No. 676,080. Patented June 11, 1901.

W. REAVELL.

APPARATUS FOR COMPRESSING OR EXHAUSTING ELASTIC FLUIDS.

(Application filed Nov. 17, 1899.)

(No Model.) 4 Sheets—Sheet 1.

FIG. 1.

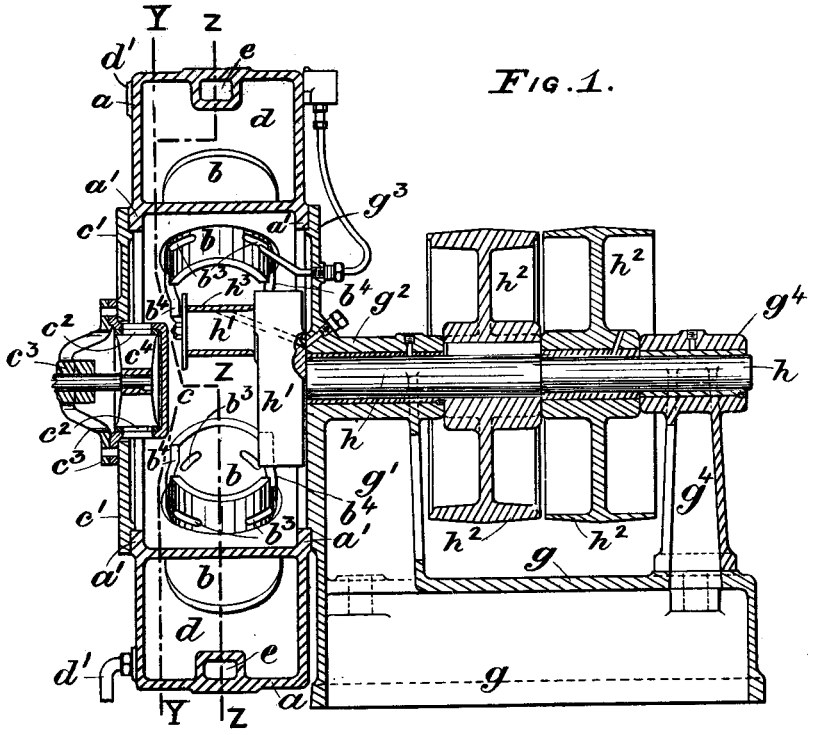
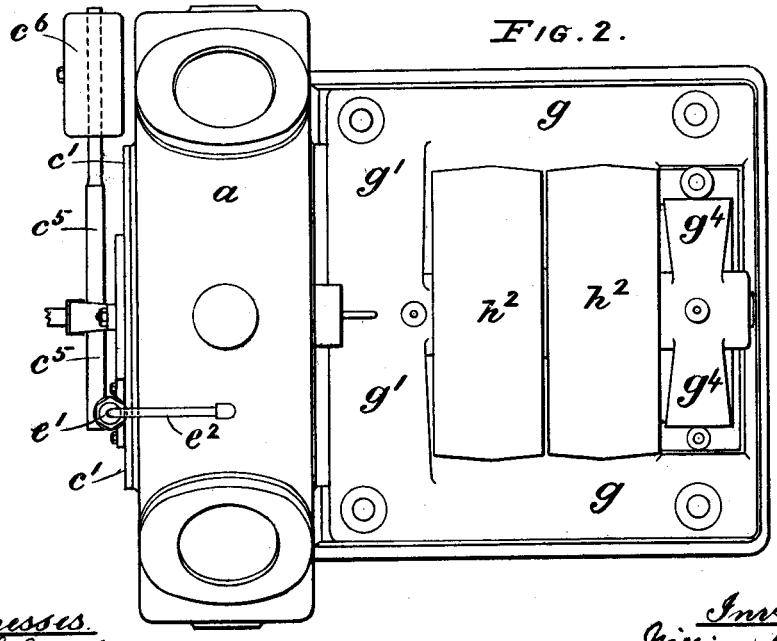


FIG. 2.



Witnesses.
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Edel A. Brett.

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FIG. 3.

