L. H. NASH.

DISPLACEMENT STRUCTURE.

APPLICATION FILED APR. 13, 1904.

953,222.

Patented Mar. 29, 1910.

3 SHEETS—SHEET 1.

Fig. 1.

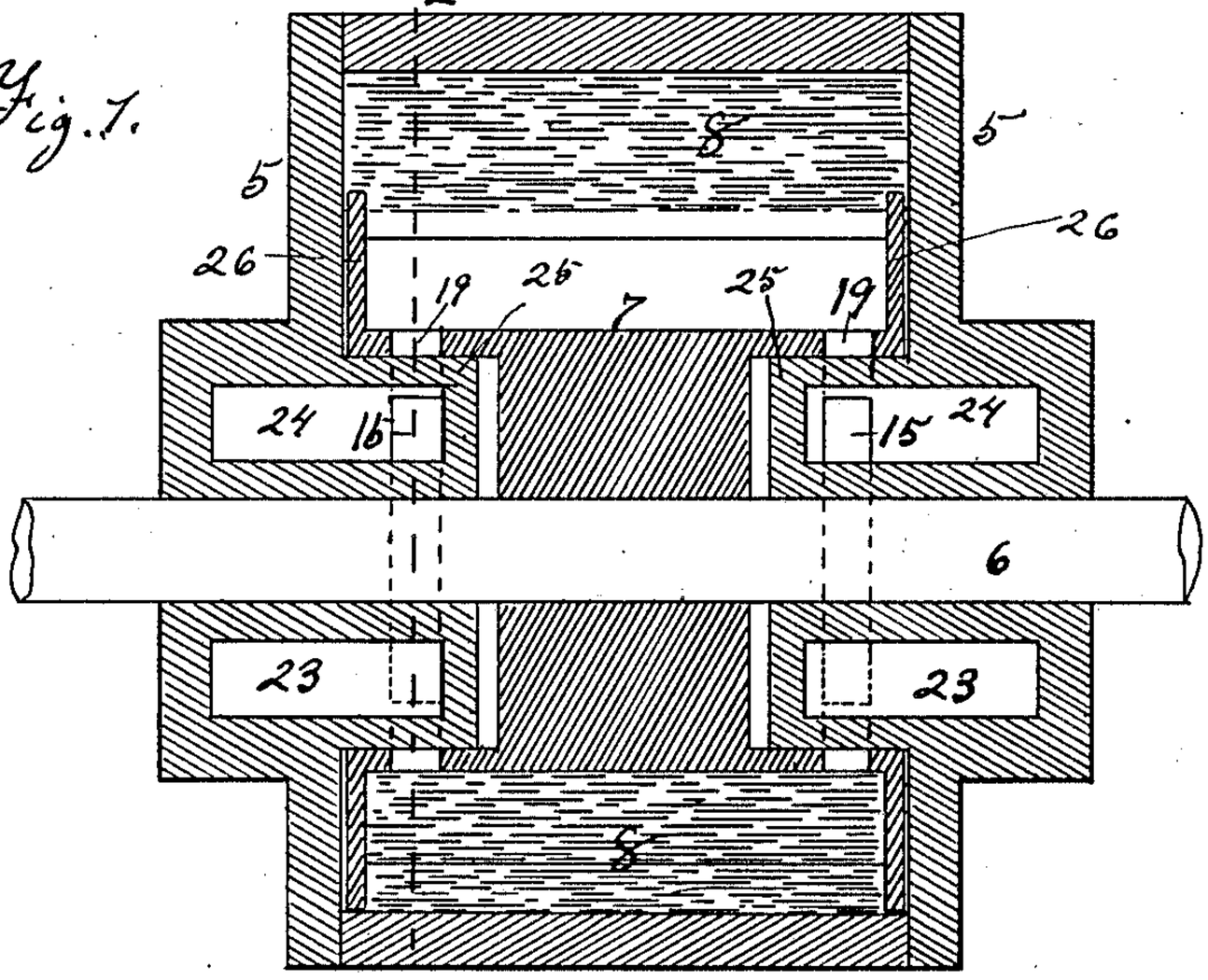
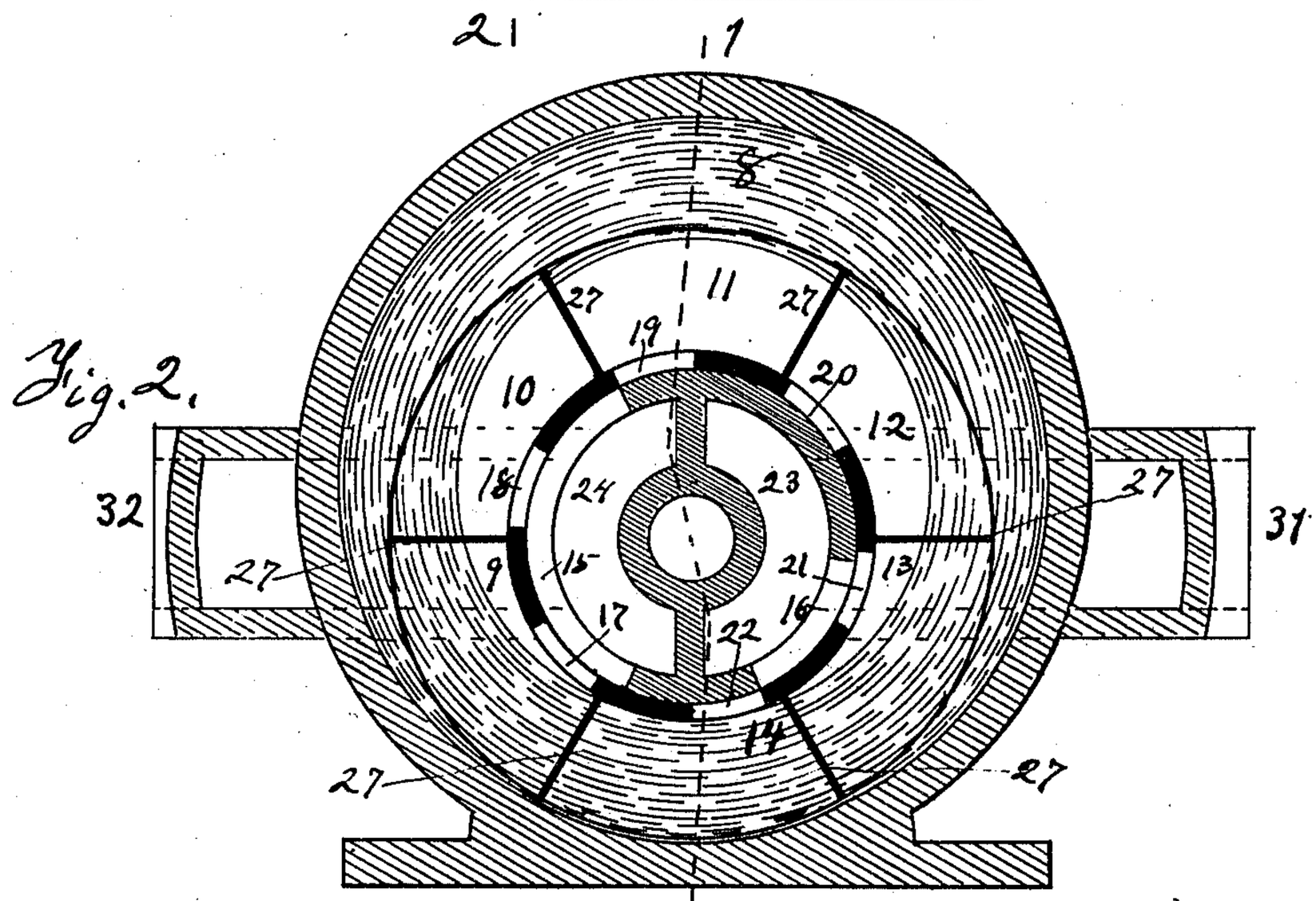


