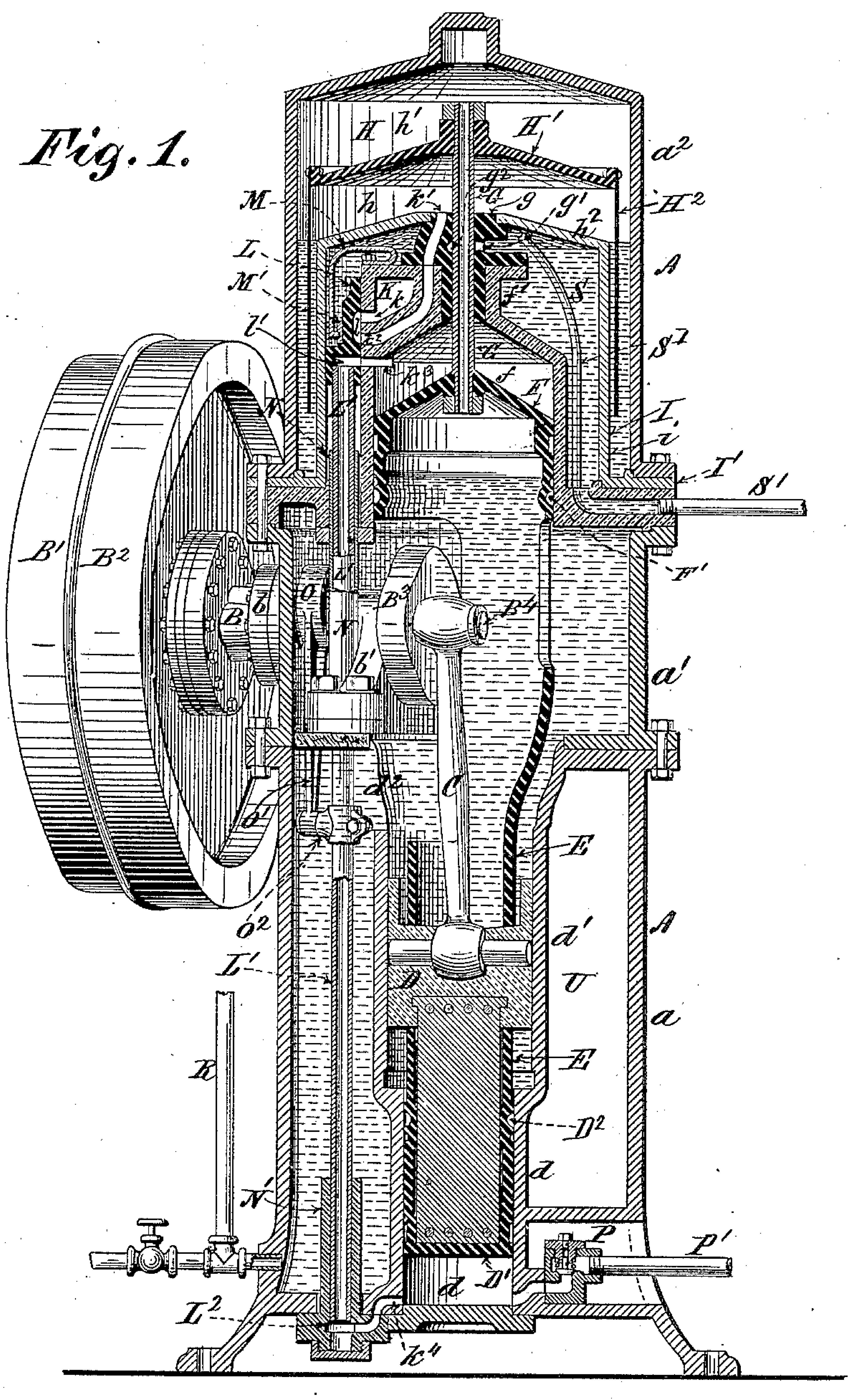
(No Model.) 3 Sheets—Sheet 1.

J. PATTEN.

APPARATUS FOR PRODUCING AND MAINTAINING HIGH VACUA.

No. 427,792. Patented May 13, 1890.

Fig. 1.



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(No Model.)

3 Sheets—Sheet 2.

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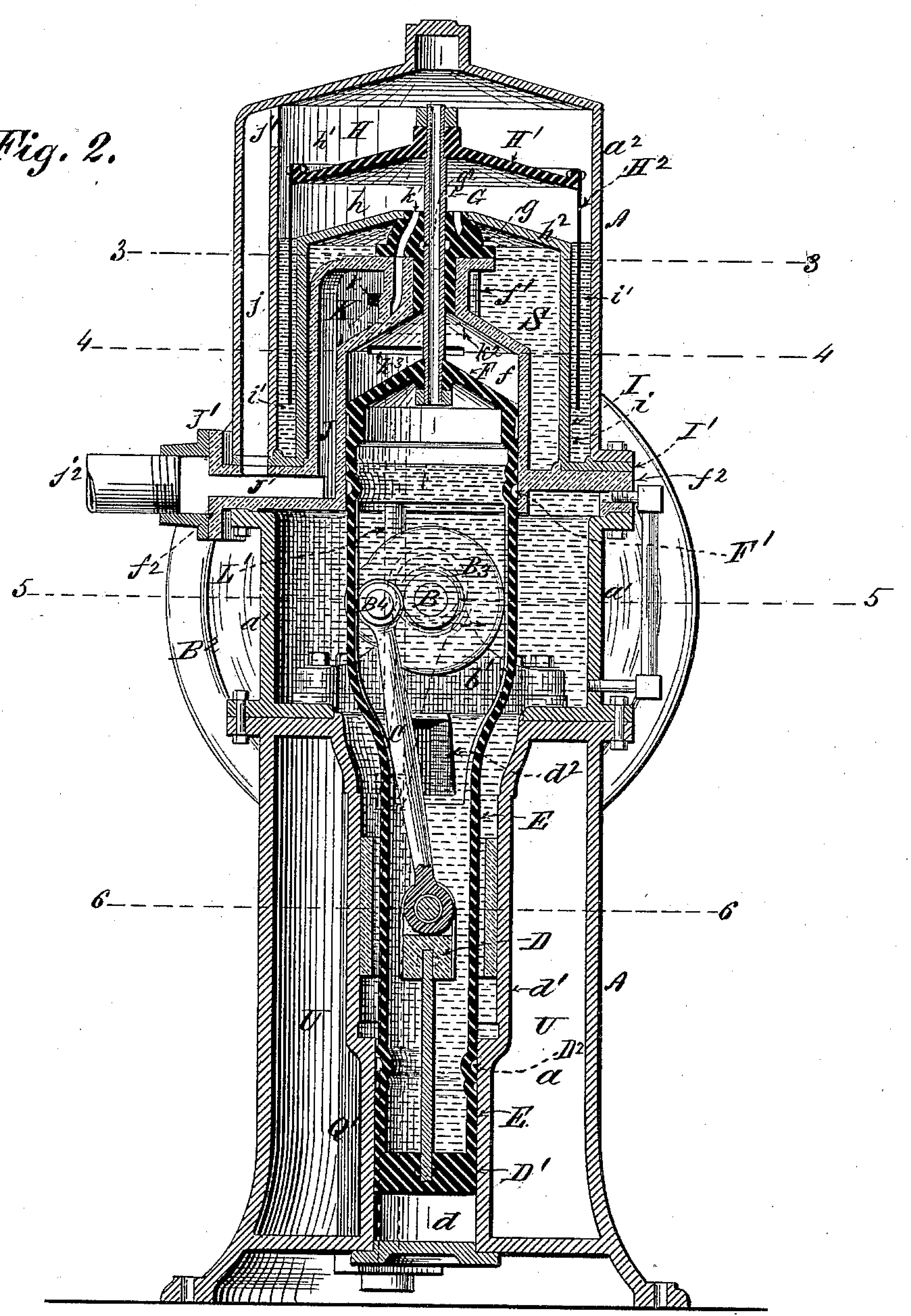
Fig. 2.



