Oct. 4, 1949. F. B. LEVETUS ET AL 2,483,705

ROTARY ENGINE, PUMP AND THE LIKE

Filed Aug. 25, 1942 5 Sheets-Sheet 1

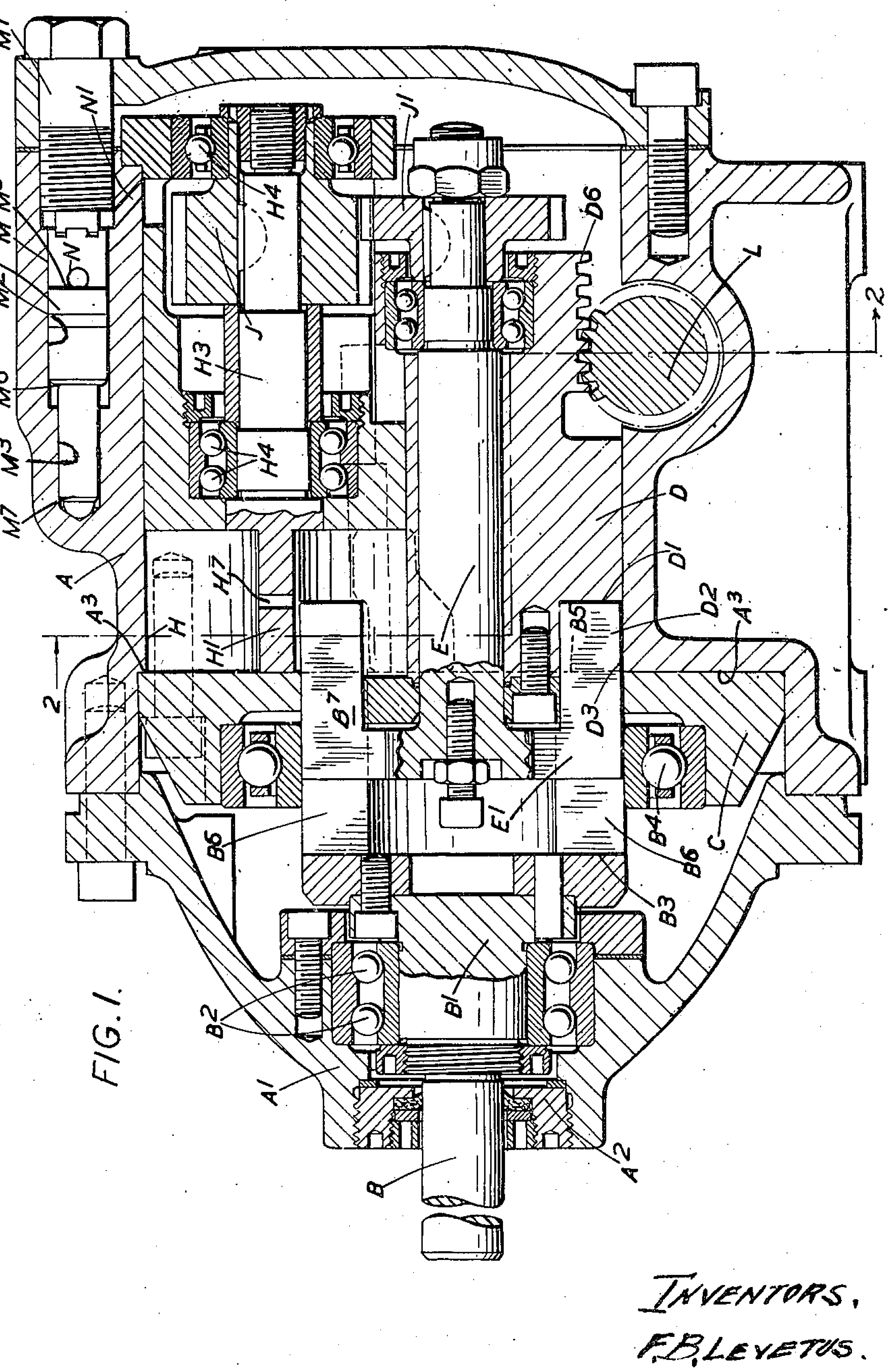

FIG. 1.

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ROTARY ENGINE, PUMP AND THE LIKE