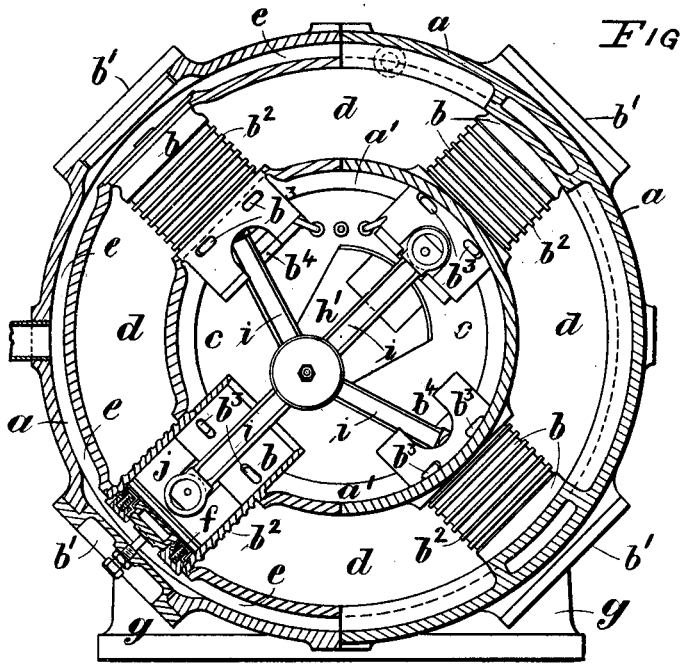

FIG. 4.

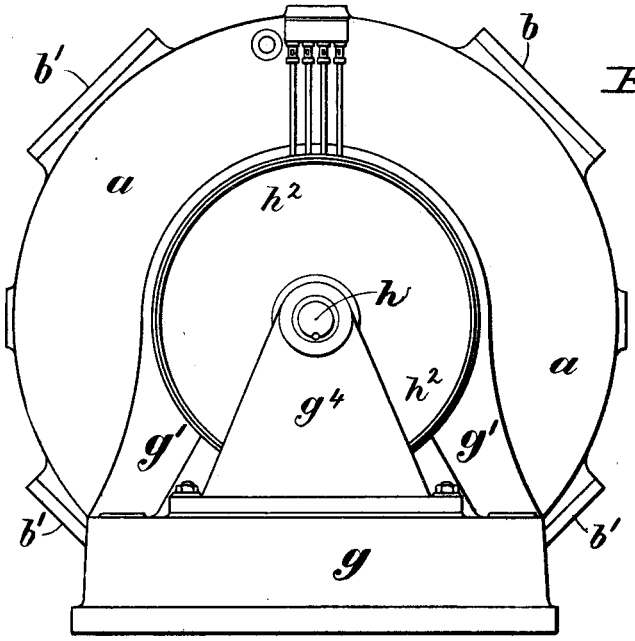

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FIG. 5.

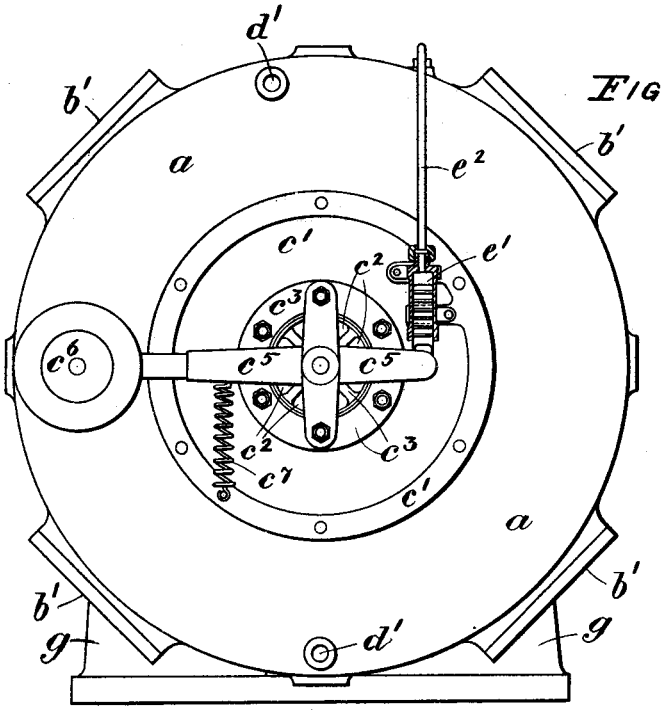

FIG. 6.