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(No Model.) 3 Sheets—Sheet 3.

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APPARATUS FOR PRODUCING AND MAINTAINING HIGH VACUA.

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Fig. 4.

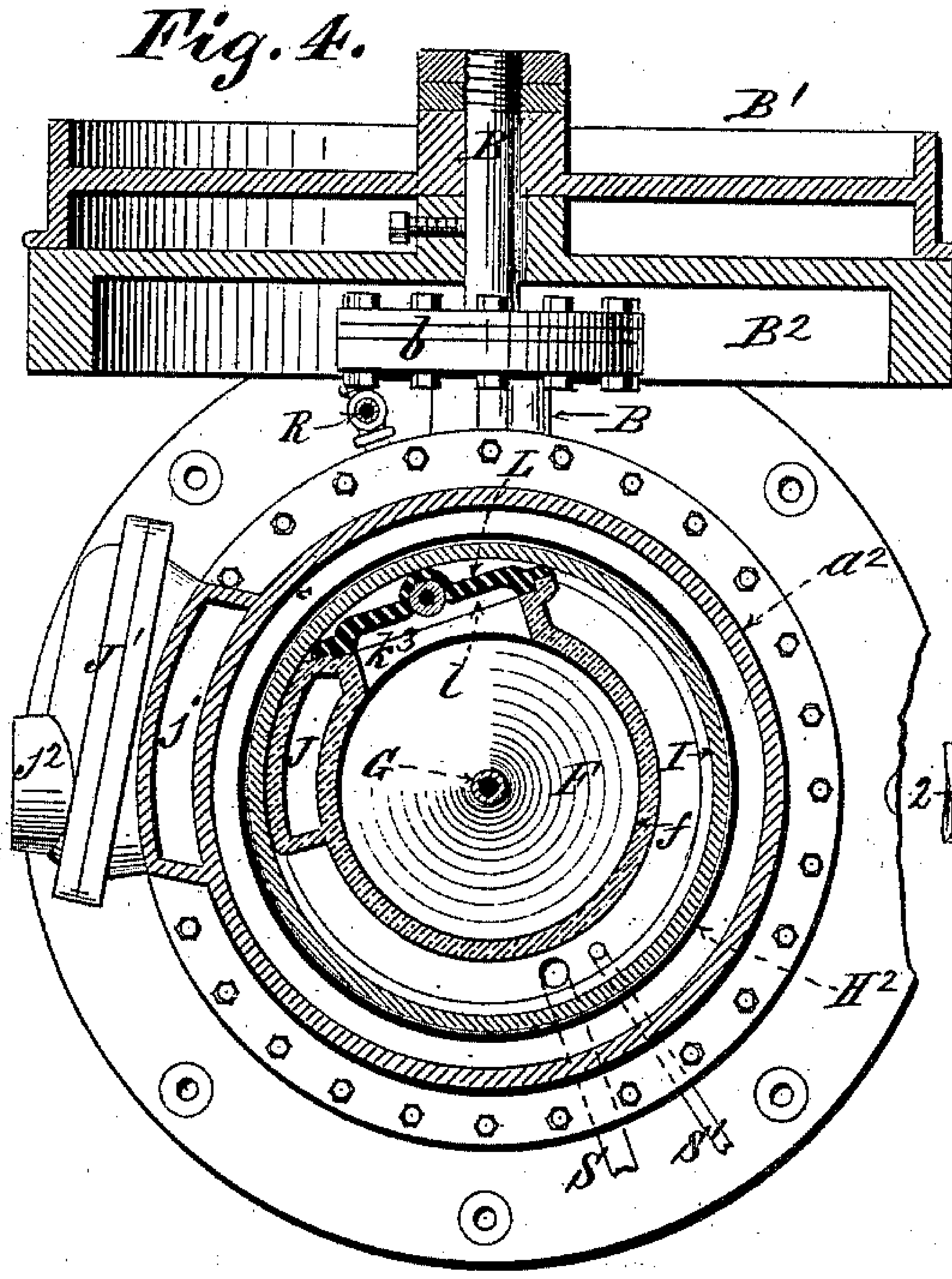


Fig. 3.