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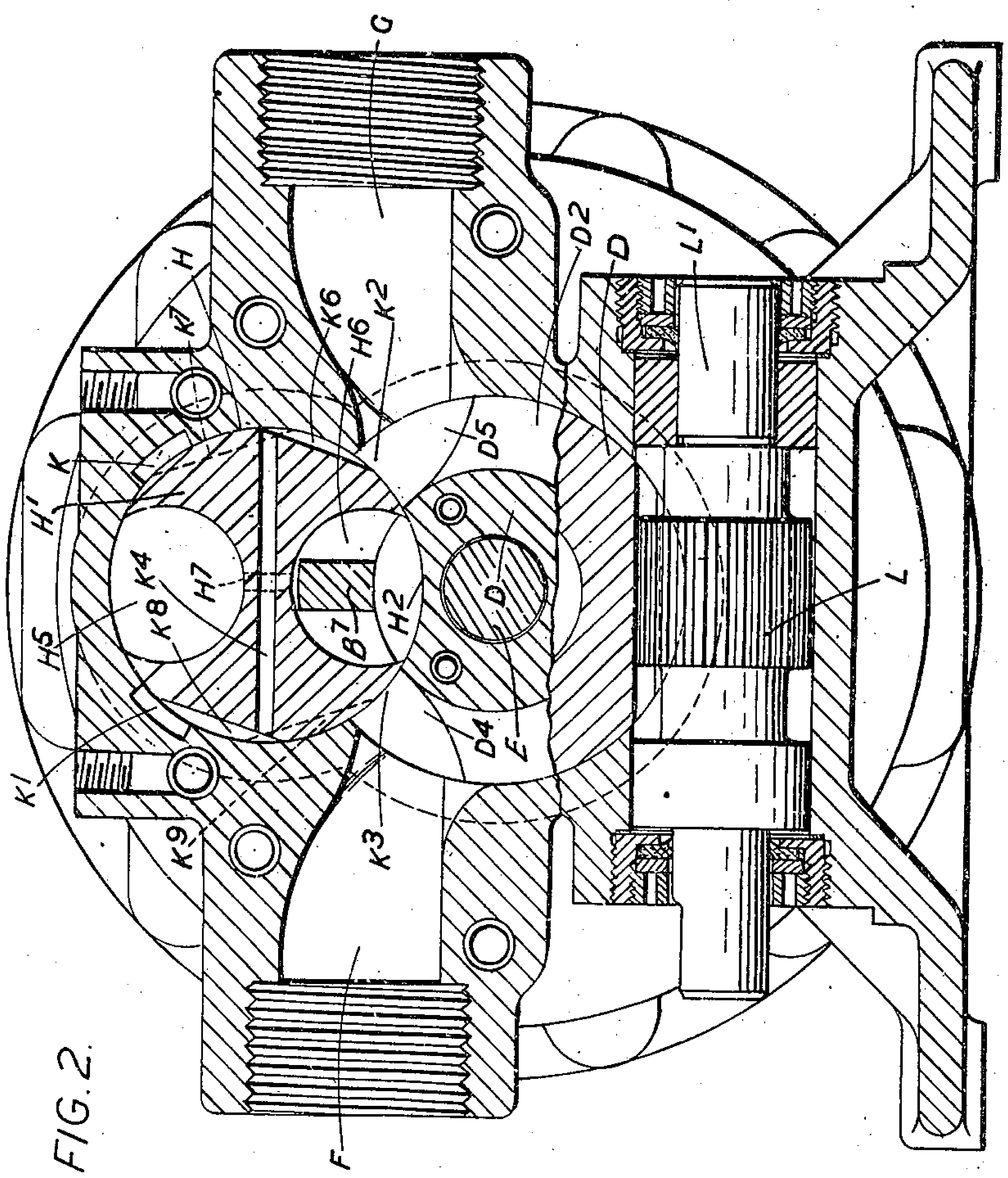