Fig. 2.



WITNESSES:

Delia K. Hallock.

Emily S. Andrews.

INVENTOR

Lewis Hallock Nash

L. H. NASH.

DISPLACEMENT STRUCTURE.

APPLICATION FILED APR. 13, 1904.

953,222.

Patented Mar. 29, 1910.

3 SHEETS—SHEET 2.

Fig. 3.

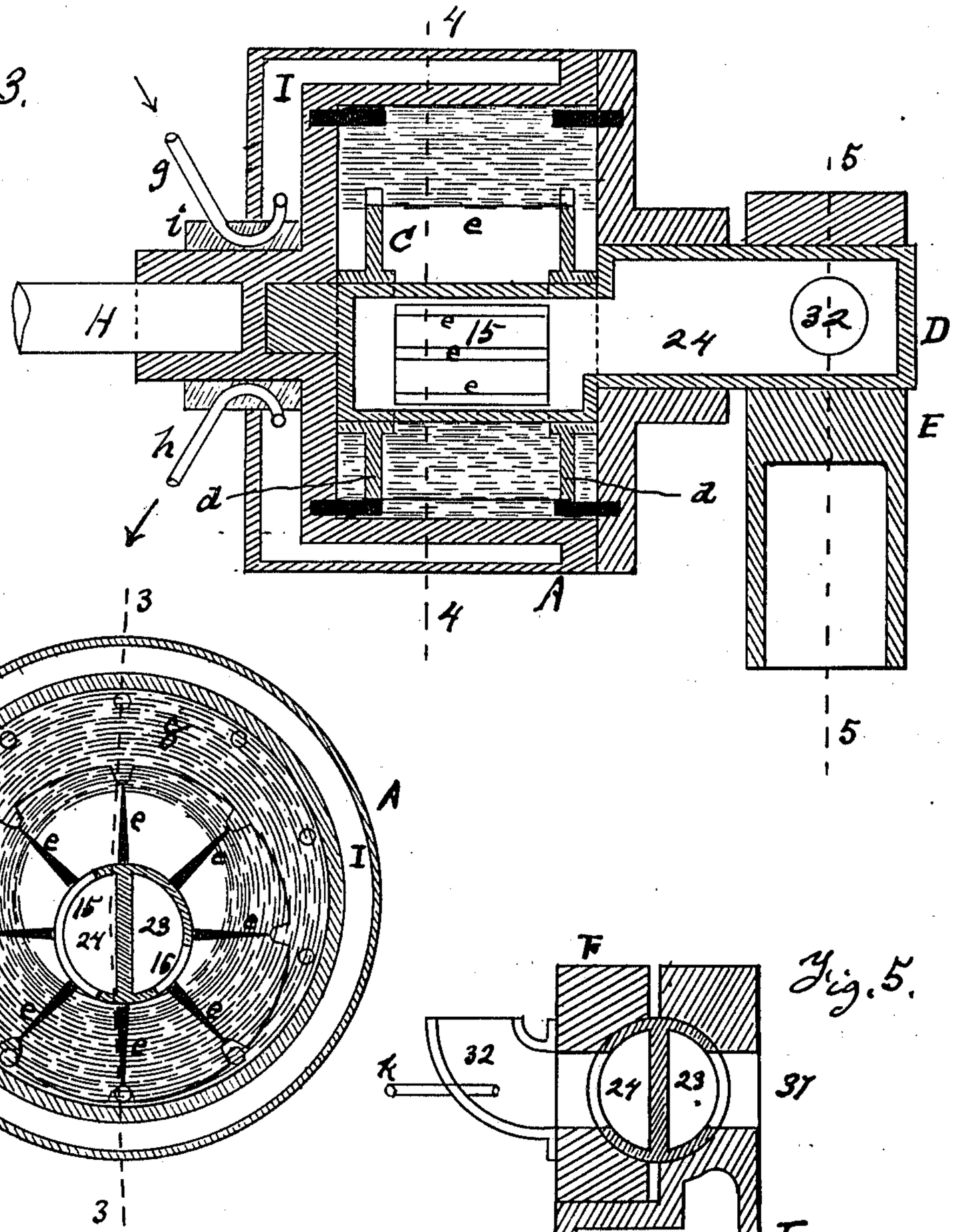


Fig. 4.

Fig. 5.

Witnesses:
Delia K. Hallock
Emily L. Andrews.

Inventor
Lewis Hallock Nash

L. H. NASH.

DISPLACEMENT STRUCTURE.

APPLICATION FILED APR. 13, 1904.

953,222.

Patented Mar. 29, 1910.

3 SHEETS—SHEET 3.

Fig. 6.