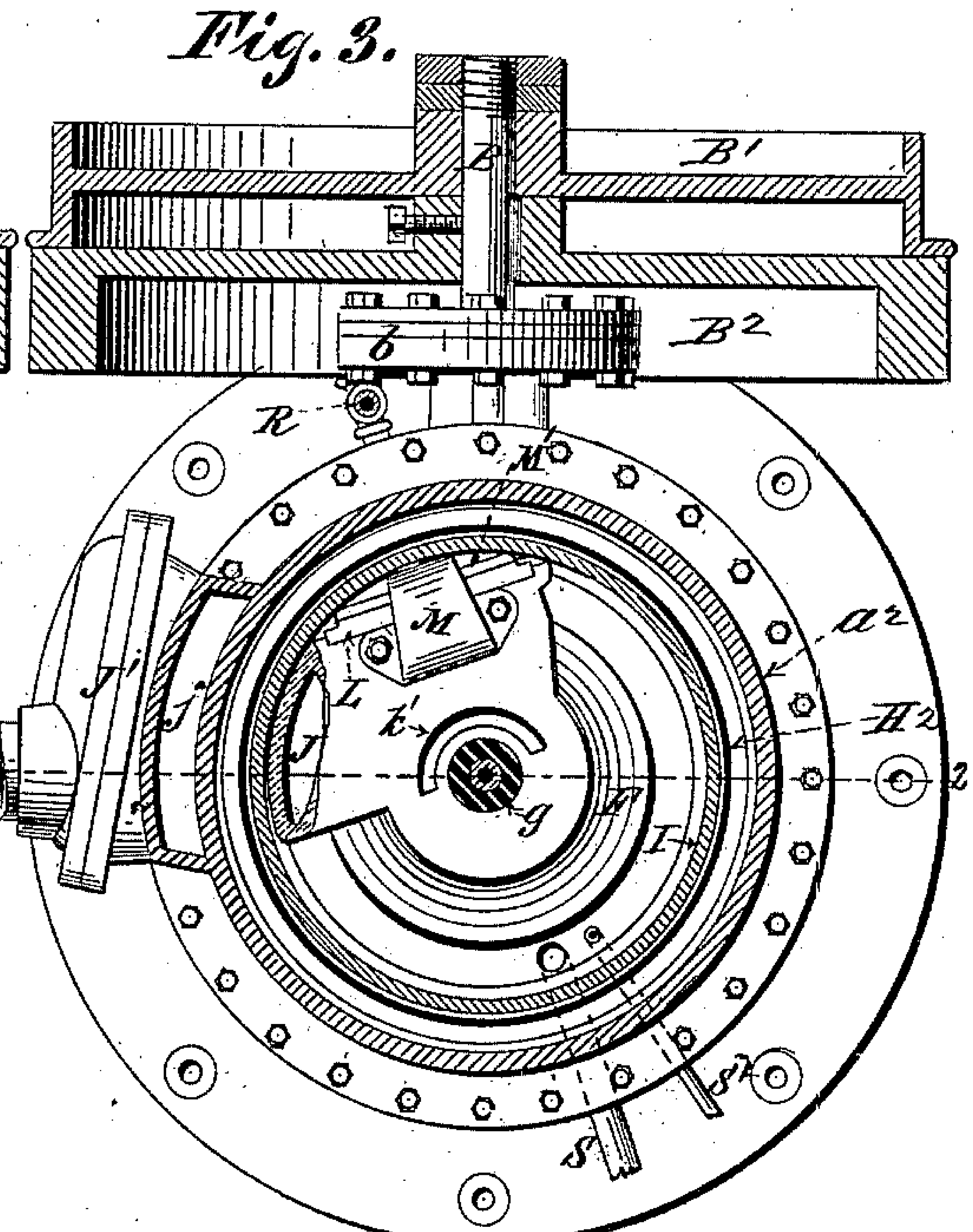


Fig. 6.