FIG. 2

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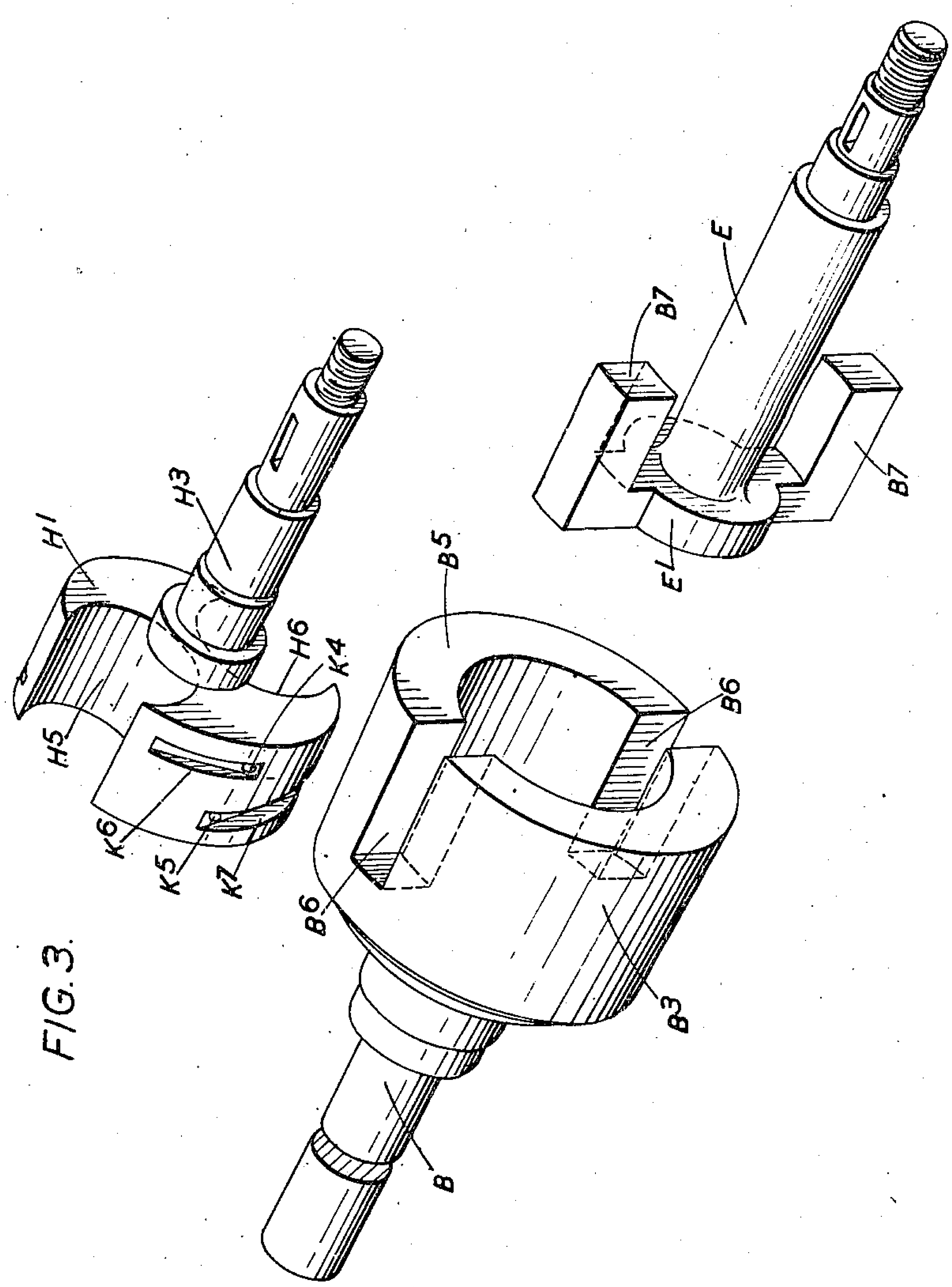