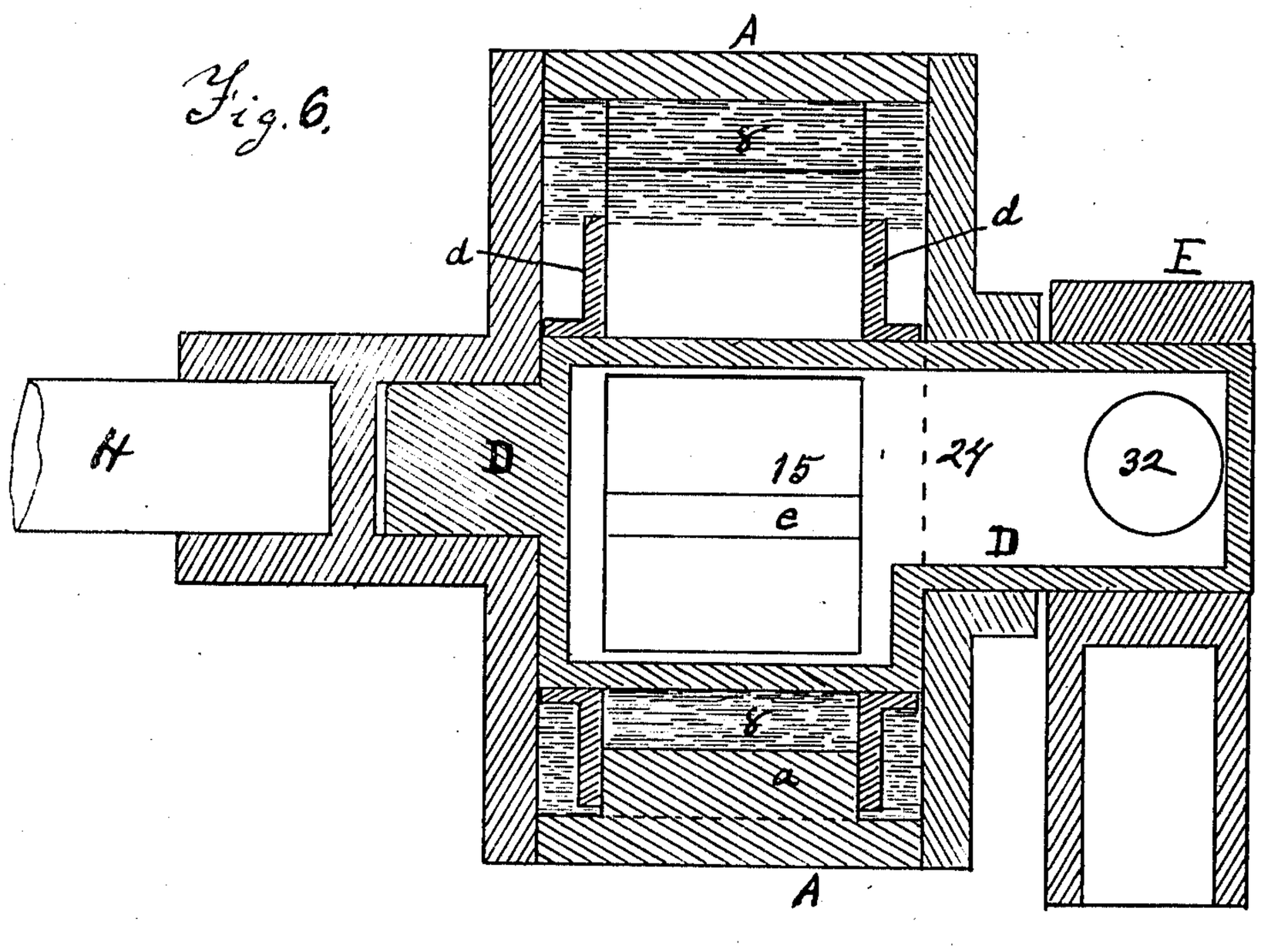
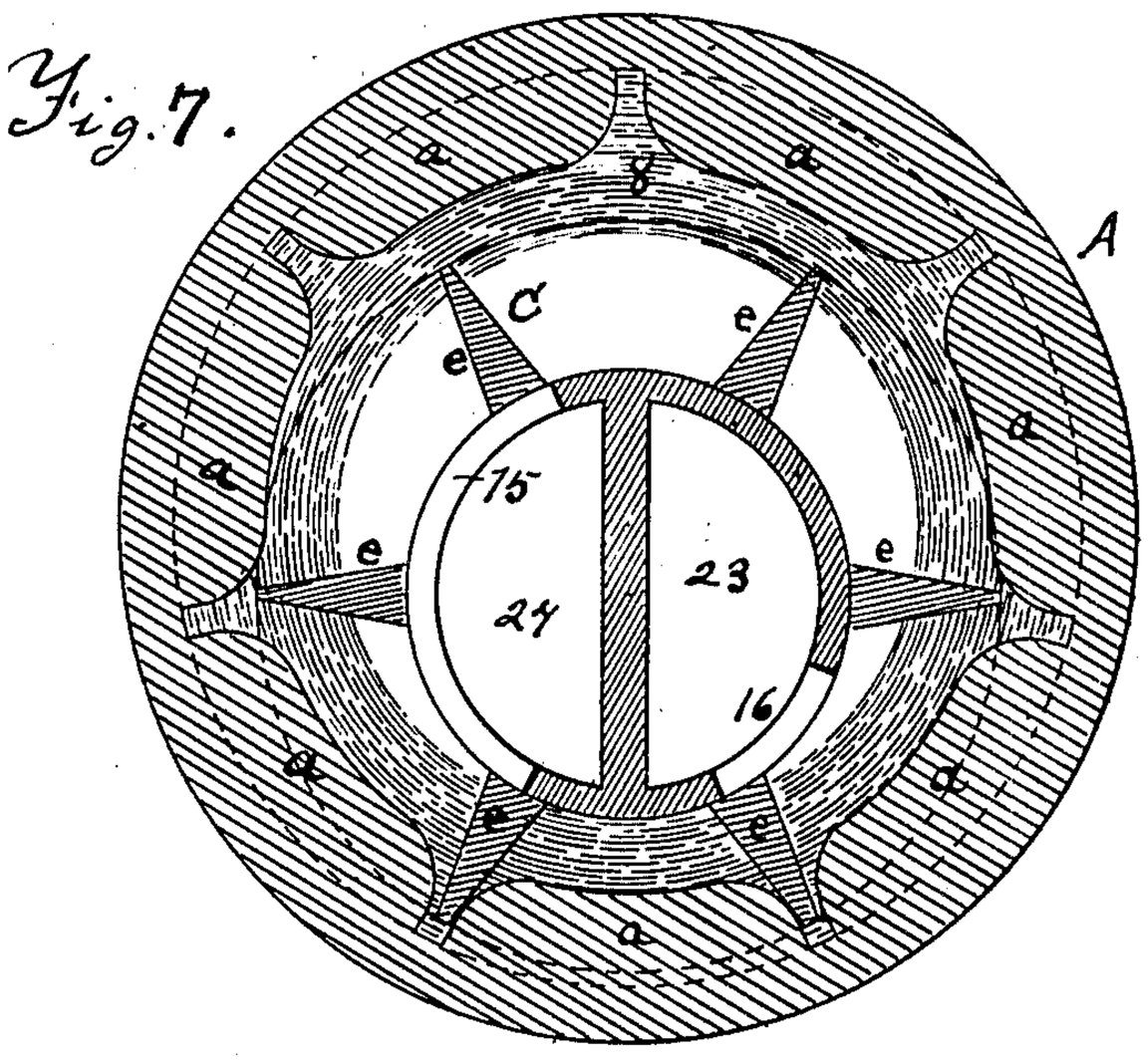