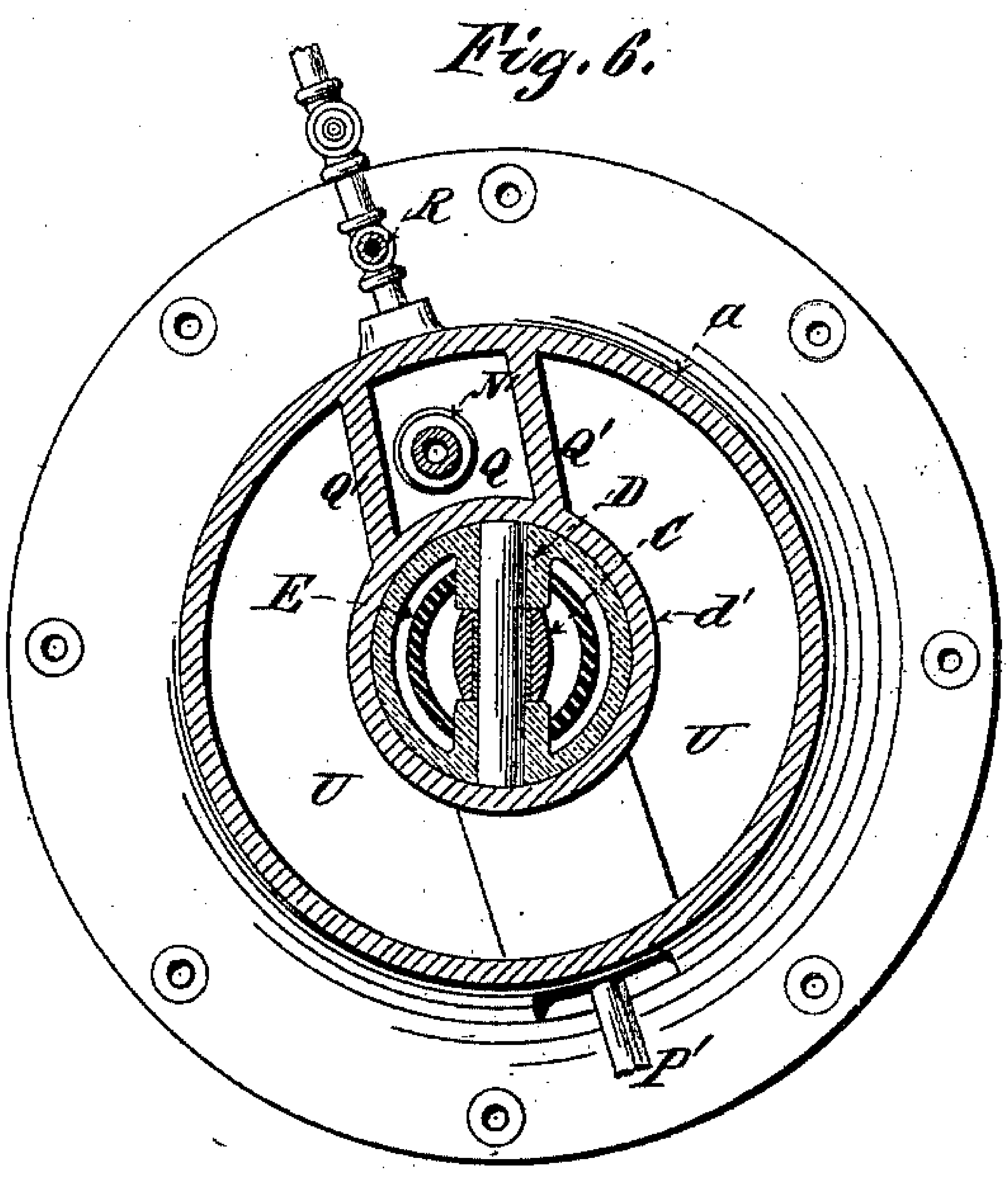
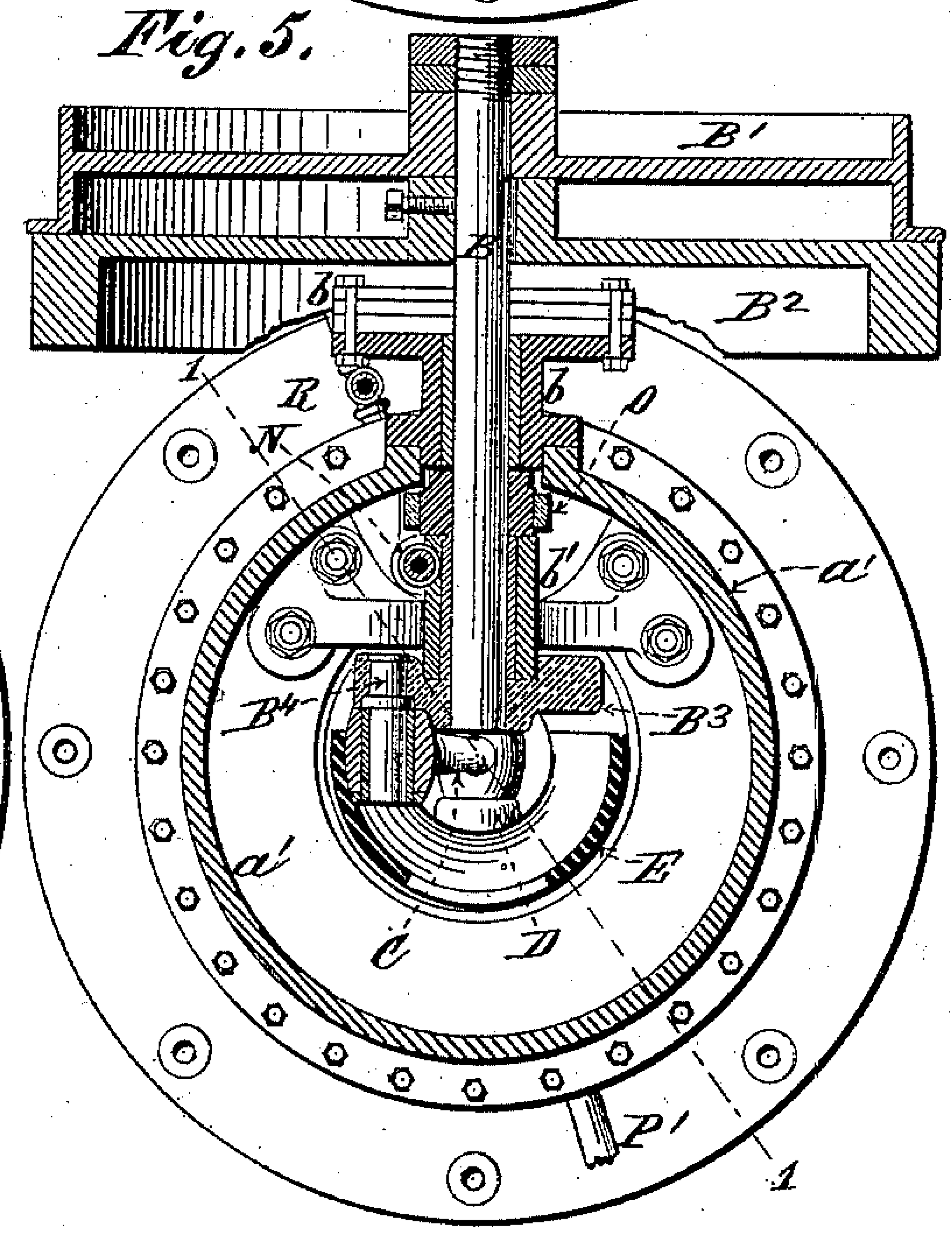


Fig. 5.



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UNITED STATES PATENT OFFICE.

JOHN PATTEN, OF NEW YORK, N. Y., ASSIGNOR TO THE JOHN PATTEN MANUFACTURING COMPANY, OF SAME PLACE.

APPARATUS FOR PRODUCING AND MAINTAINING HIGH VACUA.

SPECIFICATION forming part of Letters Patent No. 427,792, dated May 13, 1890.

Application filed May 10, 1889. Serial No. 310,316. (No model.)

To all whom it may concern:

Be it known that I, JOHN PATTEN, a citizen of the United States, residing at New York, county of New York, and State of New York, have invented certain new and useful Improvements in Apparatus for Producing and Maintaining High Vacua, fully described and represented in the following specification and the accompanying drawings, forming a part of the same.