FIG. 3.

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ROTARY ENGINE, PUMP AND THE LIKE

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FIG. 4.

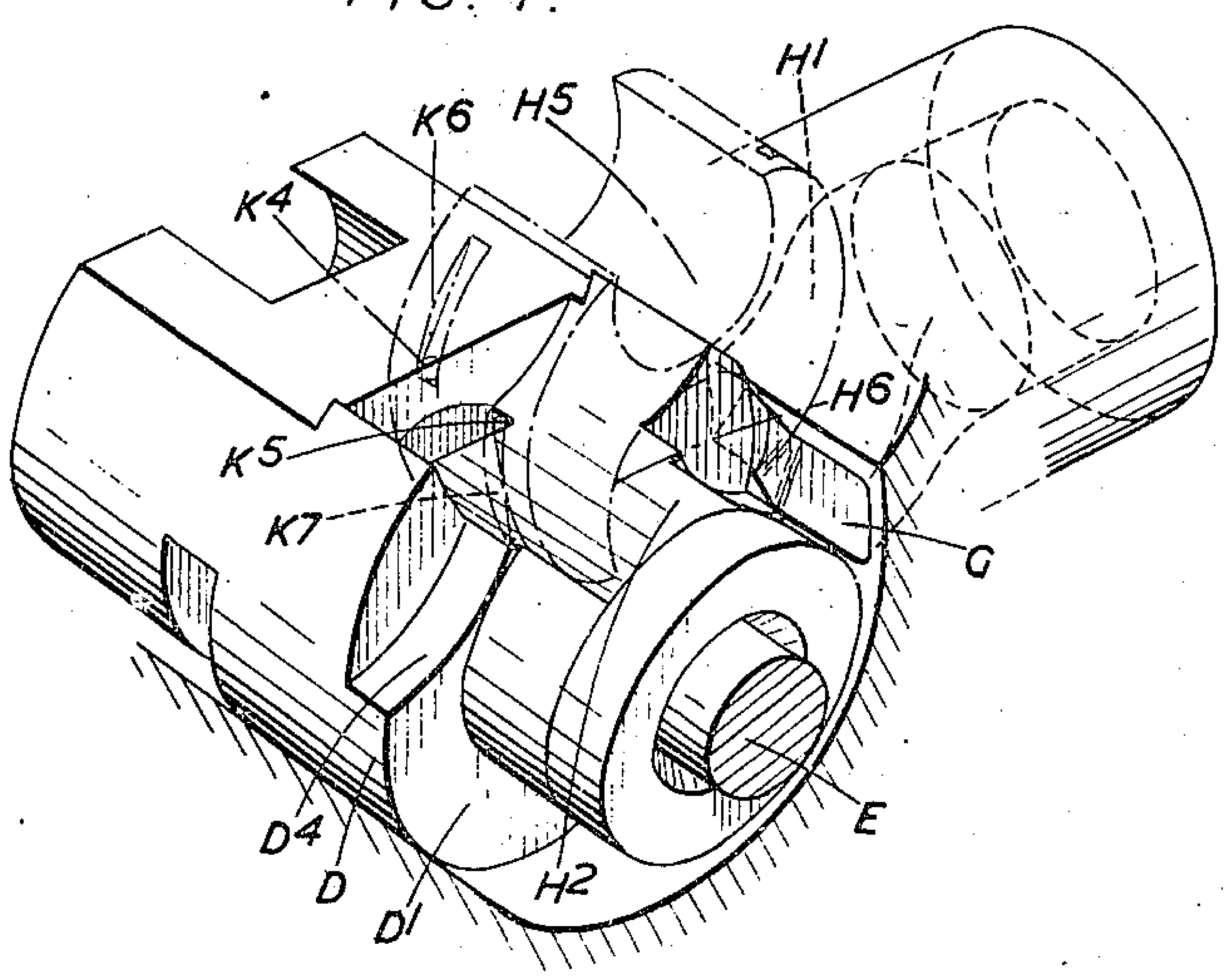
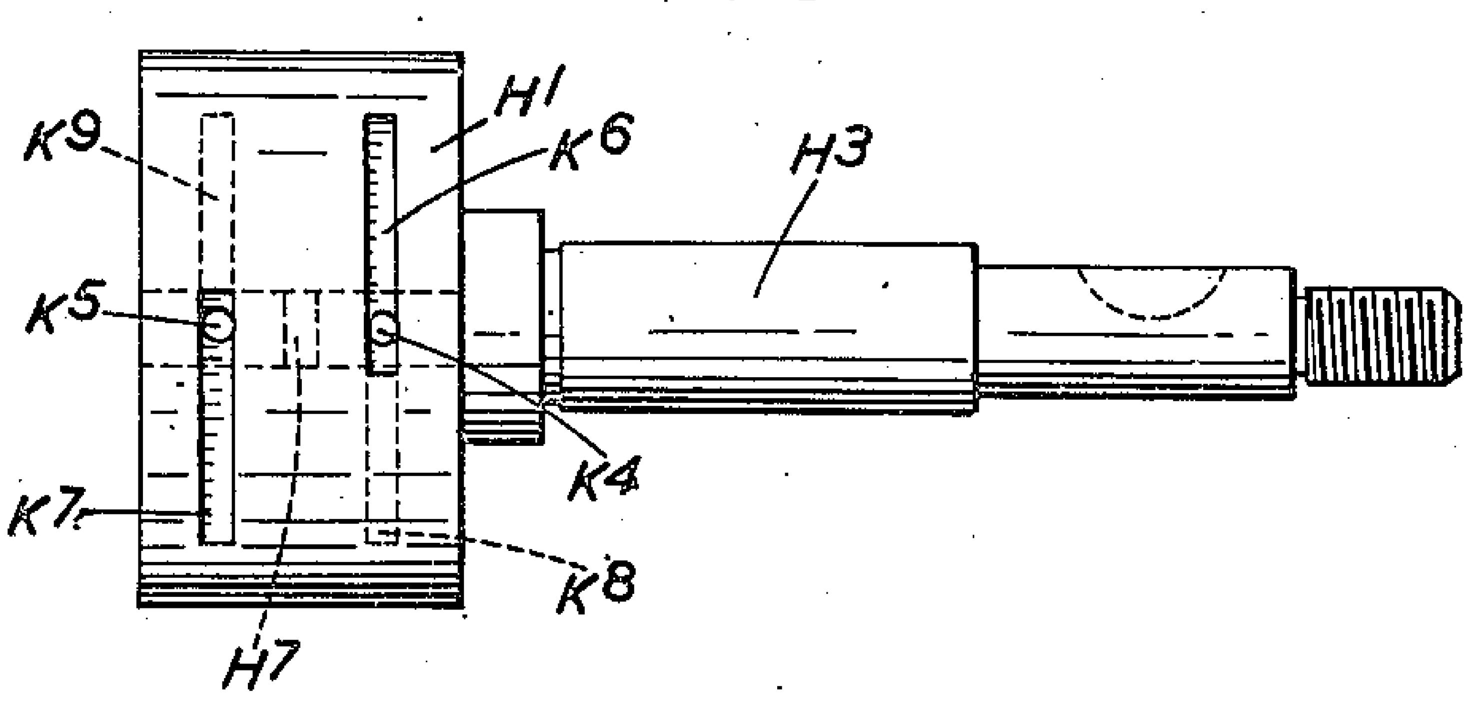


FIG. 5.



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ROTARY ENGINE; PUMP AND THE LIKE

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FIG.7.

