(No Model.)

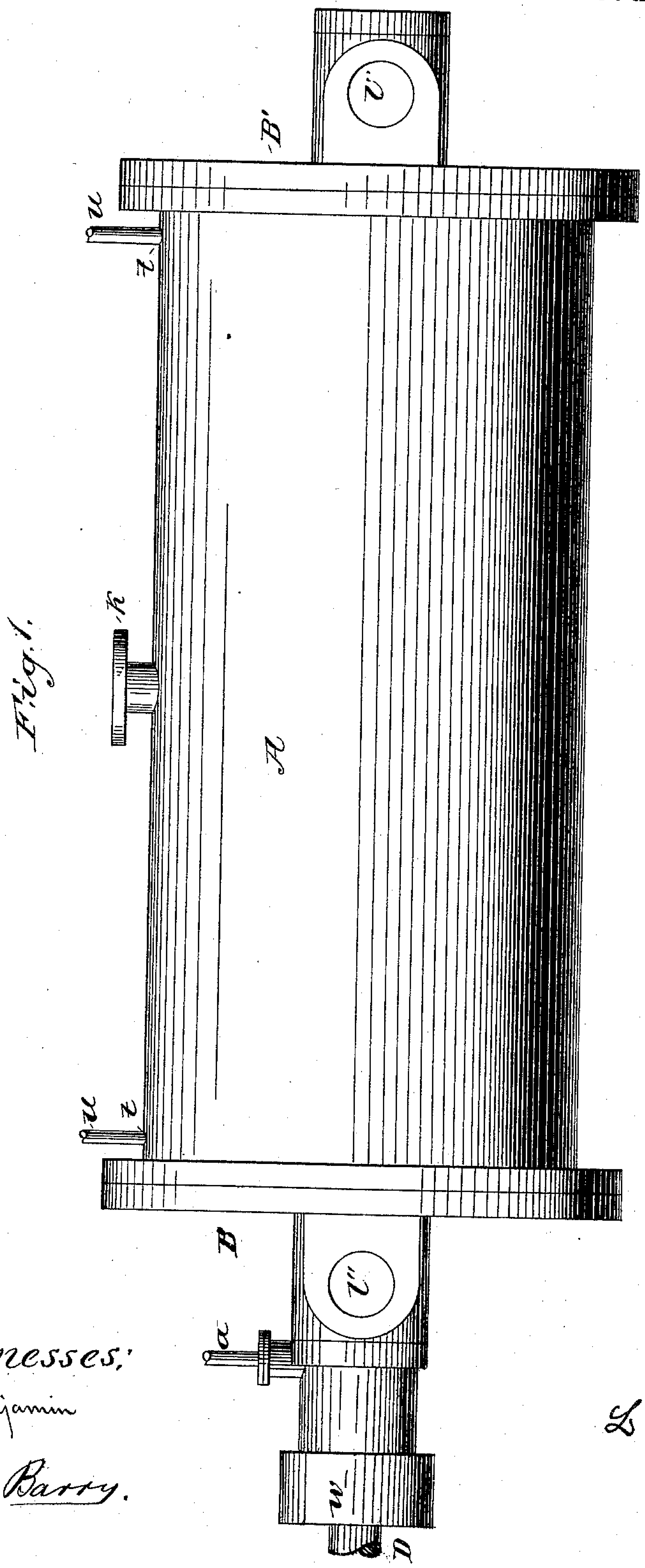
3 Sheets—Sheet 1.

L. ALLEN.

GAS PUMP.

No. 474,512.

Patented May 10, 1892.



Witnesses:

C. M. Benjamin

George Barry.

Inventor:

Leicester Allen

(No Model.)

3 Sheets—Sheet 2.

L. ALLEN.

GAS PUMP.

No. 474,512. Patented May 10, 1892.