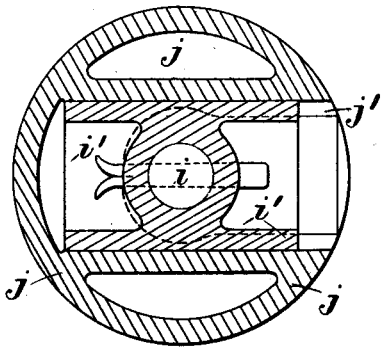

FIG. 7.

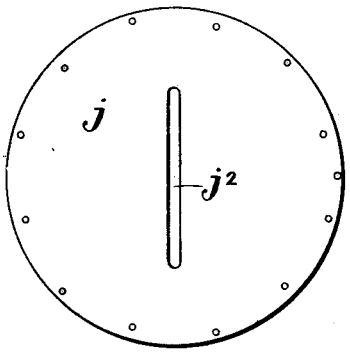

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FIG. 8.

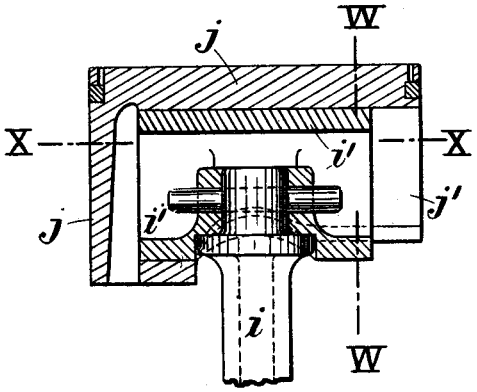

FIG. 10.

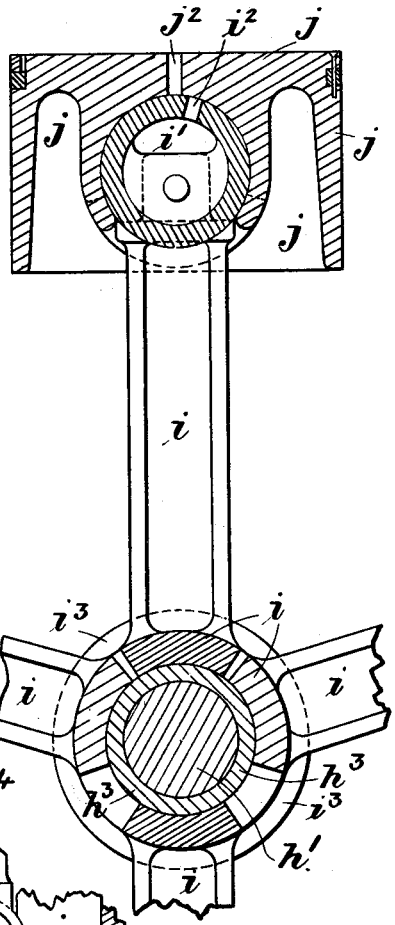

FIG. 9.