This invention consists of a triple-chambered vacuum-pump, the pump-chambers of which are preferably arranged in vertical axial alignment and are all contained within a closed cylindrical casing. In the preferable form of organizing the apparatus the three pistons, which are hereinafter collectively referred to as the "piston system," are rigidly connected with each other and are simultaneously reciprocated by means of a single crank on the inner end of a rotating shaft projecting into the interior of the casing. The three pump-chambers are of relatively diminishing volume. The first chamber, herein called the "primary" chamber, which is at the top, is the largest and is that into which the air from the vessel which is to be exhausted is first drawn by the upward stroke of the primary piston. At the commencement of the ensuing downward stroke a positively-operated valve, which has just previously closed the passage through which the air was drawn into the primary chamber, opens communication from the primary chamber into the second pump-chamber, which is herein called the "intermediate" chamber, and which is of smaller size than the primary pump-chamber. During the downward stroke of the primary piston the air is expelled from the primary chamber into the intermediate chamber, and its entrance therein is facilitated by the concurrent downward movement of the intermediate piston. At the commencement of the upward stroke of the piston system the valve which has just previously closed the communication between the upper two pump-chambers opens communication between the intermediate chamber and the third or lowest pump-chamber, which is herein called the "discharging-chamber," which is of still smaller size. It hence results that during the upward stroke of the piston system the air is expelled from the intermediate chamber and is driven into the lower end of the discharging-chamber, into which its entrance is facilitated by the concurrent upward movement of the discharging-piston. At the commencement of the downward stroke the valve, as before, opens communication between the primary and intermediate pump-chambers, having previously closed the communication between the intermediate and discharging pump-chambers, so that during the downward stroke of the piston system the air in the discharging-chamber is compressed, and when its pressure rises sufficiently is discharged therefrom through a check-valve adjusted to yield at a prescribed internal pressure. The intermediate and discharging pistons are tightly packed in the ordinary manner against the walls of the intermediate and discharging chambers, respectively; but the primary piston, instead of having a tightly-packed periphery, is provided with a downwardly-projecting cylindrical flange, which is partially immersed in a body of oil or other sealing-liquid contained in an annular cell, which extends downward from the bottom of the primary pump-chamber. The primary piston, therefore, is an inverted cup-piston. In fact, it is a slightly-conical plate affixed to and closing the upper end of a hollow cylinder, the lower end of which moves up and down in the annular body of sealing-liquid. This plate is mounted upon the upper end of a hollow piston-rod, which is seated in a bearing formed in the head of the intermediate chamber. The lower end of this hollow piston-rod is secured to the center of the intermediate piston, which is formed in one piece with a shell extending down to and connected with the discharging-piston. This shell, which for convenience is herein called the "piston-carrier," has openings in its sides, and is of sufficient diameter to allow space for the projection into it of the driving-crank, which is linked to a cross-head affixed to the discharging-piston. The space within and around this piston-carrier is in constant communication, by means of the hollow piston-rod, which has been referred to, with the space within the casing above the primary piston. It results from this organization that a comparatively small amount of power is required to impart reciprocating motions to the pistons, because they are unaffected by atmospheric pressure in their movements and because the large primary piston is moved without any friction except the moderate friction which results from the bearing of the hollow piston-rod, to which it is attached, upon its seat in the head of the intermediate chamber. The primary chamber has a hollow base, its lower end being a stationary cylinder, which is of smaller diameter than the casing, and which is closed at the top and open at the bottom, where it is provided with an outwardly-extending circumferential flange. The surface of this cylinder constitutes the inner wall, the adjacent portion of the casing constitutes the outer wall, and the flange at the lower end of the stationary cylinder constitutes the bottom of the annular cell containing the sealing-liquid. The closed head of the intermediate chamber extends up into the hollow base of the primary chamber.

For the sake of keeping the working parts thoroughly lubricated the portions of the interior of the casing containing them are also filled with oil. The intermediate and discharge pistons are provided upon their peripheries with circumferential grooves, which during the outward strokes of said pistons from their respective chambers are carried into the body of oil contained within the casing, and thus become filled, respectively, with annular masses of oil, which upon their return-strokes they carry into their chambers, and which not only serve the purpose of lubrication, but also assist in packing the pistons in their chambers.

Certain peculiarities in the mode of operation of the invention will be more conveniently pointed out after a detailed description of the structure represented in the accompanying drawings, which are as follows:

Figure 1 is a central vertical section of the apparatus in a plane which is slightly diagonal to the vertical plane of the axis of the driving-shaft, which, together with its inner bearing and the crank and pitman, is shown in isometrical perspective, the plane of section being indicated by the dotted line 1 1 on Fig. 5. Fig. 2 is a vertical section taken through the plane indicated by the dotted line 2 2 on Fig. 3. Figs. 3, 4, 5, and 6 are respectively horizontal sections taken through the planes indicated by the dotted lines 3 3, 4 4, 5 5, and 6 6 on Fig. 1.

The pump structure represented in the drawings is contained within an air-tight cylindrical casing A. This casing is composed of three sections—the base-section a, the intermediate section a', and the upper section a^2. The base-section a is closed at the bottom and has an outward circumferential flange at its upper end, and around a portion of its upper end also has an inward flange. The lower end of the intermediate section a' is similarly flanged. The upper end of the intermediate section is also provided with an outward circumferential flange, which affords the bearing for the outward circumferential flange of the hollow base of the primary pump-chamber, upon the top of which the outer circumferential flange of the uppermost section a^2 of the casing bears. The superposed outward flanges are secured to each other by vertical bolts and nuts. This sectional construction is adopted for convenience in assembling the various parts of the structure and may of course be varied without departing from the present invention. The reciprocating-piston system is actuated by a horizontal driving-shaft B, provided with one bearing b on the outside of the intermediate section of the casing and with another bearing b' inside the intermediate section of the casing. The overhanging end of the driving-shaft B has mounted upon it a loose pulley B′ and a fixed pulley B^2, to either of which the driving-belt may be applied. The inner end of the driving-shaft has affixed to it the crank-disk B^3, provided with the crank-pin B^4. The pitman or link C, hung at its upper end upon the crank-pin B^4, is pivotally connected at its lower end with the cross-head D of the discharging-piston D′, which is tightly packed and reciprocates in the discharging pump-chamber d. The latter is preferably cast in one piece with the lowest section a of the casing and is provided with an enlarged upward extension d', which affords the bearings for the cross-head D, and the flaring upper end of which unites with the inward flange of the lower section a.