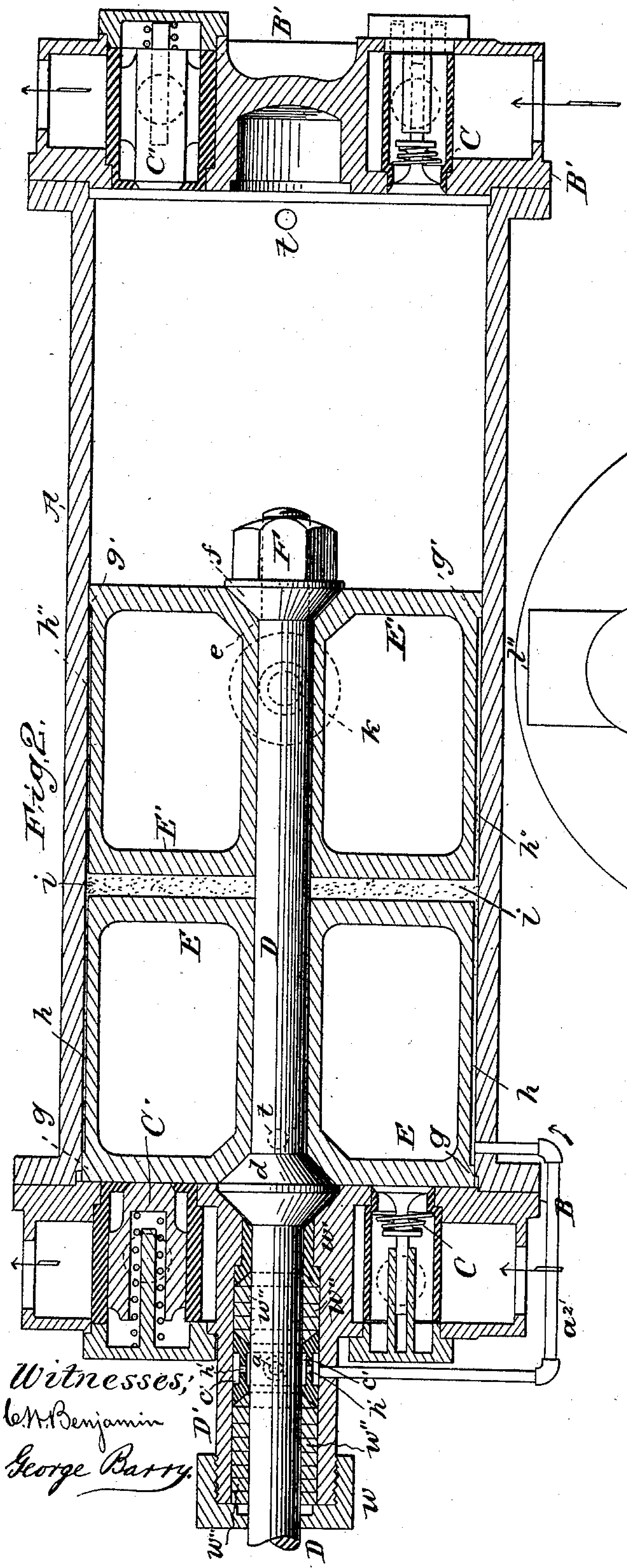


Fig. 2.