Fig. 7.



Witnesses:
Delia K. Hallock
Emily L. Andrews.

Inventor
Lewis Hallock Nash

UNITED STATES PATENT OFFICE.

LEWIS HALLOCK NASH, OF SOUTH NORWALK, CONNECTICUT, ASSIGNOR TO NASH ENGINEERING COMPANY, A CORPORATION OF NEW YORK.

DISPLACEMENT STRUCTURE.

953,222. Specification of Letters Patent. Patented Mar. 29, 1910.

Application filed April 13, 1904. Serial No. 202,968.

To all whom it may concern:

Be it known that I, LEWIS HALLOCK NASH, engineer, a citizen of the United States of America, and a resident of South Norwalk, Connecticut, have invented certain new and useful Improvements in Displacement Structures, of which the following is a specification, illustrated by the accompanying drawings.

My invention is directed to a novel form of apparatus which may be used as a rotary pump, a vacuum pump, an air compressor, or for other purposes.

One of the distinctive features of my improved pump consists in the use of a liquid piston which maintains its form under the action of centrifugal force in such a manner as to act more like a solid part and by this means it can be made to exert a strong pressure like a solid piston while at the same time it retains its fluidity. My invention can therefore be used at very high speeds, and is well adapted for use as a vacuum pump in connection with high speed machinery, and it may also be used as an air compressor with the same, or with water wheels or electric motors. Since the device can be used at high speed a small machine can be made to do a large amount of work which is a feature of great value.

I will now describe the drawings which show devices embodying my invention in a preferred form of rotary pump in order that others skilled in the art may be able to practice my invention, but it will be understood that I do not confine my invention to the exact form of device shown, as many modifications may be made without departing from the spirit and scope of my improvement.

The particular features of novelty which constitute my invention will be pointed out in the claims concluding this specification, where it will be understood that the omission of an element from any claim is a notice to the public that the particular feature omitted is not an essential feature of the invention of said claim.

Figure 1 shows a longitudinal section of a device provided with this improvement, taken on the plane 1—1 of Fig. 2. Fig. 2 is a cross section on the plane 2—2 of Fig. 1. Fig. 3 is a longitudinal section on the plane 3—3 of Fig. 4, of a device in which the external chamber also revolves as well as the piston wheel. Fig. 4 is a cross section on the plane 4—4 of Fig. 3. Fig. 5 is a cross section on the plane 5—5 of Fig. 3. Fig. 6 is a longitudinal section and Fig. 7 is a cross section of a device embodying my improvements but applied to a different form of structure.