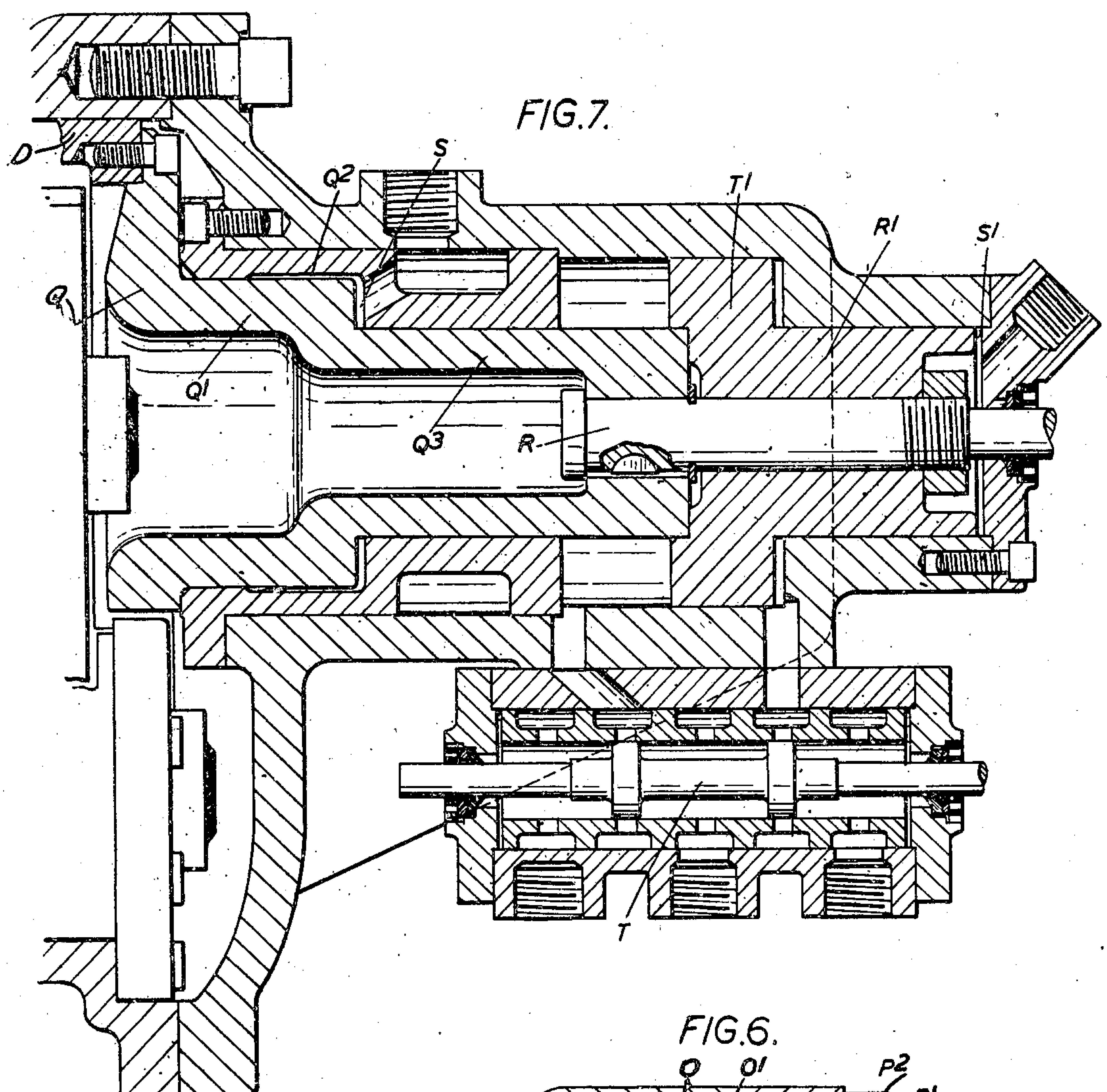
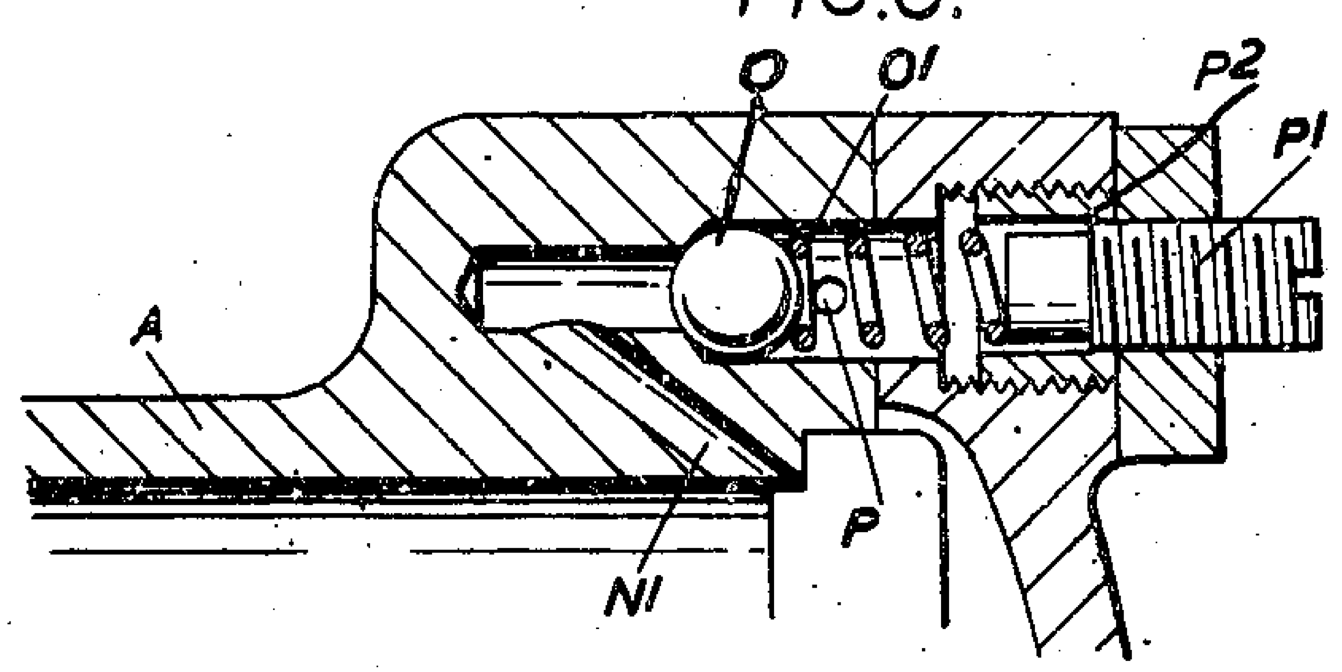


FIG.6.