The shell E, herein called the "piston-carrier," is formed in one piece with or rigidly connected with the cross-head D, and at its upper end is formed in one piece with or rigidly connected with the piston F, which is tightly packed and reciprocates in the intermediate pump-chamber f. The head of the piston F is conical and is perforated to admit the lower end of the hollow piston-rod G, which extends upward through a vertical bearing formed in the flanged plug g, which is inserted in an aperture formed in the head f' of the intermediate pump-chamber f. At its upper end the hollow piston-rod G is affixed to the center of the conical head of the primary piston H, which is an inverted-cup piston composed of the conical head H′, secured at its periphery to the upper end of the cylinder H^2, the lower end of which is open. The primary pump-chamber h h' is the space within the upper section a^3 of the casing outside of the chamber. The stationary cylindrical shell I, which is closed at the top and open at the bottom, is provided at the bottom with the outward circumferential flange I′, and which constitutes the hollow base of the primary pump-chamber.

The space between the outer casing and the vertical wall i and above the flange I′ of the hollow base of the primary pump-chamber is the annular cell i', for containing the sealing-liquid in which the lower portion of the cylinder H^2 is immersed. It will be seen that the intermediate pump-chamber is of considerably smaller diameter than the hollow base of the primary pump-chamber. This affords room for the formation upon the outside of the intermediate pump-chamber of the vertical duct J, connecting at its lower end with the horizontal passage J′, formed through the flange f^2 of the intermediate pump-chamber, and serving as the communication between the duct J and the exterior duct j, formed on the outside of the casing, which, through the aperture j', communicates at its upper end with the space within the upper end of the casing above and around the primary piston. The duct j is connected with the main induction-pipe j^2, through which air is drawn from the vessel or chamber which is to be exhausted. The duct J opens at its upper end in the cell K, formed in a portion of the head f' of the intermediate pump-chamber and provided with the port k. A sinuous passage k' is formed in the head f' of the intermediate pump-chamber and extends upward through the plug g in the hollow base of the primary chamber. The port k^2 of the sinuous passage k' is at a short distance below the port k, and at a short distance below the port k^2 an aperture is formed horizontally through the wall of the intermediate pump-chamber, the mouth of which constitutes the port k^3.

The vertical slide-valve L is provided with a suitable cavity l, which enables it when in its higher position to connect the port k of the cell K with the port k^2 of the sinuous passage k', and by reason of such connection when the primary piston is making its upward stroke air is drawn from the vessel or chamber which is being exhausted through the induction-pipe j^2, the ducts J′ and J, the cell K, the valve-cavity l, and the sinuous passage k' into the portion h of the primary pump-chamber, which is inclosed by the cup-piston. At the same time the intermediate piston F is making its upward stroke and is expelling air from the intermediate pump-chamber f through the port k^3 into the valve-cavity l', connecting with the tubular valve-stem L′. The valve L is held against its seat by a spring M, which acts upon a bearing-block M′, along the face of which the valve L slides during its reciprocating movements. The tubular valve-stem is steadied in its movements by the fixed tubular bearing N, through which it passes, and the tubular bearing N′, affixed to the base of the lower section a, with which the lower end of the valve-stem forms a telescopic joint. During the upward movements of the primary and intermediate pistons the discharge-piston D is also moving upward, and thus enlarging the capacity of the pump-chamber d. The air expelled from the intermediate pump-chamber and driven down the tubular valve-stem L′ is afforded an entrance into the pump-chamber d through the port k^4, which opens into the tube N′ at a point just below the position occupied by the lower end L^2 of the tubular valve-stem when the valve is in its elevated position.

The vertically-reciprocating movements of the valve and valve-stem are controlled by an eccentric on the driving-shaft. The eccentric-strap O is connected by the eccentric-arm O′ with the pin O^2, clamped or otherwise suitably secured to the valve-stem, as illustrated in Fig. 1. The eccentric is so timed with relation to the crank on the primary shaft that at the proper time the valve L in its downward movement closes the port k of the cell K, and thus opens communication between the port k^2 of the sinuous passage k' and the port k^3, communicating with the intermediate pump-chamber. The downward movement of the valve carries the valve-cavity l' below, and thus closes the port k^3, and also carries the lower end L^2 of the valve-stem below, and thus closes the port k^4, leading to the discharging pump-chamber d. It follows that during the downward stroke of the piston system air from the primary pump-chamber is driven through the sinuous passage k', the valve-cavity l, and port k^3 into the intermediate pump-chamber, the piston of which is at the same time descending, and thus enlarging the capacity of the intermediate pump-chamber.

The amount of pressure which the primary piston exerts upon the air contained in the primary pump-chamber is determined by the weight of the column of sealing-liquid in which the cylindrical flange of the primary piston is immersed and varies, of course, with the depth of such immersion. While the intermediate pump-chamber is thus being filled the air contained in the discharging pump-chamber d is being compressed by the downward movement of the discharging-piston D′. When the air in the discharging pump-chamber d has been compressed to the desired extent, it is discharged therefrom through the check-valve P into the atmosphere, or through the pipe P′ into another chamber, as the case may be. The check-valve P is a yielding valve, which may be held upon its seat by atmospheric pressure or by any other prescribed degree of pressure which may be desired. A portion of the inner flange of the lower section a is cut away to afford clearance for the eccentric-rod. The lower portion of the valve-stem is contained within a cell Q, formed by the vertical webs Q′ Q′, which unite the lower section of the casing a to the wall of the pump-chamber d and to its extension d'. The cell Q communicates with the interior of the extension d' through the aperture d^2, as shown in Fig. 1.

The unoccupied space within the intermediate section a' of the casing, also that within the cell Q, and also that within the extension d' of the pump-chamber d, is filled with oil through the pipe R for the purpose of lubricating the interior moving parts of the structure. Similarly the space between the exterior of the intermediate pump-chamber and the interior of the hollow base I of the primary pump-chamber constitutes an oil-chamber S, which is filled by oil forced through the pipe S′, an avenue of escape for the air displaced by such oil being afforded by the pipe S^2. The oil thus introduced serves to lubricate the bearing within the plug *g* of the hollow piston-rod G, to which it has access through the aperture *g′*, communicating with the annular recess g^2, formed in the wall of the aperture in the flanged plug *g*, through which the hollow piston-rod G passes.