Referring to Figs. 1, 2 and 3 the case chamber is cylindrical and has inclosing heads 5, 5. These heads have hubs for supporting the shaft 6, the hubs also serving as valves in connection with the wheel 7, as will be presently described. The wheel 7 is keyed upon and driven by the shaft 6, and said wheel has projecting cylinders on each side which fit over the hubs 25, so as to form a valve joint therewith. The wheel 7 has flanges 26, 26, on each side and vanes 27, extending from flange to flange, these vanes dividing the wheel into a series of buckets 9, 10, 11, 12, 13 and 14, as seen in Fig. 2. Each of these buckets has ports 17, 18, 19, 20, 21 and 22, which operate in connection with the ports 15 and 16, in the hubs 25, 25. The ports 16, 16, are outlet ports and communicate with the outlet passages 23, 23. The ports 15, 15 are inlet ports and communicate with the inlet passages 24, 24. As the wheel 7 revolves the buckets 9, 10, etc. are brought in succession over the ports 15, and 16, so as to admit the fluid to the wheel buckets on one side of the case and to discharge it on the other side of the case. The liquid piston 8 is the displacing member and operates as follows: The drawings assume that the piston is in rapid rotation and that the position shown is a position of the device at some given instant. Under these conditions the liquid 8 will assume a position concentric with the case, as shown in Fig. 2, wherein the inner edge of the liquid piston will form a definite outline leaving the central portion of the chamber free from liquid. The wheel 7 is placed eccentric to the case so that upon one side the wheel buckets are completely submerged, while upon the other side the ends of the vanes and flanges dip just enough below the surface of the liquid to form a joint and complete the closure of the buckets. It will thus be seen that there is formed between the liquid and the wheel, a series of enlarging and contracting chambers which increase in volume on one side

of the wheel as it revolves, while upon the other side the chambers are contracting in volume, and we therefore have present all the conditions necessary for a displacement device adapted to be used as a pump or engine. In this combination the liquid piston is the important element and I will now describe its action more completely.

The usual impression of a liquid is that it will readily change its shape under the action of a force and that it can not be depended upon to retain a definite form as a solid can. But when a liquid is subjected to strong forces, as for instance inertia or centrifugal force, it is capable of exerting the greatest resistance to any thing that tries to oppose it. A good illustration of this fact may be found in the water jet as it issues from the nozzle under the high pressure used in hydraulic mining. It has been found that a heavy blow with a crow-bar can be struck upon the issuing water and that it will hardly indent the jet at all. I have discovered that a rapidly moving liquid may be made to serve the purpose of a solid body in forming a piston or other moving part of a machine and that it has many advantages. For instance, it will fit itself to the place it is to occupy and make a perfect joint, it will lubricate itself and will run without wear and the friction of the liquid body is much less than that of a solid body, and it has many other advantages which it is not necessary to enumerate.

In the devices shown in the figures the liquid is caused to rotate at a rapid rate and the centrifugal force and the inertia of the liquid will serve to hold it in shape against considerable pressure, and this effect can be increased to any desired extent by increasing the speed of rotation of the wheel. That is to say, the centrifugal force may, if desired, equal many thousand times the force of gravity, and the inertia of the liquid may make it nearly rigid.

The operation of the device is as follows: The pump being under high speed the liquid piston 8 will assume a position concentric with the case, as shown in Fig. 2, and by reason of the strong centrifugal force it will retain this shape with considerable rigidity. The inner edge of this liquid piston will form a closure in connection with the wheel 7, and because this wheel revolves eccentrically to the case, there will be formed enlarging and contracting spaces in the buckets 9, 10, 11, 12, 13, 14, between the wheel buckets and the liquid piston. As the wheel revolves in the direction of the hands of a clock the bucket spaces 9 and 10 are enlarging while the bucket spaces 12 and 13 are contracting, the space 11 has just reached its maximum size while the space 14 is at its minimum size. The air will enter the spaces 9 and 10, through the case port 15, and the wheel ports 17 and 18; the port 19 just closed. As the wheel continues to revolve, the air in the bucket 12 is being compressed and this compression will continue until the port 20 opens communication with the case port 16, when the air will be forced out into the discharge passage 23. The air in bucket 13 is being forced out, while the port 22 has just been closed, into chamber 14. This operation will continue as the wheel revolves so that there will always be enlarging spaces on the one side and contracting spaces on the other side of the wheel, and the amount of air discharged in each revolution will be the volume of the space 11, multiplied by the number of buckets.

In Figs. 1 and 2 the case chamber is stationary and the liquid is forced to rotate by the action of the wheel 7. This is the simplest form of device and may be used to advantage for many purposes. In this form there will be hydraulic friction between the liquid and the case, caused by the flow of the liquid over the surface of the case. When very high speeds are used the loss of power caused by this hydraulic friction may become very great, and I have shown in Figs. 3 and 4 a form of device in which this loss is greatly reduced. To accomplish this I cause both the external case and the wheel to revolve so that the liquid is carried around in the case without flowing over the surface of the case. By this means the hydraulic friction of the device is reduced to that caused by the dipping of the buckets in and out of the liquid. The displacing action of the device is not changed by this modification and the liquid piston is subjected to the same conditions as before.