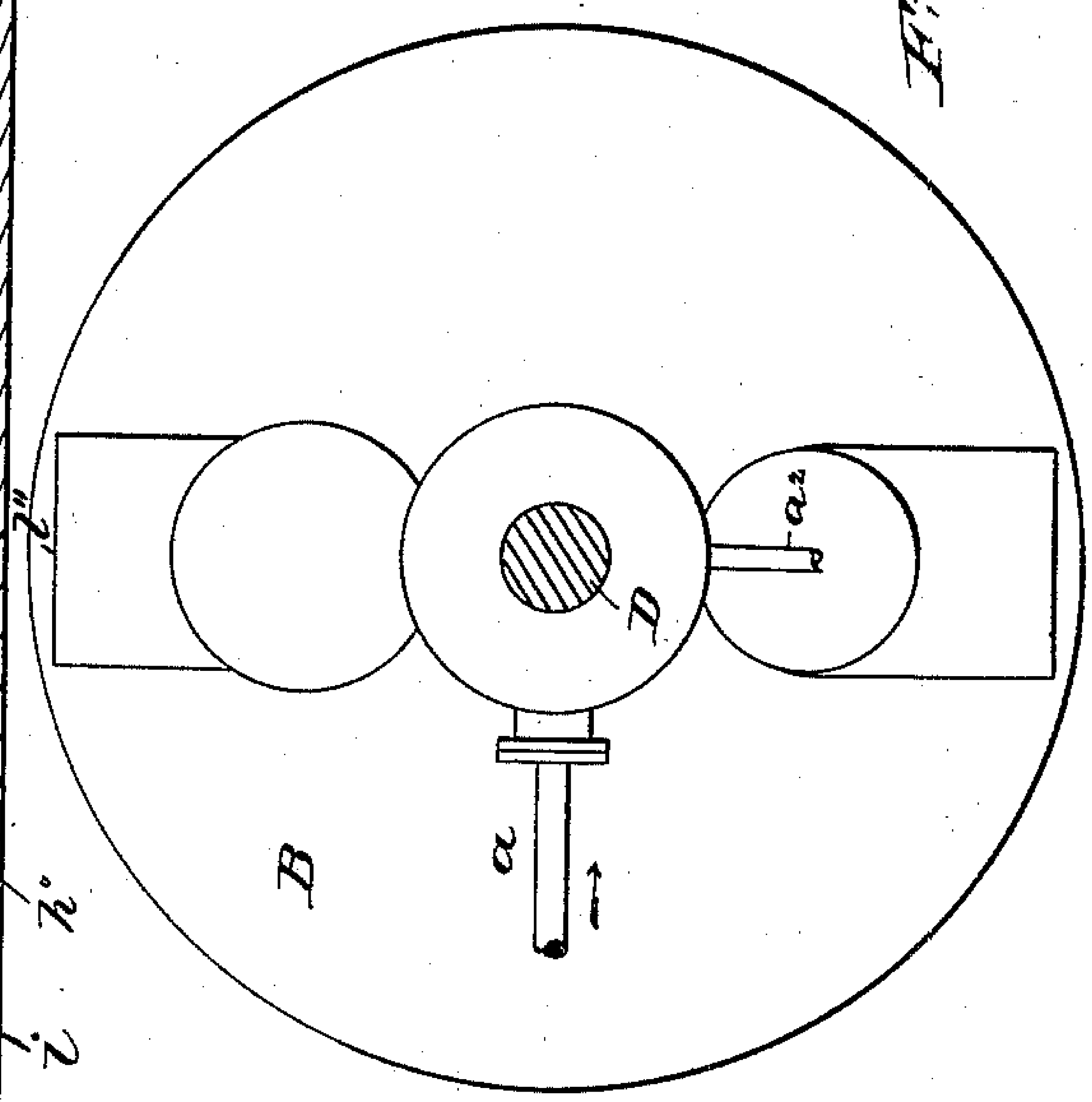


Fig. 3.

Witnesses;
C.W. Benjamin
George Barry.

Inventor;
Leicester Allen

(No Model.)

3 Sheets—Sheet 3.

L. ALLEN.

GAS PUMP.

No. 474,512. Patented May 10, 1892.