The intermediate piston F and the discharge-piston D′ are respectively provided exteriorly with circumferential grooves F′ and D^2, which are alternately carried into the body of lubricating-oil with which the interior of the structure is filled and carried back again into their respective cylinders. The oil caught in these grooves is carried into the cylinders and not only lubricates the pistons, but forms liquid packing for them. The pistons F and D′ are also in addition provided with the usual packing-rings. It will of course be understood that the driving-shaft where it enters the casing must be so packed as to prevent the leakage of oil from the interior of the structure. The space U in the lower section *a* may be employed for the circulation of cooling or heating liquids, such as may be required to maintain the apparatus at any prescribed temperature.

With this invention an unusually high vacuum can be produced and maintained by the expenditure of a comparatively small amount of power.

The primary pump-chamber is of comparatively large capacity. Its cup-piston is not exposed to atmospheric pressure, and, by reason of having its lower cylindrical portion immersed in the sealing-liquid, operates without leakage and without appreciable friction.

Great difficulty has been heretofore experienced in the production and maintenance of a high vacuum in a chamber containing any substance which vaporizes *in vacuo* and liquefies under atmospheric pressure or under pressure less than atmospheric pressure. The vapor of such a substance when drawn into the chamber of an air-pump, and then compressed by the expelling movement of the piston, is liable to condense into a liquid and to thus become of so little volume as not to be expelled from the pump-chamber. In such case when the piston makes its exhausting movement, and thereby creates a partial vacuum in the pump-chamber, the liquid revaporizes and so fills the pump-chamber as to leave little or no room for the entrance of a fresh supply of vapor from the vessel which it is sought to exhaust, and hence, of course, prevents the establishment of a high vacuum in such vessels. In the present invention the occurrence of this difficulty is prevented by effecting the necessary compression of the exhausted vapor in different pump-chambers and by avoiding any degree of compression in the primary pump-chamber which would be sufficient to cause the vapor therein to liquefy.

The positively-operated valve M′ is so timed that it commences to move downward from its highest position at the instant after the piston system has concluded the first half of its upward stroke, and immediately after the piston system has arrived at the end of its upward stroke the valve M′ has moved down so far that all the valve-ports are covered. Immediately after the commencement of the downward stroke of the piston system the valve-ports k^2 and k^3 begin to be uncovered by the downwardly-moving valve M′, thus opening communication by way of the valve-cavity *l*, through which air or vapor from the primary pump-chamber is both forced and drawn into the intermediate pump-chamber to occupy the space vacated by the descending piston F. Thus the compressing action of the downwardly-moving primary piston tending to force the air into the intermediate pump-chamber is co-operated with by the exhausting action of the intermediate piston, and there is never any backward rush of the air or vapor from the intermediate pump-chamber into the primary pump-chamber. Similarly the positively-operated valve M′ is so timed that it commences to move upward from its lowest position at the instant after the piston system has completed the first half of its downward stroke. Immediately after the conclusion of the downward stroke of the piston system all the valve-ports are again covered; but the instant after the commencement of the upward stroke of the piston system communication between the valve-ports *k* and k^2 begins to be established through the valve-cavity *l*, and the valve-ports k^3 and k^4 begin to be uncovered, thus opening communication by way of the valve-cavity *l′* and hollow valve-stem L′, through which air or vapor from the intermediate pump-chamber is both forced and drawn into the discharging pump-chamber to occupy the space therein vacated by the ascending piston D. Thus the compressing or expelling action of the upwardly-moving intermediate piston, tending to expel the air or vapor into the discharging pump-chamber, is co-operated with by the exhausting action of the discharge pump-piston, and there is never any backward rush of air from the discharge pump-chamber into the intermediate pump-chamber.

In starting the apparatus into operation the primary cup-piston will at each upward stroke become filled with air or vapor at or near atmospheric pressure, but at each successive stroke as the process of exhaustion goes on a less and less quantity of air or vapor will be drawn into the cup-piston. The annular chamber containing the sealing-liquid affords an avenue of escape for any compressed air from the cup-piston in excess of the quantity which can be discharged into the intermediate pump-chamber. Such excess of compressed air depresses the annular body of sealing-liquid between the vertical wall of the hollow base of the primary pump-chamber and the inside of the cup-piston and escapes under the lower edge of the cup-piston upward through the body of sealing-liquid outside of the cup-piston into the space in the upper part of the casing. During the upward stroke of the piston the sealing-liquid falls back by its own gravity to its normal position. As the process of exhaustion goes on, the air or vapor drawn into the cup-piston is more and more rarefied, and the extent of displacement of the sealing-liquid is gradually diminished, until finally the weight of the column of sealing-liquid is sufficient to counterbalance the compressed air or vapor in the cup-piston during the downward stroke thereof.

It will of course be understood that the series of pump-chambers of relatively diminishing size need not necessarily be arranged in vertical axial alignment, and that if not so arranged the terms "upward" and "downward," applied to the strokes of the several pistons, would not necessarily apply, for the several pumps might be so arranged that the downward strokes would in all cases be the expelling or compressing strokes, whereas in the organization shown in the drawings the expelling or compressing stroke of the intermediate piston is its upward stroke.

The arrangement in vertical alignment of the several pump chambers and pistons is advantageous because of the compactness of organization which it permits and the facility with which the working parts of the structure may be inclosed in a cylindrical casing.

What is claimed as the invention is—

1. A compound vacuum-pump consisting, essentially, of a main induction-pipe, a series of three pump-chambers of successively diminishing size, a like series of reciprocating pistons, suitable passages for keeping all three of the pump-chambers at one end in constant communication with the main induction-pipe, suitable valve ports and ducts, and a positively-operated valve apparatus for appropriately opening and closing communication between said pump-chambers and between the main induction-pipe and the end of the largest one of said series of pump-chambers opposite the end of said chamber which is in constant communication with the main induction-pipe, substantially as and for the purposes hereinafter set forth.