Referring to Figs. 3, 4 and 5, the case A is mounted upon a stationary shaft D so as to revolve freely upon it. This shaft is provided with an eccentric portion on which the ring piston C is mounted. Thus both the piston and the case revolve together upon this shaft so as to preserve their eccentric relation to each other. The case and piston ring are provided with pins and toothed recesses to preserve the coacting relation of the revolving parts. This piston consists of the side flanges *d*, *d*, which are joined together by the vanes *e*, *e*, etc., and the spaces between these vanes serve as ports in connection with the inlet and outlet ports 15 and 16, as in Figs. 1 and 2. These ports communicate with the inlet and outlet passages 24, 23, formed in the shaft D, and this shaft is supported upon a standard E to which it is clamped by the binder F, and the pipes 31, 32 connect with the passages 23, 24, of the hollow shaft, as seen in Fig. 5. The shaft H transmits the power to drive the pump from any source. I is a chamber for cooling water formed in the case walls. The

water is introduced into this chamber through the pipe *g*, and escapes therefrom through the pipe *h*. These pipes are supported in the casing *i*, so as to be stationary and not revolve with the case, and the action is as follows: The water enters the chamber through the pipe *g*, and is carried around by the revolving case. When the water fills the chamber up to the orifice of the pipe *h* it will flow into the pipe *h* by its inertia and thus will escape from the chamber. In this way a continuous circulation of water can be secured.

In Figs. 6 and 7 I have shown a case having a modified form which possesses many important advantages. In the form before described I have shown a form of case in which the forces of inertia and gravity are depended upon to hold the liquid piston in position, rather than the form of the case itself, but in Figs. 6 and 7, the case is provided with extended projections and recesses to retain the liquid piston in place and also to reduce the amount of space between the wheel vanes and the case walls. These parts may be made to approach each other as closely as desired. The effect of this is to make it more difficult for the liquid under pressure to escape from one recess to another, and thereby greater pressures than formerly can be carried in this form of case at a given speed of rotation. In the drawings A is the case having the projections *a*, *a*, which also form gear teeth for controlling the rotation of the wheel or piston C. This piston has vanes *e*, *e*, which divide its circumference into chambers and the ends of which dip into the teeth spaces of the case. On each side of the piston are the flanges *d*, which complete the closure of the piston chamber upon the sides. The space between these flanges is of the proper width to pass over the tooth projections *a*, *a*, as the parts revolve. The piston is supported upon an eccentric shaft D on which the piston and case revolve, and this shaft contains the inlet and outlet passages and ports. This shaft is supported upon a pillow-block E which contains supply and discharge pipes similar to that shown in Fig. 5. The device shown in Figs. 6 and 7 has other features like that shown in Figs. 3, 4, and 5, and I have used the same letters to designate these features which are common to both. The drawings show the device at a given instant when rotating at full speed, and therefore in the description of its operation this condition of affairs must be kept in mind. In Figs. 3 to 7 both cases and piston revolve, and the liquid piston 8 also revolves, being carried around by the case; but since the liquid does not flow around in the case chamber as in the device shown in Figs. 1 and 2, the hydraulic friction caused by such flow is avoided. The liquid is, however, subjected to the same centrifugal force and is held out against the case walls as before. The displacing action of the device is the same, that is to say, the metal piston and the liquid piston both revolve around the eccentric bearing and the air or gas enters the enlarging chambers on one side of the piston through the port 15, and escapes from the contracting chambers on the other side of the piston through the outlet port 16, as has already been described in connection with Figs. 1 and 2.

I have thus described a few of the modifications that may be made of my improved liquid piston pump. I do not limit my invention to the exact form of the devices shown, so long as the improvements herein described are embodied in the structure.

I will now describe some of the special uses to which my invention is applicable.

As a vacuum and condensing pump for a steam engine the pipe 32, would receive the mixed steam and water from the engine or condenser. This mixture would pass into the pump where the water would be carried outwardly to the outside of the case and the surplus water would flow out through the outlet port 16, while at the same time the steam and contained air would be compressed by the action of the pump and be forced out of the same port. The pump itself may act as a condenser by injecting the cooling water into the supply pipe as by the pipe *k*, of Fig. 5. When used as an air compressor, I may also introduce cooling water into the supply pipe with the air. In this case the air will be compressed in the presence of water and the heat of compression will be absorbed by the water. The combined air and water will pass out through the discharge pipe and the water can be separated from the air in the usual manner. When moisture in the air is objectionable I may use a liquid for the liquid piston which will not evaporate, and in this case the cooling water can be supplied to the case water jacket. This form of device can be used in series so as to form a compound compressor, in which case the air from the low pressure pump will pass through an inner cooler to the next in the series in the same manner as is done in the piston type of air compressors.