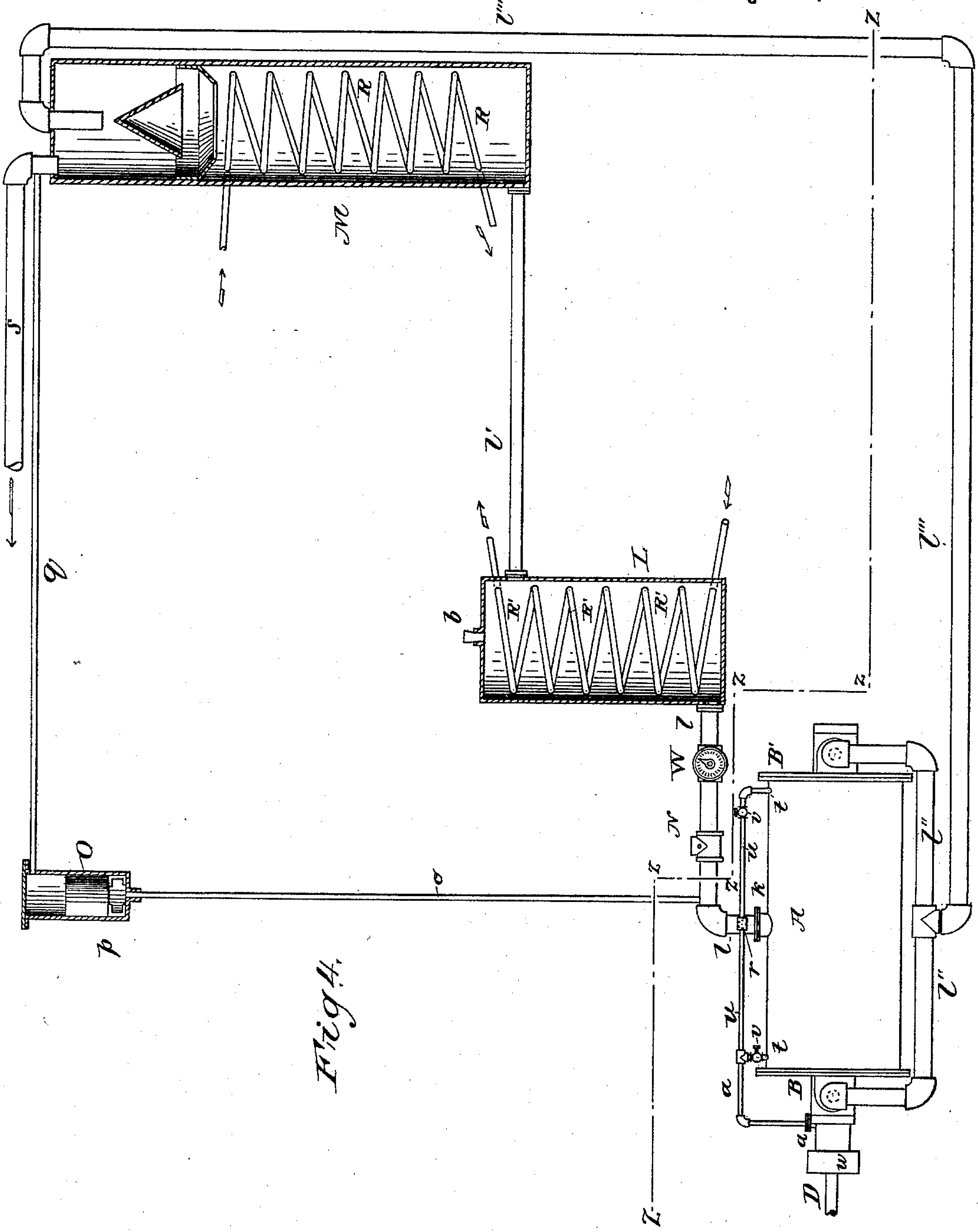


Fig. 4.

Witnesses;

C. H. Benjamin.

George Barry.

Inventor:

Leicester Allen

UNITED STATES PATENT OFFICE.

LEICESTER ALLEN, OF NEW YORK, N. Y.

GAS-PUMP.

SPECIFICATION forming part of Letters Patent No. 474,512, dated May 10, 1892.

Application filed January 15, 1891. Serial No. 377,813. (No model.)

To all whom it may concern:

Be it known that I, LEICESTER ALLEN, of the city, county, and State of New York, have invented a new and useful Improvement in Gas-Pumps; and I do hereby declare that the following is a full, clear, and exact description of the same, reference being had to the accompanying drawings, forming part of this specification.

My invention consists in the construction of the pump-piston hereinafter described, whereby the solid parts of the piston are permitted to work flush up against the heads or covers of the pump barrel or cylinder and thus entirely avoid the clearance usually allowed between the piston and heads of such pumps and by which the packing of the piston is effected by the liquid which forms a part of the piston.

My invention further consists in means for automatically restoring to the piston the liquid that may leak out of it and be discharged from the pump with compressed gas.

Another part of the invention is the combination, with the pump and the piston, of a peculiar relief mechanism, whereby should any inaccuracy in keying up the connecting-rod which drives the piston allow the piston-rod to move farther than either of the predetermined limits of the piston stroke the latter will still not pass such limit and the heads of the pump-cylinder will not be endangered.

The invention also consists in a peculiar means of lubricating the piston-rod, valves, and stuffing-box and of automatically supplying to the cylinder at each stroke of the piston, in advance of the latter, a measured amount of liquid sufficient to fill any spaces around the valves that would otherwise remain filled with gas after each discharge of the pump.

Although other liquids may be found suitable, a good lubricating mineral oil is at present preferable in working this pump, and, although I do not limit myself to the use of such oils, I will, for purposes of description, hereinafter chiefly consider the liquid as "oil" and so term it.

Referring now to the drawings, Figure 1 is a top view, Fig. 2 a vertical longitudinal section, and Fig. 3 a view, of the piston-rod end of a pump constructed to carry out my invention. Fig. 4 is a partly-diagrammatic view of the general arrangement of the pump and its appurtenances, explanatory of the invention, the part below and at the left of the broken line *z z z z z* being in plan and that above and to the right of the line being in elevation.

A, Figs. 1, 2, and 4, is the barrel or cylinder of the pump, provided with heads or bonnets B B', each of which contains in suitable valve-chambers an inlet-valve C and an outlet-valve C'. The directions of inflow of the gas to and from the pump are indicated by arrows in Fig. 2.

As my improvement in no way relates to any particular construction, position, or operation of the induction and eduction valves of gas-pumps, it will only be necessary to the full explanation of my invention to say that the valves shown in my drawings are puppet-valves operated in closing by coiled springs in a manner familiar to those versed in the art of constructing gas-pumps, and are to be considered as typical of any good approved system of inlet and outlet valves.

The pump, as shown, is of the kind known as "horizontal" and "double-acting." In use the barrel or cylinder is rigidly attached to a bed-plate or foundation after any approved manner, and its piston receives motion through a reciprocating piston-rod or pump-rod D. On this piston-rod is forged and turned or otherwise fitted a boss *d*, Fig. 2, which may be of any form, but which I prefer to make in the form of two truncated cones joined by their bases to a short intermediate cylindrical portion. Near the inner extremity of the rod D is a shoulder *e*, against which a conical collar *f* abuts, and is there rigidly held by a nut F.

Upon the rod D are fitted parts E E' of the piston, these parts being preferably ground to fit both the rod upon which, under certain conditions to be hereinafter described, they may slide, and also to fit against the interior of the pump-barrel where their perimeters are carried out to meet the barrel, as indicated at *g g'*. The fitting of these parts should be as tight as is compatible with their easy sliding on the rod or over the interior surface of the cylinder, when the rod and cylinder are thoroughly lubricated.