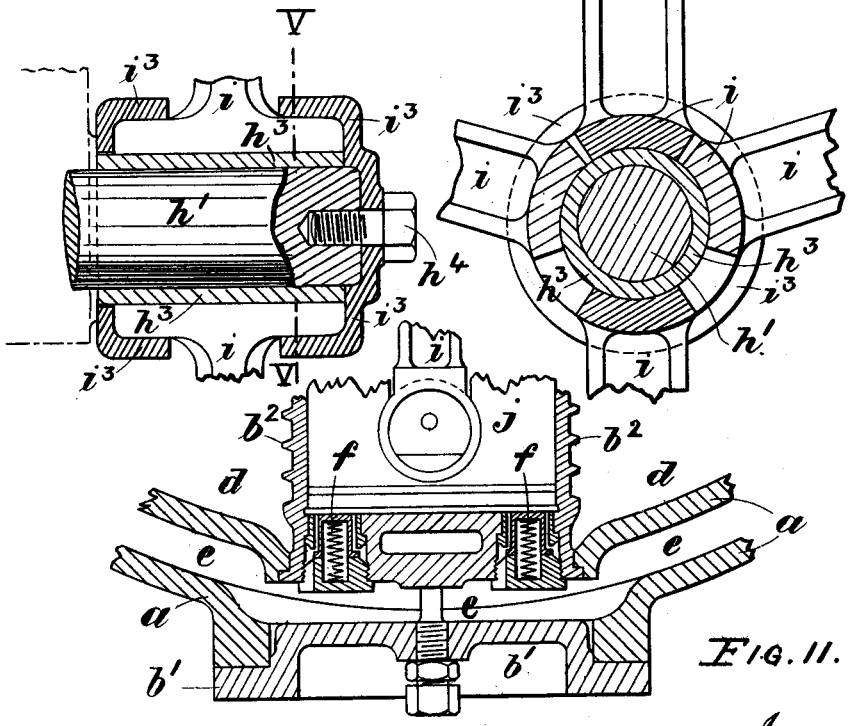

FIG. 11.

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UNITED STATES PATENT OFFICE.

WILLIAM REAVELL, OF IPSWICH, ENGLAND, ASSIGNOR TO REAVELL & COMPANY, LIMITED, OF SAME PLACE.

APPARATUS FOR COMPRESSING OR EXHAUSTING ELASTIC FLUIDS.

SPECIFICATION forming part of Letters Patent No. 676,080, dated June 11, 1901.

Application filed November 17, 1899. Serial No. 737,361. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM REAVELL, a subject of the Queen of Great Britain and Ireland, residing at Ipswich, in the county of Suffolk, England, have invented certain new and useful Improvements in Apparatus for Compressing or Exhausting Elastic Fluids, (for which I have applied for a patent in England, dated June 24, 1899, No. 13,161,) of which the following is a specification.

The object of this invention is to improve the arrangement and construction of an apparatus for compressing or exhausting air or other elastic fluid, whereby its efficiency is increased, economy is effected, and facility in making repairs or renewing parts is afforded.

The improved apparatus may be directly driven by steam or other motive-power engine, by an electromotor, by belt and pulley from power-shafting, or other equivalent means without departing from the nature of the invention.

In the further description of this invention reference is made to the accompanying drawings, in which—

Figure 1 is a longitudinal sectional elevation (the connecting-rods omitted for clearness) of an improved four-cylinder air compressing or exhausting apparatus adapted for pulley-driving. Fig. 2 is a plan of the same. Fig. 3 is a sectional elevation taken through the air-compressing end, partly on the line Y Y, Fig. 1, to show the arrangement of the cylinders and water-jacket, and partly through the line Z Z, taken through the center of one of the cylinders. Fig. 4 is an exterior elevation from the pulley end of the apparatus; and Fig. 5 is also an exterior elevation of the opposite or cylinder end of the apparatus, showing the air-inlet-regulating device. Figs. 6, 7, 8, 9, and 10 are detailed drawings, on an enlarged scale, of the piston and connecting-rod of each of the four air-compressing cylinders employed, with their connections to the single crank-pin, Fig. 6 being a sectional plan of a piston on the line X X of Fig. 8; and Fig. 7 is a plan of a piston, showing the slot or port of an air-valve. Fig. 8 is a vertical section of a piston, showing its connection to the outer end of a connecting-rod. Fig. 9 is a section at the crank-pin, showing how the inner ends of the connecting-rods are kept in contact with the pin; and the upper part of Fig. 10 is a vertical section through the piston on the line of W W in Fig. 8 and at its lower part a vertical section through the crank-pin on line V V of Fig. 9. Fig. 11 is also a detailed drawing, on a slightly-reduced scale to the other details, of the outward end of a cylinder, with its delivery air-valves and means of access to the same from the exterior of the ring-shaped casting forming the frame for the four cylinders.