It will be seen that in my improved pump it is the liquid under tension of centrifugal force that does the work, and it is also true that a liquid subjected to centrifugal force is in a different condition from a free liquid subjected to gravity only. The effect of centrifugal force may be considered in its relation to my pump as a magnified force of gravity; that is to say, the force increases as the square of the number of revolutions and as the radius of the curve of motion of the particle. At 1800 revolutions per

minute the force of the centrifugal effect would be 1100 times greater than the force of gravity, and a pressure that would change the level of a free liquid one inch would only change the level of the liquid when subjected to the above force 1/1100 of an inch.

In the claims the term "displacement structure" is employed to designate broadly that class of mechanisms which are characterized by the presence of enlarging and contracting chambers with means, such as ports, for controlling the entrance and exit of fluid—such structures being utilized in displacement pumps, and the like.

Without enumerating the many modifications of which this device is capable, what I desire to secure by Letters Patent are the following:

1. The combination of a cylindrical case and a propeller wheel eccentric to said case, of a liquid revolving in said case, buckets upon said wheel, said buckets forming enlarging and contracting spaces, and separate inlet and outlet ports adapted to control the entrance to and discharge from said spaces.

2. A displacement structure for a pump consisting of a case chamber, a liquid revolving in said chamber, a wheel adapted to revolve in said chamber and provided with buckets, said case chamber having a form non-concentric with said wheel whereby the liquid enters and recedes from said wheel buckets and means located at the center of the wheel for controlling the cycle of entrance and discharge of fluid to each bucket to and from the spaces within said wheel.

3. A mechanism having a piston, comprising a body of liquid subjected to the action of centrifugal force, combined with a chamber having inlet and outlet passages therein and with ports for controlling said inlet and outlet passages.

4. The combination of a revolving case chamber having tooth projections, with a revolving wheel intermeshing into said tooth projections and a liquid partly filling said case and forming the seal between the wheel and the case.

5. The combination of a revolving case having alternate projections and recesses with a piston revolving on a center eccentric to that of the case and having projections co-acting with the case projections and a liquid partly filling said case and co-acting with said piston to form enlarging and contracting spaces, and inlet and outlet ports for controlling the inflow and outflow of the fluid.

6. A displacement structure, comprising a case chamber, a liquid revolving in said chamber, a wheel adapted to revolve in said chamber and provided with buckets, such case chamber having a form non-concentric with said wheel whereby the liquid enters and recedes from said wheel buckets, and means for retaining a portion of the fluid and for controlling the inflow and outflow of a fluid.

7. The combination of a case, and a piston dividing the case chamber into enlarging and contracting spaces, with a liquid in rotation in said chamber partly filling said spaces when they are at their maximum size and completely filling said spaces when they are at their minimum size.

8. In a liquid piston pump, the combination of a cylindrical case, a wheel adapted to revolve within said case, said wheel being mounted eccentrically within said case, liquid within said case adapted to form a seal between the said case and said wheel, and a plurality of separate inlet and outlet ports adapted to admit and discharge air from the center of said wheel, within said case, substantially as set forth.

9. In a liquid piston pump, the combination of a cylindrical case, heads inclosing said case, a shaft supported eccentrically within said heads, a wheel mounted upon said shaft, said wheel being provided with a series of vanes forming buckets, inlet and outlet ports in the center of said heads, ports in said buckets adapted to coöperate with said inlet and outlet ports, a liquid within said case forming a seal between said case and said wheel, and means for rotating said wheel, substantially as described.

10. In a liquid piston pump, the combination of a case chamber, a liquid within said chamber, means for causing said liquid to revolve, said means consisting of a wheel provided with buckets, said buckets being wholly immersed in said liquid on one side and partly immersed in said liquid upon the other side, and means located in the center of said wheel for admitting and expelling air from said case, substantially as described.

11. In a liquid piston pump, the combination of a revolving case chamber, a liquid contained therein, a member revolving within said chamber and adapted to divide the said chamber into enlarging and contracting spaces and valves situate near the center of said revolving member adapted to control the flow of gas into and out from said chamber, substantially as set forth.

12. The combination of a revolving case chamber having tooth projections, with a revolving wheel intermeshing into said tooth projections and a liquid partly filling said case and forming the seal between the wheel and the case, and inlet and outlet ports for the case.

13. The combination of a revolving case having alternate projections and recesses with a piston revolving on a center eccen-

tric to that of the case and having projections co-acting with the case projections and a liquid partly filling said case and co-acting with said piston to form enlarging and contracting spaces, and inlet and outlet ports for the case.

Signed at Brooklyn in the county of Kings and State of New York this eighth day of April A. D. 1904.

LEWIS HALLOCK NASH.

Witnesses:
CHAS. A. HAVILAND,
E. W. MEEK.