Except at the parts *g g'*, the diameters of the parts E E′ are less than that of the cylinder, having a distinct annular space h or h'' around each of them, and between these parts there is also left a space i, as shown in Fig. 2. The spaces h, h'', and i are continuous with each other, forming a single space which in use is filled with oil under pressure through a pipe connection k. (Shown in all the figures.) The preferable position for this connection is at the middle of the pump-cylinder, and it is desirable, though not absolutely essential, that the length of the cylinder and the oil-space between the parts g g' should be so proportioned that the pipe connection k will in any part of the stroke communicate freely with this space.

The parts E E′ and the intervening liquid constitute the piston, as these parts move together, and the oil is a transmitter of power between the parts, as will be more fully explained. Each of the parts E and E′, or "piston-heads," as I shall hereinafter style them, is formed hollow and gas-tight, so far as communication with its interior is concerned, and is so proportioned that its weight is as nearly as possible that of a bulk of the intervening liquid, which it would displace if immersed in such liquid. These parts are therefore separately and independently in hydrostatic equilibrium and of themselves do not press nor tend to press materially against the cylinder or piston-rod. They hence work with the minimum friction possible to a reciprocating piston and do not wear materially when sliding on the piston-rod.

The liquid may be forced into the space between the parts E and E′ by a special pump to a pressure equal to that necessary to effect the discharge of the compressed gas; but I prefer to make the pump in all respects automatic by certain appliances, which I will now describe in connection with the partly-diagrammatic Fig. 4. For this purpose I connect the pump-barrel at k with the bottom of an oil tank or reservoir L by means of a pipe or passage l, the top of this reservoir being connected with some part of the space or receiver or condenser into which the compressed gas is delivered from the pump by a pipe or passage l'.

In Fig. 4, l'' and l''' represent the discharge-pipe and branch connections leading to an oil-separator M, in which such oil as may leak out of the piston, together with such oil as is required for lubricating the valves, is collected after its discharge from the pump and separated from the absorbed gas, as hereinafter explained. The oil in the tank L is by this construction continually subjected to the highest pressure of the gas after the latter has been discharged from the pump, and as this pressure is freely transmitted through the pipe l and pipe connection k to the oil-space h h'' i, between and around the heads E and E′ of the piston, it follows that whenever the pressure in the gas-space of the pump is less than the pressure in L (as will be the case during the entire period of induction and during the period of compression until the maximum pressure is reached) the piston-heads will be pressed asunder, E against the boss d and E′ against the collar f. A check-valve N, Fig. 4, prevents any escape of this oil back through the pipe connection and pipe l. Its only avenue of escape is therefore by leaking out of the piston into the gas-space in the pump. This action will be so extremely slow in a pump fitted by grinding, as I have described, that other provision for lubricating the valves will be necessary, as hereinafter explained. It will be seen that this construction completely packs the piston without the use of packing-rings, and also insures its perfect lubrication. No gas can slip by the piston against a liquid-pressure practically never less than that of the gas itself and during the periods of induction and of compression always greater than that of the gas, and this perfect piston-packing is secured with the minimum friction, as, on account of the hydrostatic balance of the piston-heads the liquid packing and the constant lubrication of every part of the interior of the pump-barrel the friction is substantially reduced to that of a liquid column moving to and fro in the cylinder. As has already been stated, the piston-heads work flush up to and against the cylinder-heads, this position of the piston being shown in Fig. 2. As the liquid between the piston-heads is nearly as incompressible as a solid, the piston could not be so operated without danger of breaking out the cylinder-heads unless a special, complete, and positive means for preventing such an accident were provided. Such a device I will next describe.

Connected with and extending from a part of the pipe l between the check-valve N and the cylinder is a pipe o, which connects with the bottom of a vertical relief-valve chamber O. This chamber contains a freely-working but rather heavy relief-valve p, fitted to a seat in the chamber and also fitted to the interior of the chamber, so that it may rise and fall without allowing any material slip of oil by it from below the valve to the upper part of the chamber. The upper part of the chamber is connected by a small pipe q with the upper part of the oil-separator M, and the space is therefore filled with gas at the pressure under which it is delivered from the pump, while the space below the valve p is always filled with liquid or gas or a mixture of gas and liquid.