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Patented Oct. 4, 1949

2,483,705

UNITED STATES PATENT OFFICE

2,483,705

ROTARY ENGINE, PUMP, AND THE LIKE

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Application August 25, 1942, Serial No. 456,060
In Great Britain September 16, 1941

7 Claims. (Cl. 103—125)

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This invention relates to rotary engines, pumps and the like of the kind comprising an annular blade chamber, a rotor rotating about the axis of the blade chamber and carrying blades which extend across the blade chamber and make a sealing fit with its inner and outer circumferential walls, and an abutment extending across the blade chamber between inlet and outlet ports, the abutment or each blade being arranged to rotate about its own axis and being provided with a gap or recess which comes into position at the appropriate times during rotation of the rotor to permit the blades to pass the abutment. Thus the invention is applicable for example to rotary engines, pumps or the like of the kind referred to in United States Patent No. 2,277,661 in which a rotary abutment making a sealing fit at all times with abutment recesses in the inner and outer circumferential walls of the blade chamber extends across this chamber between inlet and outlet ports or of the type in which each blade makes a sealing fit with blade recesses in the inner and outer walls of the blade chamber, the abutment being fixed while the blades not only rotate bodily with the rotor and the circumferential walls of the blade chamber but also about their own axes.

The invention is applicable to rotary engines, pumps or the like of the kind referred to whether employed primarily to act upon or be acted upon by fluid or incorporated in fluid pressure apparatus such as hydraulic transmission apparatus and for the sake of convenience all such rotary engines, pumps and the like will hereinafter be termed rotary engines.

The invention is more particularly concerned with rotary engines of the kind in question wherein the blades extend into the annular blade chamber through one end wall and the required working clearance between the blades and the other end wall is maintained by one or more suitable thrust bearings, and is especially applicable to arrangements in which to enable the capacity of the rotary engine to be varied one end wall of the blade chamber is movable axially with the blades relatively to the other end wall through which the blades extend.

In rotary engines of the kind in question, whether of variable capacity or not, there are unbalanced fluid pressures acting axially on the blades and on the rotating end wall of the blade chamber, as well as on the sliding end wall which does not rotate. These loads, as regards the rotating parts, have to be taken by the bearings or surfaces acting as bearings, and, particularly

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when high pressures are concerned, place considerable stress on these bearings. Further as regards sliding parts in the variable capacity type which do not rotate, these loads constitute an unbalanced force on the capacity controlling device.

The object of this invention is to reduce the load on the bearings or bearing surfaces, and also to tend to reduce the unbalanced loads produced by pressure leakage between the sealing surfaces, while reducing the extent of such leakage and increasing the general efficiency and life of the rotary engine, and in the case of the variable capacity type reducing the load on the capacity controlling device.

To this end in a rotary engine of the kind referred to according to the present invention the blade chamber, the rotor and the abutment are contained within a casing with means for maintaining within this casing during operation of the rotary engine a fluid pressure between the inlet and outlet pressures, that is to say between the pressures respectively in the parts of the blade chamber in communication with the inlet and outlet ports at any moment.

Preferably the means for maintaining the pressure within the casing are such as to maintain this pressure at approximately the mean of the inlet and outlet pressures.

The means for maintaining this pressure may vary but conveniently the pressure is maintained automatically by leakage from the blade chamber and is controlled by a relief valve adapted to open to permit escape of fluid from the casing at a predetermined pressure or at a predetermined pressure ratio between inlet and outlet or between working and atmospheric pressures. Thus in a simple and effective form of the invention, the working parts are all enclosed in a pressure-tight casing provided with a relief valve set to open at an appropriate pressure, which is conveniently approximately half the delivery or working pressure where the inlet or outlet pressure is approximately atmospheric pressure.

In an alternative arrangement the working parts are enclosed in a pressure-tight casing provided with a relief valve in the form of a two-diameter piston the largest face of which is subject to the pressure within the casing and controls a relief port while the two other faces are subject respectively to the inlet and outlet pressures and are conveniently of approximately equal area.

In any case means such as an adjustable spring may be provided for adjusting the pressure at which the casing is maintained or the relationship between this pressure and the inlet and outlet pressures.

It will be seen that with the invention not only will the pressure within the casing act in opposition to the pressure in the blade chamber to relieve the load on the thrust bearings but will also reduce leakage by reducing the pressure drop across the pressure sealing surfaces.

Further in any construction which is symmetrical with relation to a plane passing through the axis of the rotor and the centre of the abutment the pressure in the casing acting on the working parts in one direction is the mean of the pressures acting in the opposite direction taken over a complete revolution of the rotor.

