown in the drawings at C. These valves (shown more at large in Fig. 3) are circular and work in a valve-seat on the inner surface of the cylinder-head. The valves consist of the V-shaped body C, made of iron or other suitable metal, to which is secured, by means of the bolts *k*, the face-plate K. Between the body C and plate K is placed a rubber ring or cushion, I. The valve is held in the valve-seat by the stems G, arranged to allow the valve to play up and down in the seat, and provided with the spring *g*, to force the valve in when the pressure of the air in the cylinder against the face or plate K is removed. As the valve is forced in or opened by means of the spring *g*, the air, entering through the passage *c*, passes between the valves and valve-seat and enters the cylinder. As the piston moves toward the head of the cylinder and compresses the air within, it forces the valve against the valve-seat and closes the valve, thus preventing the passage of the air between the valve and seat. By means of the rubber cushion or packing I, as the valve is pressed against its seat, a more perfect and effective air-tight joint is insured, and at the same time the blow or impact of the valve is lessened.

To insure a tight joint between the cylinder heads or valves and the sides of the cylinder,

rubber bands or packing are arranged in the sides of the valves, which is pressed closely against the sides of the cylinder by the compressed air introduced through the tubes V, communicating with the side pipe, D.

In my improved compressor I require very little extra force or power to move the valves, and as the valves slide but a little distance they are subject to but little wear, and do not require to be frequently refitted, as is the case with the valves now in use; and, moreover, as the valves are held in place by the force of the compressed air in the diaphragm, which is the same as in the reservoir, the valves adjust themselves to any pressure required, always moving when the air in the cylinder is compressed to the degree desired or to the same degree as that in the reservoir. By a suitable arrangement of the plates R and projections *t* the diaphragm can be made to resist any degree of pressure required. This construction of diaphragm may also be used as a buffer wherever it is necessary to resist or overcome pressure.

What I claim as new is—

1. In an air-compressor, an exhaust-valve connected with a flexible diaphragm communicating with the reservoir of compressed air and containing air at the same degree of pressure as is produced in the cylinder, so as to be held in place by the pressure in the diaphragm and thus balanced between the two pressures, substantially as and for the purposes set forth.

2. In an air-compressor, the combination, with the air-cylinder provided with movable heads, of a diaphragm or equalizer having flexible ends connected with the movable heads of the cylinder and adapted to contain air at the same degree of pressure as is produced in the cylinder, substantially as and for the purposes set forth.

3. In an air-compressor, the combination of the air-cylinder A, having the ports *d* at or near each end and provided with the movable heads B B′, forming the outlet-valves, with the diaphragm L, communicating by a pipe with the reservoir of compressed air in order to contain air at the same degree of pressure as is produced in the air-cylinder and having flexible ends connected with the cylinder-heads B B′, substantially as and for the purposes set forth.

4. In an air-compressor, the combination of the air-cylinder A, having the ports *d* at or near each end and provided with the movable heads B B′, having the valves C, and cups E, with the diaphragm L, communicating with the reservoir of compressed air, so as to contain air at the same degree of pressure as is produced in the air-cylinder, and provided with the flexible rings O, disks N N′, elastic plates R, and frames T T′, connecting with the movable cylinder-heads B B′ and having projections *t*, for acting upon the elastic plates R, arranged and operating substantially as described, and for the purposes set forth.

5. In an air-compressor, the diaphragm or equalizer L, capable of containing compressed air, consisting of the hollow body L, having the central disks, N N′, the flexible rings O, attached to and connecting such disks with the sides of the diaphragm, the elastic plates R, arranged on the rings O, and the frames T T′, secured to the disks N N′ and provided with projections *t*, adapted to act on the plates R, substantially as and for the purposes set forth.

6. In an air-compressor, the combination, with the cylinder-heads B B′, of the movable cups E, fitting and moving in suitable recesses in such heads, constructed with or having a cavity or air-space, F, and provided with channels or discharge orifices *f* and valves to close the same, as and for the purpose set forth.

Dated this 28th day of September, 1885.

WILLIAM T. FORSTER.

Witnesses:
JULIET M. FORSTER,
FRANCIS L. GROSS.