The operation of this part of my invention is as follows, under the supposition that an inaccuracy in keying up some part of the driving mechanism has moved the piston out of its proper central relation with the cylinder-heads, say, from one thirty-second to one-sixteenth of an inch. In the latter extreme case one of the heads E or E′ will reach and come into contact with a cylinder-head at one-sixteenth of an inch from the end of the stroke of the piston-rod. Suppose the one so coming in contact to be the head E. It will stop against the head B, while the piston-rod and the head E' continuing their motion the space $hh''i$ is reduced in volume an amount equal to area of the cylinder multiplied by the distance the piston-head E' continues to move after the stoppage of the head E. To compensate for this reduction of volume with only a very slight increase of pressure between the piston-heads, the liquid, being prevented from returning to the oil-tank by the check-valve N, backs up through the pipe o into the lower part of the chamber O under the relief-valve p, raising the latter sufficiently to allow the displaced liquid to enter. When the stroke is reversed, this liquid being under higher pressure than that in the pipe l, is immediately forced back into the space between the piston-heads. It is easy to so proportion the weight of the valve p as to make the difference in pressure when working, as described, only about one pound per square inch more than the pressure of the gas as delivered from the pump. As the mean piston-speed of compression gas-pumps is usually low, rarely exceeding one hundred and sixty to one hundred and eighty feet per minute, or a velocity of three feet per second, and as in a stroke of, say, twenty-four inches the velocity of the piston at one-sixteenth of an inch from the termination of the stroke would be only 0.394 feet per second, the piston-head cushions softly against the head and meets it without the least danger to the integrity of the cylinder-head, whereas if the piston-head were rigidly attached to the piston-rod the head would either be broken out or some exterior breakage would result.

It will be seen that when the piston is properly set its heads may work so close to the heads of the cylinder as to practically abolish the clearance commonly maintained as a measure of safety between the pistons of gas-pumps and their cylinder-heads. Yet as this will not wholly obviate clearance, as there must be some allowed between the boss d and the head B, and also between the nut F and the head B and in the counterbore of the cylinder, and as, moreover, in different arrangements and constructions of inlet and outlet valves for use with this pump there may be more or less clearance necessarily introduced, it is desirable that the evil effects of such clearances should be obviated by filling them at the end of each stroke with liquid, thus reducing their gas-holding capacity to from one-fourth to one-fifth their volume or to a proportion of such volume dependent upon the coefficient of absorption which the liquid has for the gas; and as a certain amount of oil or other liquid is necessary to lubricate the valves it is also desirable that the liquid used for filling the clearances should be a good lubricant and be regularly supplied to the cylinder and discharged therefrom. A part of my invention, which I will now describe, does this with certainty and automatically. At some point, as at r, Fig. 4, between the check-valve N and the pipe connection k I insert a small T or other suitable pipe connection, and connect small branch pipes u from thence to small openings t in the pump-cylinder near its ends. In these branch pipes I place regulating-valves or plug-cocks v, which may be opened equally to permit equal or nearly equal flow, and in the pipe l I place a fluid-meter W, which indicates the amount of oil passing during any interval of time or during any given number of strokes. The exact amount of clearance having been computed, this multiplied by the number of strokes in a given time will give the quantity that should pass through the meter in the same time to supply a mean volume of oil at each stroke equal to the clearance. The valves or plug-cocks can easily be so regulated that the amount of oil passing through them added to the quantity which leaks out of the piston, both of which are measured by the meter, will be the quantity required for this purpose, and as an equal amount will also be regularly passed through the outlet-valves in the same time these valves will always be well lubricated and packed. If greater refinement in supplying oil to the cylinder for filling clearances be desired, a meter may also be placed in each of the branch pipes $u\ u$. It is also desirable that the oil so passed into the pump and between the piston-heads shall be, as far as possible, free from absorbed gas. To effect this, I do not rely upon the separation of the gas by the action of gravity alone, as has been done by others, but I also aid the separation by heat. The separator M may be of any approved kind; but it is shown in Fig. 4 as a tank into which the compressed gas is discharged against a conical baffle-plate, whence it drips down to the bottom of the tank. I connect with this separator, or any other I may elect to employ, a small heater R, preferably a steam-coil, by which a temperature in the oil is maintained considerably higher than that of the discharged gas, which, passing into the separator through the pipe L''', passes, after throwing down its oil with the gas therein mixed and absorbed, through the pipe s on its way to a condenser. (Not shown.) Only a very slight accession of heat is thus imparted to the principal body of the gas, while the gas absorbed in the oil is superheated and driven out of the liquid, mingling with the other part of the gas and passing onward with it. As the oil passes through the separator it runs out through the pipe l' into the oil-tank L. Here it is cooled by a water-coil R', contained in this tank, from which it passes, as needed, cold and freed from gas to and into the pump. As a given volume of the oil can contain only a specific volume of the gas under any specific pressure and as the effect of heating the gas under constant pressure is to immediately and largely increase its volume, it will be seen that a considerably more effective separation of the gas from the liquid can be effected by this method than by the mere gravitation of the oil in a separator. The steam for the steam-coil R may be taken from any source, and, if desired, the very small quantity of condensed water produced may be taken out by a steam-trap. Water for the water-coil R′ may be taken by a branch pipe from any source of supply.