In carrying out this invention a ring-shaped casting *a* is adapted to form two separate annular chambers and a frame for carrying four equally-spaced radially-arranged cylinders *b*, all opening inward to an inclosed central space forming both a crank and an air-suction chamber *c*. The cylinders being arranged in pairs, each pair upon the same axial line and at right angles to each other, may be bored in position by a boring-bar passing right across and through openings in the casting *a*. In the smaller sizes of the apparatus the cylinders may be cast integral with the ring-shaped casting, a small central hole being left in the outward end of each cylinder for the passage of the boring-bar; but in the larger sizes it is convenient to cast the cylinders separately and after boring them to turn their outer diameter to fit into seating-holes in the frame, as shown by the left-hand half of Fig. 3, which are bored on the same axial line as above described for the integral cylinders, outer covers *b'* being fitted subsequently to close the holes through which the boring-bar is passed. The casting *a* is arranged to form two annular belt-chambers, one a cooling-chamber or water-jacket *d*, surrounding most of the length of the cylinders *b*, which in those separately cast have cooling-surface ribs b^2 formed thereon. The other annular belt-chamber, *e*, receives the air as compressed in the cylinders through delivery-valves *f*, one or more of which is or are inserted in the cylinder's outward end, as shown in Figs. 3 and 11. The belt-chambers *d* and *e* thus form a self-contained rigid circular frame *a*, surrounding and supporting the cyl-

inders b, whether the latter are cast integral with the said frame or separately and fitted into the axial holes bored in the frame, as above stated.

A box-shaped base-plate g, having standards g', carrying a central boss g^2 and circular end plate g^3, is provided, and the boss g^2 is bored and bushed to receive the crank-shaft h. The circular end plate g^3 is shown in Fig. 1 as cast integral with the base g and slightly overhanging the bed-plate g in order to be faced and turned to receive the ring casting a where the latter is bored through (at right angles to the axial lines of the cylinders) to form the crank and air-suction chamber c. A pedestal g^4 is mounted on the base g and adapted to receive the further end of the crank-shaft h and pulleys h^2 h^2; but this part of the apparatus is liable to modification if other means are provided for driving the shaft.

The ring casting a has a slightly-projecting flange a' extending into the crank and suction chamber c on each face of the casting, which is bored and faced. This is fitted upon and secured to the stationary faced and turned circular end plate g^3, which thus carries the casting a and closes the aperture of the chamber c on the driving or inner face; but on the opposite or outer face of the ring casting a circular door c' is fitted and secured to the corresponding flange a' to inclose the central crank and suction chamber c on that side. Radiating or other orifices c^2 are formed in the door c' or in a supplemental cover c^3 thereon, which is adapted to carry a grid or circular valve c^4 on a central pin, the valve having corresponding orifices and arranged to be capable of a slight rotative movement with the pin when the latter is turned by the lever c^5, attached thereto. An adjustable balance-weight c^6 is fitted on the lever, and a spring c^7 is also secured thereto at one end and to the circular door c' at the other end, all as shown in Figs. 1, 2, and 5.

An air-cylinder e' is mounted on the door c', and through the bottom open end thereof a piston is adapted to bear upon the end of the lever c^5 opposite to the adjustable balance-weight c^6 when compressed air is admitted to the cylinder from the belt air-chamber e through the communicating pipe e^2. The air-pressure in the belt-chamber e and in the cylinder e' is therefore the same, so that when air is compressed (for example) beyond a predetermined pressure the piston is forced outwardly against the lever c^5 and turning the grid or circular valve c^4 so as to close the orifices c^2 in the door against the effect of the adjusted balance-weight c^6 on the lever; but when the air-pressure falls below that required in the belt air-chamber e the weighted lever returns the piston within the air-cylinder e' and the valve c^4 opens the orifices c^2, thus supplying more air to the air-suction chamber c to be compressed within the cylinders b. It will be seen, therefore, that while air is being compressed the devices described operate automatically to regulate its pressure to the desired degree, while, conversely, the apparatus may likewise be used to produce a similar degree of exhaustion, and in order that the valve c^4 may not act too quickly a suitable spring, such as c', is combined, as shown, with the weighted lever c^5 to partially check its action. For marine purposes or where a weight is objectionable spring-pressure alone may be used for both purposes and the weight dispensed with.