The form of the rotary engine to which the invention is applied may vary but one construction according to the invention as applied to a pump is illustrated by way of example in the accompanying drawings, in which

Figure 1 is a longitudinal section in the vertical plane in which the axis of rotation lies,

Figure 2 is a section on the line **2—2** of Figure 1,

Figure 3 is an exploded perspective view of main rotary parts of the pump,

Figure 4 is a perspective view showing certain details of the interior of the pump somewhat diagrammatically and with parts cut away,

Figure 5 is a side elevation of the abutment,

Figure 6 is a cross-sectional view showing a modification embodying a compensating piston, and

Figure 7 is a longitudinal sectional view showing another modification.

In the construction illustrated the pump comprises a pressure-tight casing A through one end wall A^1 of which extends through a pressure-tight gland A^2 a driving shaft B engaging a coupling member comprising a boss portion B^1 mounted in ball bearings B^2 and an annular extension B^3 rigidly secured to the boss portion and mounted in ball bearings B^4 carried in a transverse plate C located between a shoulder A^3 on the casing A and the end wall A^1.

Mounted to slide axially within the casing A is a body part D in which is formed an annular recess constituting one end wall D^1 and the inner circumferential wall of a blade chamber D^2 the other end wall of which is constituted by the end face B^5 of the annular extension B^3 while its outer circumferential wall is constituted by a part D^3 of the wall of the casing A.

Formed in the annular extension B^3 are two diametrically opposite longitudinal slots B^6 while a shaft E mounted in bearings in the body part D carries at one end a rotor E^1 formed with two blades B^7 which engage with a close fit and can slide in the slots B^6 and extend therefrom across the blade chamber D^2 to make a substantially fluid-tight seal with the end wall D^1. The shaft E is thus free to rotate within the body part D but is held from axial movement relatively to it while the part D can move axially within the casing A but is held from rotation relatively thereto. It will further be seen that the rotor E^1 is supported in the ball bearing B^4.

Communicating with the blade chamber D^2 are inlet and outlet ports F and G and mounted in a part-cylindrical abutment recess H between these ports is a rotary abutment H^1 which extends across the blade chamber to make a fluid-tight seal with a part-cylindrical recess H^2 in the part of the member D constituting the inner circumferential wall of the blade chamber.

The abutment H^1 is carried by a shaft H^3 mounted in bearings H^4 and connected by 1 to 1 ratio gearing J, J^1 to the shaft E.

The abutment H^1 is provided with two blade-receiving recesses H^5, H^6 diametrically opposite one another each adapted to receive one of the blades as it comes to the part of the blade chamber across which the abutment extends and thus permit it to pass the abutment. The two blade-receiving recesses communicate with one another through a passage H^7 in the abutment.

Formed in the abutment recess H are balancing pressure recesses K, K^1 each lying diametrically opposite to and having approximately the same effective area exposed to the abutment as one of the portions K^2, K^3 of the blade chamber adjacent to the abutment. Also formed in the abutment diametrically opposite to one another and communicating with one another through pressure balancing passages K^4, K^5 are two pairs of pressure balancing chambers K^6, K^7 and K^8, K^9 formed by slots and so disposed that either a blade-receiving recess or a pressure balancing chamber is in communication with each part K^2, K^3 of the blade chamber at all times.

The end face D^1 of the blade chamber has two recesses D^4, D^5 which during the first part of the travel of each blade from the abutment and the last part of this travel as the blade approaches the abutment permit fluid to pass the end of the blade respectively into the blade chamber from the inlet port and out of the chamber from the outlet port.

A rack D^6 formed on the body portion D is engaged by a pinion L on an adjusting shaft L^1 whereby the axial position of the body D and with it that of the rotor E^1 can be varied relatively to the annular extension B^3 so as to vary the effective axial length of the blade chamber D^2 and hence the capacity of the pump.

It will be seen that the radial pressures exerted on the abutment H where it is exposed to the blade chamber at K^2, K^3 will at all times be counterbalanced by equal and opposite pressures in the balancing recesses K, K^1, the effective areas exposed to each of the two opposite pressures always being the same at any moment in the rotation of the parts owing to the diametrically opposite arrangement and interconnection of the blade-receiving recesses H^5, H^6 and of the balancing chambers K^6, K^7 and K^8, K^9.

In addition owing to the provision of the two recesses D^4, D^5, the reduction of the areas of the abutment exposed to the pressures in the blade chamber which would otherwise occur with axial movement of the body D to reduce the capacity of the blade chamber is eliminated.

Formed in the wall of the pressure-tight casing A is a valve chamber M closed at one end by a plug M^1 and comprising a larger diameter part M^2 and a smaller diameter part M^3. Mounted to slide freely in the valve chamber is a differential piston valve M^4 the largest end face of which M^5 controls a relief port N communicating with the atmosphere fluid reservoir or the inlet port while the two other faces M^6, M^7 which are conveniently of equal area are exposed through passages in the casing respectively to the pressures in the inlet and outlet ports.

The part M^2 of the valve chamber communicates with the interior of the pressure-tight casing A through a port N^1.

The valve M^4 acts to maintain in the casing A a pressure approximately equal to the mean of the inlet and delivery pressures in the following manner:

As long as this pressure remains below the mean of the inlet and delivery pressures, the latter pressures acting on the valve M^4 maintain it with its face M^5 bearing against the plug M^1 so that the relief port N is closed.