2. In a compound vacuum-pump, the combination, as herein set forth, of a series of three pump-chambers of successively diminishing size arranged in vertical alignment and contained within a closed casing, a like series of reciprocating pistons rigidly connected with each other and moving as a unit, a main induction-pipe and a discharge-pipe connected with said casing, suitable passages for keeping all three of said pump-chambers in constant communication with said main induction-pipe, suitable valve ports and ducts, and a positively-operated valve apparatus for appropriately opening and closing communication between said pump-chambers and between the main induction-pipe and the end of the largest one of the said series of pump-chambers opposite the end of the pump-chamber which is in constant communication with the main induction-pipe.

3. In a compound vacuum-pump, the combination, as herein set forth, of a primary pump-chamber provided at the bottom with an annular cell adapted to contain a sealing-liquid for a cup-piston, an intermediate pump-chamber and a discharge pump-chamber composing a series of three pump-chambers of successively diminishing size arranged in vertical axial alignment and contained within a closed casing, a like series of reciprocating pistons rigidly connected with each other and moving as a unit, and embracing, first, a cup-piston of relatively large diameter; second, an intermediate piston of smaller diameter, and, third, a discharge-piston of still smaller diameter; a duct connecting the upper part of the first or primary pump-chamber with the space within the casing beneath the intermediate pump-chamber, a main induction-pipe communicating with the upper part of the said primary pump-chamber, suitable valve ports and ducts, and a positively-operated valve apparatus for alternately opening and closing communication between the adjoining pump-chambers and between the interior of the cup-piston and the main induction-pipe.

4. In a vacuum-pump, the combination, as herein set forth, of the pump-chamber *h h'*, the reciprocating inverted-cup piston H, the annular cell *i'*, adapted to contain a body of sealing-liquid for packing said cup-piston, suitable valve ports and ducts, and a positively-operated valve apparatus for keeping the space *h* inside the cup-piston in communication with part *h'* of the pump-chamber outside the cup-piston during the upward stroke of said cup-piston and for closing such communication and opening an eduction-passage for the discharge of air or vapor from the space *h* within the cup-piston during the downward stroke thereof.

5. In a vacuum-pump, the combination, as herein set forth, of the pump-chamber *h h'*, the reciprocating inverted-cup piston H, the annular cell *i'*, adapted to contain a body of sealing-liquid for packing said cup-piston, suitable valve ports and ducts, and a positively-operated valve apparatus for keeping the space *h* inside the cup-piston in communication with the main induction-pipe j^2 and with the part *h'* of the pump-chamber outside the cup-piston during the upward stroke of said cup-piston and for closing such communication and opening a passage for the dis-

charge of air or vapor from the space h within the cup-piston during the downward stroke thereof.

6. In a vacuum-pump, the combination, as herein set forth, of a primary pump-chamber of relatively large size, the reciprocating inverted-cup piston H, the annular cell i' at the bottom of said primary pump-chamber, adapted to contain a sealing-liquid for packing said cup-piston, the pump-chamber f, of smaller diameter than the said cup-piston, and the piston F, reciprocating in said chamber f, suitable valve ports and ducts, and positively-operated valve apparatus for keeping the interior of the cup-piston H in communication with said pump-chamber f only during the compressing-stroke of the piston H and the exhausting-stroke of the piston F, and for keeping the interior of the cup-piston H in communication with the main induction-pipe j^2, and at the same time keeping open the passage through which the contents of the pump-chamber f are discharged during the exhausting-stroke of the piston H and the compressing-stroke of the piston F.

7. The combination, as herein set forth, of the reciprocating inverted-cup piston H, the primary pump-chamber provided with the hollow base I, the outer side of which constitutes the inner wall of the annular cell i', the pump-chamber f, extending upward into the hollow base I and provided near the top with the aperture k^3 and suitable valve ports and ducts, and positively-operated valve apparatus, as and for the purposes described.

8. The combination, as herein set forth, of the primary pump-chamber, the reciprocating inverted-cup piston H, packed by the immersion of its lower edge in a body of sealing-liquid contained in the annular cell i', the intermediate pump-chamber f and its piston F, of smaller diameter than the said cup-piston, the discharge pump-chamber d and its piston D′, respectively of smaller diameter than the pump-chamber f and piston F, the check-valve P, adapted to yield to a prescribed internal pressure and to thus permit the discharge of air from the discharge pump-chamber d, suitable valve ports and ducts, and positively-operated valve apparatus for keeping open communication between the interior of the cup-piston H and the main induction-pipe j^2 and between the pump-chamber f and the discharge pump-chamber d only during the upward stroke of the piston system, and for keeping open the communication between the interior of the cup-piston H and the pump-chamber f, and also keeping the communication between the pump-chamber f and the pump-chamber d closed during the downward stroke of the piston system.

9. The combination, as herein set forth, of the hollow piston-rod G, the cup-piston H, and the intermediate piston F, for the purpose of keeping the upper portion h' of the primary pump-chamber in communication with the interior of the casing below the piston F.

10. The combination, as herein shown and described, of the middle section a' of the casing, for containing a body of sealing and lubricating liquid, the extension d' of the discharge pump-chamber, opening at its upper end into the said middle section, and the intermediate pump-chamber f, opening at its lower end into the said middle section, and the pistons D′ and F, respectively provided exteriorly with the circumferential grooves D^2 and F′.

11. The combination, as herein shown and described, of the hollow base I, the primary pump-chamber and the exteriorly-flanged intermediate pump-chamber f, contained within the said hollow base I, the oil-supply pipe S, and air-escape pipe S^2, as and for the purposes set forth.

12. The combination of the intermediate pump-chamber f, provided with the aperture k^3, the discharge pump-chamber d, and passage k, with the hollow valve-stem L′, for serving as the duct of communication between the said aperture K^3 and the said passage k, substantially as and for the purpose set forth.

13. The piston-carrier E and pistons D′, H, and F, connected to said carrier and arranged in vertical axial alignment, in combination with the driving-crank disk B^3 and pitman C, projecting into the interior of the piston-carrier E, as shown and described.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

JOHN PATTEN.

Witnesses:
J. J. KENNEDY,
T. H. PALMER.