The inward end of each radial cylinder b projects its full diameter into the central crank and air-suction chamber c, with those ends spaced sufficiently far apart to give room for the insertion and working of the crank arm and pin h', with the four attached connecting-rods i, each secured at the other end to a cylindrical or roller-shaped cross-head i', Figs. 6 and 8, which pivotally works in a suitable transverse socket-boring in its corresponding piston-block j, so that the one crank-pin works all four pistons single-acting in compressing or exhausting air in the cylinders. The cylinders b project sufficiently into the suction-chamber c to permit a port or ports b^3 to be formed therein, which ports are just uncovered by each piston j at the end of its inward stroke to admit air from the suction-chamber to its corresponding cylinder for the purpose of compressing it in its outward stroke.

A space b^4 is formed or cut transversely through the aforesaid projecting end of each cylinder, as shown in Figs. 1 and 3, to permit the removal or insertion of each connecting-rod i, with its cross-head i', sidewise from or to the piston-block j. This object is further facilitated by cutting away one side of the piston-block j at the point indicated by j' in Figs. 6 and 8; but sufficient metal is left, as shown in Fig. 10, to surround and safely withstand the inward strain or pull upon the rod i on the return stroke without fitting half-brasses or other loose parts.

In Figs. 7 and 10 a long slot or port j^2 is shown on the outward end of the piston j, and this, together with a port i^2 in the connecting-rod, cross-head i', and the angular motion of the connecting-rod i derived from the revolution of the crank h', forms a valve-seat and valve which is alternately opened and closed in a revolution of the crank-shaft.

The inner end of each of the four connecting-rods i abuts upon the crank-pin h', as shown in Fig. 10, in a similar manner to that followed in the well-known three-cylinder single-acting engines or air-compressors, a bush h^3 being interposed between the crank-pin proper and the segmentally-fitted ends of the rods i. The rods are cut away radially where they adjoin in order to clear each other in their various angular positions when they are working. In addition thereto the segmental eye portion of the rod extending from each axial face thereof is turned to fit neatly into an

end socket or cap i^3 on one or both faces, Fig. 9, which thus incloses the said eye portions of the four rods to take any pull from them. A screw h^4 secures the cap i^3 on the outer end of the crank-pin h', and on removing it from the tapped hole in the crank-pin, together with the cap aforesaid, while the piston end is also made free for withdrawal from the piston-block j at the point j', as above mentioned, each connecting-rod can in turn be removed from its respective piston and cylinder when the crank-pin is at its farthest point therefrom, the transverse space b^4, formed in the projecting inner end of the cylinder, being provided for this purpose, as already stated. Moreover, the whole operation is performed after the removal of the circular door c', the diameter thereof, as inclosing the crank or suction chamber c, being sufficiently large to enable workmen to accomplish this with facility.

When compressing air, the supply enters the four cylinders b through the air-ports b^3 from the inclosed crank and suction chamber c, the pistons j in rotation passing beyond the air-ports on their inward stroke toward the axis of the crank-shaft to permit the inlet of the air to their corresponding cylinders. As each piston in turn begins its return or outward stroke it first closes its air-ports b^3 and then compresses the air within the cylinder until its pressure has increased sufficiently to open the non-return delivery valve or valves f at the outward end of the cylinder against the spring-pressure of the valve, which pressure may be varied to the desired degree by screw adjustment or any other known way. The compressed air is thus delivered through the valves f into the annular or belt air-chamber e up to the end of the outward stroke, and as the other cylinders in the series of four follow in close succession with their charge of compressed air the feed-delivery into the chamber e is practically continuous; but when the supply of air so compressed is greater than the working requirements, the pressure rises in the air-chamber e and the communicating pipe e^2, so that the increased pressure forces the piston in the small cylinder e' down upon the end of the weighted and pivoted lever c^5, which, turning the attached grid or circular valve c^4, closes the orifices c^2 and automatically cuts off the supply of air to the suction-chamber c. Conversely, when the air-pressure falls in the belt air-chamber e the weighted lever c^5 presses the piston back into the air-cylinder e' and automatically opens the valve c^4, thus admitting air into the suction-chamber c. The balance-weight c^6 is adjustable on the lever c^5 to suit the pressure required in the belt air-chamber e, and to prevent a sudden movement of the lever a spring c^7 is provided as a check. If a weight is objectionable, spring action may be substituted for both purposes.