When, however, the pressure in the casing A exceeds the mean of the inlet and delivery pressures this pressure moves the valve M^4 to the left to uncover the relief port N to permit escape of fluid from the casing A until the pressure is reduced to the mean of the inlet and delivery pressures.

Means are conveniently provided for locking the shaft L^1, and the pump shown may either have this shaft permanently locked so as to be of constant capacity or may be provided with means for readily adjusting the shaft. In a modification instead of the valve M^2 M^3, a valve constructed and arranged as shown in Figure 6 may be provided. This valve comprises a ball O having a spring O^1 tending to retain it on a seating so as to resist escape of fluid from the casing A through the port N^1, past the valve O to an outlet port P. The spring O^1 is conveniently adjustable by means of an adjustable abutment screw P^1 engaging a screwthreaded bore in a plug P^2 closing the outer end of the housing in which the valve assembly lies.

It will be seen that the valve O will serve to maintain a certain pressure within the casing A depending on the adjustment of the spring O^1 which is conveniently adjusted to maintain during operation a pressure within the casing which is the mean of the inlet and delivery pressures of the engine.

In the alternative construction shown somewhat diagrammatically in Figure 7 the movement of the axially movable parts is effected by a part Q part of which forms a piston Q^1 moving in a fixed cylinder Q^2 while an extension Q^3 is connected to an operating rod R which in turn is connected to a differential piston R^1.

The piston part Q^1 is of the same effective area as the axially movable parts of the engine so that when the body part D is moved to the left or right in Figure 7 to reduce or increase the effective size of the working chamber and hence the capacity of the rotary engine, the piston Q by moving into or out of the casing ensures that the free volume of the casing remains unaltered.

In addition the space S is in communication with the outlet port of the engine or pump while the space S^1 is in communication with the inlet port of the engine, the area of each of the piston faces in these spaces being half that of the piston Q. Thus, the whole axially movable assembly is substantially free from unbalanced axial forces and the adjustment of this assembly to vary the pump capacity is thus facilitated.

In the construction shown a valve T is arranged to admit fluid under pressure to one side or the other of the piston part T^1 to move the axially movable assembly to vary the pump capacity but this arrangement per se forms no part of the invention.

It will be seen that with the invention the pressure maintained within the casing reduces bearing loads by counterbalancing the pressures in the working chamber and reduces leakage by reducing the pressure drop across the pressure sealing surfaces of the pump.

No claim is made herein to the subject matter claimed in United States Patent No. 2,344,879, issued March 21, 1944, in the name of Edward Harry Johnson, one of the joint applicants of the invention described and claimed herein.

What we claim as our invention and desire to secure by Letters Patent is:

1. In a rotary engine the combination of a blade chamber comprising inner and outer circumferential walls and annular end walls and provided with inlet and outlet ports, a rotor, blades carried by said rotor and extending into the blade chamber, an abutment extending across the blade chamber between the inlet and outlet ports, an outer casing within which said parts lie, and means for maintaining within said casing during operation of the rotary engine a fluid pressure substantially greater than the pressure outside the chamber and lying between that at the inlet port and that at the outlet port, said means being responsive to variations from normal in the respective pressures existing at the inlet and outlet ports to vary the pressure maintained within said casing.

2. A rotary engine as claimed in claim 1 which is of the kind in which the blades and one end wall of the blade chamber and the circumferential wall of the blade chamber not carrying the abutment are movable longitudinally relatively to the other end wall of the blade chamber, the other circumferential wall and the abutment to vary the capacity of the engine, including a compensating piston arranged to move with the axially movable parts of the engine, and a cylinder opening into the engine casing in which the compensating piston operates, the area of the compensating piston corresponding approximately to the effective area of the axially movable parts regarded as a piston so that the movements of the compensating piston withdraw from or displace into the casing approximately the same quantity of fluid as would otherwise be respectively forced from or drawn into the casing by the axially movable parts of the engine.

3. A rotary engine as claimed in claim 2 in which the end of the compensating piston remote from the engine chamber is provided with a portion of reduced diameter working in a corresponding cylinder forming a differential piston having two head spaces, one of said head spaces being connected to the inlet port and the other to the outlet port of said engine.

4. A rotary engine as claimed in claim 1 in which the means for maintaining the pressure within the casing are such as to maintain this pressure at approximately the mean of the inlet and outlet pressures.

5. A rotary engine as claimed in claim 1 in which the rotary engine is of the kind wherein the blades, one end wall of the blade chamber and the circumferential wall of the blade chamber not carrying the abutment are movable longitudinally relatively to the other end wall of the blade chamber, the other circumferential wall and the abutment to vary the capacity of the engine.

6. A rotary engine as claimed in claim 1 in which the pressure within the casing is maintained by leakage from the blade chamber, and a pressure relief valve adapted to open and permit escape of fluid from the casing at a predetermined pressure.

7. A rotary engine as claimed in claim 1 in which the pressure within the casing is controlled and maintained by a relief valve compris-

ing a two diameter piston the major end face of which is subject to the pressure in the casing and is adapted to open a relief port when moved under this pressure while the two minor end faces are subject respectively to the inlet and delivery pressures.

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