It remains to describe the construction and connection of the stuffing-box by which it is constantly lubricated. I make the stuffing-box D′ with either a screw-cap or a gland. The example in the drawings shows a screw-cap w. The usual bushing is shown at w', Fig. 2, and rings w'' of soft packing or metallic packing or any other approved packing may be used in the box. The metallic ring a, recessed both on the inside and outside, forms, in combination with the piston-rod and the shell of the stuffing-box, two annular concentric oil-chambers c and c', Fig. 2, and a pipe connection a or passage for oil through the shell of the box into the outer of these annular chambers or recesses. The two chambers or recesses c and c' communicate freely with each other by an oil hole or holes h'. From the pipe l, or directly from the oil-tank or from pipe u, I connect an oil-pipe with the pipe connection a and allow the oil from the tank L to freely press into the annular chambers c and c'. The ring A′ is placed midwise between two series of packing-rings, and the pressure in the annular chambers c and c' being always that of the gas discharged from the pump the oil in these chambers will during the periods of induction and compression tend to work through both series of packing-rings and during the period of discharge to work through the series of rings nearer the cap or gland of the stuffing-box; but at all times there will be interposed a compact body of cold oil between the gas confined in the pump and the exterior of the stuffing-box, which, while being thus effectually packed without screwing down the gland with excessive force, affords the most perfect lubrication for the piston-rod and packing, and thus reduces the friction to the minimum possible in a gas-tight stuffing-box.

To hydraulic packing for ammonia-pumps as heretofore used, the oil has been supplied from gravity-separators with an amount of absorbed gas such as it will hold at the temperature of the discharged gas or at a lower temperature under the maximum pressure of discharge. There is in this method an inevitable and continuous though of course a small waste of valuable gas, which escapes from the oil oozing out of the box; but in the method of separation I have described the percentage of such loss is greatly reduced, as the oil in the tank M, from which the stuffing-box derives its supply, always contains much less absorbed gas than it would hold were this method of separation not applied. A part of the oil passing into the annular chambers in the stuffing-box will pass slowly out at the front end of the box through the packing, and as gas will also seek egress in the same direction through the oil in the annular chambers this oil, if retained in the chamber a sufficient length of time, will become saturated with the gas, which, passing out with the oil, will escape into the external air and be lost. I therefore prefer to cause a free passage through the annular chambers of oil which has been separated from gas in such manner that the oil in the stuffing-box is continually and rapidly changing, and has not time to become saturated or even to absorb gas except in an extremely limited quantity. To accomplish this, I connect the outer annular chamber c' by a small pipe a^3 with the interior of the barrel of the pump, preferably near the end, and arrange the valve or cock v at a point between the junction of the pipes a and u and the connection t of the pipe u with the pump. By adjustment of the valve v and properly proportioning the size of the pipe a^2 I may compel as much or as little of the oil flowing through the pipe u to flow through the pipes a and a^2, and through the stuffing-box back into the pump as may be desired, and as the space comprised in the annular chambers c c' is very small the oil may be changed in these chambers as often as once for each reciprocation of the piston, as the oil will flow into the pump by this route at all times when the pressure in the pump is less than in the tank L.

I have described my invention as applied to horizontal pumps; but it is obvious that it is equally applicable to vertical pumps.

By constructing the pump of glass, which its construction easily admits for small sizes, using asbestus packing in the stuffing-box and sulphuric acid as the liquid, the pump becomes a very efficient air-pump for exhausting the bulbs of electric lamps, the air absorbed by the acid being expelled by heat in the separator. By substituting mercury for oil in a pump constructed of iron an air-pump of considerable exhausting power may also be produced. Highly-concentrated glycerine is also a good liquid for an air-pump of this construction.

In charging and starting this pump on ammonia a sufficient quantity of oil is supplied to the oil-tank L through plug-opening b, which is temporarily left open. An opening is made through a suitable valve to the atmosphere for discharge of air from the pump, and communication from the outlet-valves to the condenser through the separator and from the condenser to the oil-tank is also stopped by suitable valves. The pump is then started and run until the air has been sufficiently displaced from the condenser. Connection between a supply of ammonia and the inlet-pipes is then made, the plug-opening in the oil-tank stopped, and the valves opened as for normal working. The working will be normal as soon as the pressure on the delivery side of the outlet-valves becomes that due to temperature of the condenser or receiver into which the gas is discharged.

I am aware that pistons and stuffing-boxes with liquid packings have been used and are in practical use. I do not therefore broadly claim as my invention such a piston or stuffing-box; but

I claim as follows:

1. In a gas-pump, a piston composed of separate relatively-movable heads and intervening liquid which is a means of transmitting motion from one head to the other, substantially as described.

2. In a gas-pump, a piston composed of separate relatively-movable heads and an intervening compressed-liquid column which is a means of transmitting motion from one head to the other, substantially as and for the purpose set forth.