When the circular valve c^4 is closed automatically, as above described, while working, a partial vacuum would be formed within the cylinders, which would lead to the air-pressure in the suction-chamber acting upon the crank side of the piston and cause a knocking action of the connecting-rod end upon the crank-pin h' at the ends of the stroke, thus reversing the well-known continuous or constant thrust action upon the crank-pin of single-acting pistons, whereon depend their quick-running qualities. This knocking is avoided by passing a little air from the suction-chamber through the port i^2 in the crosshead i' and the port j^2 in the piston j. (Shown in Figs. 7 and 10.) The port i^2 is so arranged that equilibrium is established on the inward stroke of the piston (when the piston is moving toward the axis of the crank-shaft) by the angular movement of the connecting-rod i when the two ports i^2 and j^2 come more or less into line; but the passage is closed entirely on the outward stroke when the piston j is moving to compress air.

It will be seen in Figs. 3 and 11 that the delivery-valves f at the outward ends of the cylinders are quite accessible from the exterior through the holes in the casting a, which are adapted, as already stated, for boring purposes, and these holes are closed and the surrounding belt-chamber e made continuous by means of the covers b', which are suitably bolted on. Suitable water-pipe connections d' are provided as convenient to convey water into and out of the belt cooling-chamber d to provide a water-jacket to the cylinders b.

What I claim, and desire to secure by Letters Patent, is—

1. In an apparatus for compressing or exhausting elastic fluids, the combination of a base-plate having bearings mounted thereon, the outer face of one of said bearings being slightly overhung and extended to form a circular end plate; a frame supported upon said end plate and carrying four cylinders, equally spaced and radially arranged, and having an air-chamber and a water-chamber within the said frame, the said cylinders passing through the said water-chamber and adapted to be kept cool thereby; a chamber in the center of said frame inclosed by the said end plate on one face and a cover with an air-regulating valve on the other face, adapted to form an air-supply chamber to the cylinders opening into the same; a crank-shaft rotatable in the said bearings with its crank and pin adapted to work in said central space; means for driving said crank-shaft, and means such as connecting-rods and pistons for compressing or exhausting elastic fluids in said cylinders by the revolution of said crank-pin; and communicating means such as valves at one end of each cylinder, opening into said air-chamber, substantially as and for the purpose described and shown in the drawings.

2. In an apparatus for compressing or exhausting elastic fluids, the combination of an annular frame having two annular chambers

and a central space therein, with four single-acting cylinders extending radially at equal distances apart through one of the said chambers, in which a cooling fluid is adapted to circulate, the open end of each cylinder projecting into the said central space to draw its air-supply therefrom through suitable ports, and the closed end of each cylinder adapted with suitable valves to communicate directly into the other annular chamber, an exterior cover in the outer wall of the said frame at the closed end of each cylinder adapted to uncover the valves thereof, means to support said frame, and to close the opposite faces of the central space, and means to automatically regulate the admission of air to the said central space, substantially as and for the purpose described and shown in the drawings.

3. In an apparatus for compressing or exhausting elastic fluids, the combination of an annular frame having separate chambers for air and water and carrying four cylinders opening into a central space, with a crank-pin h', and connecting-rod i for each cylinder having an inclosing socket or cap i^3 embracing the segmental ends of said rods, a transverse space b^4 formed in that part of the wall of each cylinder which opens into the said central space, a piston-block j for each cylinder, and a space j' corresponding to the said space b^4, whereby either of the said connecting-rods can be in turn transversely removed or replaced from or to the said crank-pin and piston-block, substantially as and for the purpose herein described and shown in the drawings.

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