3. In a gas-pump, a piston which comprises separate relatively-movable heads with intervening liquid constantly compressed to a tension, substantially the same as that of the compressed gas discharged from the pump, and which is also a means of transmitting power from one head to the other, substantially as herein described, and for the purposes set forth.

4. In a gas-pump, the combination of a piston-rod with a piston comprising relatively-movable heads fitted to slide one toward the other on said rod and intermediate liquid which is a means of transmitting motion from one head to the other, substantially as and for the purposes specified.

5. The combination, with the cylinder of a gas-pump, of a piston composed of separate relatively-movable heads and interposed liquid which is contained within the cylinder and surrounds the said pistons and which is a means of transmitting motion from one of said heads to the other, substantially as and for the purposes herein explained.

6. The combination, substantially as herein described, with the cylinder of a gas-pump, of a piston composed of separate relatively-movable heads, and a column of liquid intervening between and surrounding said pistons, constantly compressed to a tension substantially the same as that at which the compressed gas is discharged from the pump.

7. The combination, with the piston having separate relatively-movable heads and an interposed stratum of liquid which is a transmitter of motion from one to the other, of a tank exterior to the pump-barrel in which a liquid is contained under pressure and a pipe connecting the interior of such tank with said interposed stratum of liquid, substantially as and for the purposes herein set forth.

8. The combination, with the piston having separate relatively-movable heads, an interposed stratum of liquid which is a transmitter of motion from one to the other, an exterior tank containing liquid, and a pipe connecting the interior of said tank with said interposed liquid stratum, of a check-valve in said pipe, substantially as described.

9. The combination, with a piston having separate relatively-movable heads, an interposed stratum or column of liquid which transmits motion from one head to the other, an exterior tank containing liquid, a pipe containing a check-valve and connecting the interior of said tank with the the said interposed liquid stratum, and a pipe connecting the interior of said tank with the interior of the inclosure into which compressed gas is discharged from the pump, of a relief-valve chamber containing a relief-valve, a pipe or passage connecting the bottom of said chamber with the interposed liquid stratum, and a pipe or passage connecting the upper part of said chamber with the interior of the inclosure into which the gas is discharged after compression in the pump, all substantially as herein described, and for purposes specified.

10. The combination, with the barrel of the pump, the piston constructed as described, the exterior tank containing a lubricating and packing liquid, a pipe containing a check-valve and connecting said tank with the liquid stratum forming part of the piston, and a pipe connecting the interior of said tank with the interior of the inclosure into which compressed gas is discharged from the pump, of branch pipes or passages, one connected with the pump-barrel at or near each end of the pump-barrel, substantially as and for the purposes herein set forth.

11. The combination, with the barrel of the pump, the piston constructed as described, the exterior tank containing liquid for lubrication and packing, a pipe l, containing a check-valve and connecting the interior of said tank with the liquid part of the piston, a pipe l', connecting said tank with the interior of the space for holding gas discharged by the pump, branch pipes u, the same being a continuation of a passage for the lubricating-liquid from said tank to the interior of the pump, and regulating valves or cocks v, placed in said pipes u, of a liquid-meter placed in the passage for the lubricating-liquid from the oil-tank to the pumps, all substantially as herein described, and for the purposes specified.

12. The combination, with the pump, its pistons, a separator M, and an oil-tank L, all connected by pipes, substantially as herein described, of a stuffing-box D′, containing annular chambers c c', a connecting pipe or pipes between the tank L and the said chambers, and a connecting pipe or tube a^2, leading from the chambers in said stuffing-box and communicating within the interior of the pump-cylinder, all substantially as and for the purposes herein set forth.

13. The combination, with a pump-cylinder, its valves, and stuffing-box, of the piston-rod D, having formed thereon the boss d, the

piston-heads E and E', movable each toward the other, an interposed stratum of liquid h h'' i, a discharge-pipe l''', a separator M, connected with said discharge-pipe, a heater R, connected with the separator, an outlet-pipe l', connected with the separator, a tank L, connected with the pipe l', a cooler R', connected with the tank L, a pipe l, connected with the tank L and with the pump-cylinder A, a meter W and a check-valve N, both connected with the pipe l, a pipe o, connected with the pipe l, a relief-valve p, connected with the pipe l, branch pipes u, connected with the pipe l and with the pump-cylinder, regulating cocks or valves v, connected with the pipe u, the metallic ring A' in the stuffing-box, and a pipe connection a, connecting the pipes u with the stuffing-box, all substantially as herein described, and for the purposes specified.

In testimony that I claim the foregoing as my invention I have signed my name, in presence of two witnesses, this the 14th day of January, 1891.

LEICESTER ALLEN.

Witnesses:
GEORGE BARRY,
L. N. LEGENDRE.